UPDATED GEOTECHNICAL EVALUATION REPORT

Mass Grading, Utilities, and Roadways
Hillview Crossing – Missoula
Missoula, Montana
Project 15-3338G

Submitted by

SK GEOTECHNICAL

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Prepared for

Territorial Landworks, Inc.
P. O. Box 3851
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December 3, 2015

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December 3, 2015 Project 15-3338G

Mr. Nathan Lucke, PE
Territorial Landworks, Inc.
P.O. Box 3851
Missoula, Montana 59806-3851

Dear Mr. Lucke:

Re: Updated Geotechnical Evaluation for Mass Grading, Utilities, and Roadways, Hillview Crossing – Missoula, Missoula, Montana

We have completed our update of the geotechnical evaluation for the above-referenced project, which you authorized on April 21, 2015. The purpose of the updated evaluation was to evaluate the current design and site conditions and to assist Territorial Landworks, Inc., in designing public utilities, earthwork, and pavements, and in preparing plans and specifications for construction of the new Hillview Crossing – Missoula Subdivision, formerly known as the Southern Hills Subdivision. The geotechnical evaluation update was completed in general accordance with our proposal to you dated April 14, 2015.

Summary of Results

Engineering Reconnaissance. An engineering reconnaissance was performed by our personnel in May of 2015 to observe the current site topography. The site conditions appear to be little changed and relatively similar to the conditions observed during our fieldwork in 2006. Six piezometers were still in place to allow for additional water level measurements. In 2006 and 2007, groundwater was not observed in these piezometers. However, in 2015, groundwater levels were observed in three of the piezometers at depths ranging from about 42 1/2 to 43 1/2 feet. Wet mud was also observed in one of the piezometers, indicating groundwater was near the bottom of the piezometer or had been previously wet, but had since drained away. The water level measurements indicate static groundwater levels are generally below depths of about 33 1/2 to 42 1/2 feet and below future cut depths. However, some seeps should be anticipated in deeper utility excavations. Also, some periodic seepage, most likely from rain and snow melt, could be encountered in future cut slopes, excavation sideslopes, basement excavations, and utility trenches. We anticipate surface water infiltrates into the ground surface through more permeable sand and gravel layers, and then travels laterally along more clay and silt layers until it either exits the slope face or encounters a more permeable sand or gravel layer and infiltrates deeper.

The ground surface observations indicate the current slopes are stable and signs of current instability were not observed. We did observe somewhat lusher grass present near the southeast corner of the subdivision. It is our opinion this is most likely due to the presence of more clay soils being present on this side of the subdivision that can better retain surface water, allowing lusher vegetation to establish. The western two-thirds of the subdivision appear to be more gravelly near the surface, which is less likely for lush vegetation to establish.

Soils. Twelve soil borings (six to 20 feet and six to 45 feet) were completed in 2006 on or near the proposed residential street alignments, and at more critical slope cross sections in maximum cut and fill areas. The current subdivision layout is relatively similar to the original layout, but has been somewhat modified.

The general soil profile at the borings generally consisted of about 1 1/2 to 3 feet of topsoil and root zone underlain by alluvial deposits consisting of interbedded clayey sands, silty sands, gravels, silts, and lean clays. These interbedded soils vary in thickness and depth across the site. As indicated above, groundwater was generally not observed in the borings at the time of drilling. However, a waterbearing zone was observed at a depth of about 12 1/2 feet in one boring at the time of drilling. Groundwater was originally not observed in the piezometers, but most recent water level measurements indicate groundwater present in at least three of the piezometers.

Summary of Analysis and Recommendations

Cut and Fill Slopes. It is planned to construct the future fill slopes out of a mixture of the on-site clays, silts, sands, and gravels. Due to the current slope and the desire to use on-site soils for embankments, roadways, and residences, it is critical all earthwork be properly constructed with a high degree of inspection and testing. This will allow you to better evaluate the earthwork is properly keyed into the existing slopes, properly compacted, and variations requiring additional recommendations (if encountered) are properly addressed. Based on the results of our additional slope stability analysis, we recommend all future fill slopes be constructed at a slope of 2.5:1 (horizontal:vertical), or flatter. We also recommend the embankment fill slopes below the future residences incorporate geogrid reinforcement to provide additional strength at the embankment toe and provide a higher factor of safety for slopes near or below the future residences. Alternatively, the slopes can be placed at 3.0:1 or flatter. The 3.0:1 fill slopes will still need to be properly keyed into the existing slopes and properly compacted, but the geogrid can be eliminated. It is our opinion the embankment fill slope on the left hand (uphill) side of the entrance access road can be constructed at a slope of 2:1, but the downhill sideslope should be constructed at 2.5:1, assuming no residences are planned along these slopes.

It is our opinion cut slopes can be constructed at a slope of 2.5:1 or flatter. Topsoil seeding and erosion control measures should be implemented to control surface erosion. We wish to point out, however, slopes (cut or fill) of 3.0:1 are generally considered the practical maximum (steepest) for maintenance operations, erosion control, and safety.

Streets. The streets servicing the subdivision will be local/residential streets, and it is our opinion the City of Missoula Asphalt Paving Section for Medium Subgrades can be used for design. This section consists of 3 inches of asphalt concrete over 6 inches of crushed gravel base over 8 inches of gravel subbase for a total thickness of 17 inches, not including the 6 inches of compacted subgrade.

Utilities. The borings indicate the soils will generally be suitable for direct support of the proposed utilities. However, low permeability trench backfill plugs should be constructed at each individual service and at 200-foot intervals along the main lines. This is critical along trenches to reduce the risk of bedding acting as a conduit for water. A high level of testing and inspection is also recommended during trench work to reduce the risk of excessive backfill settlement.

Drainage. Proper control of surface water, roof run-off, and subsurface drainage will be critical for proper performance of the future slopes, roadways, and residences. We recommend all surface water run-off in the roadways be collected by a properly constructed series of curb and gutter, and storm sewer manholes and inlets. All roof run-off from the residences should also be collected by high quality gutters, downspouts, and piping systems, and this water routed to defined collection ditches to carry surface water down and away from the subdivision. We recommend any ditches constructed above future residences be lined with an impermeable PVC or HDPE liner to prevent surface water from infiltrating into the ground surface and affecting adjacent homes.

Although the borings indicate groundwater will likely not be encountered in permanent cut slopes, there is some risk of seepage exiting the cut slopes. If seepage areas are identified during or after construction, seepage collection systems should be implemented to control seepage exiting the slope face and route it down and away from the subdivision.

The need for perimeter foundation and subfloor drains will need to be determined by the lot specific project geotechnical report recommended for each individual residence as they are designed. At a minimum, they are recommended for any below-grade spaces, such as basements and crawl spaces. Water collected in these systems should also be routed to the stormwater collection system, and not discharged on adjacent residential lots.

Geotechnical Report Limitations

It should be noted, this geotechnical work is only to be used for design of the proposed streets, utilities, and mass grading. It is ***not*** to be used for design of the proposed residences. Individual geotechnical evaluations will be needed for each individual residence, including site-specific soil borings, laboratory testing, and geotechnical recommendations addressing the specific structure, and homeowner and design needs.

This updated geotechnical report is based on the current site observations and design information provided. Over time, surface and/or subsurface conditions can change along with code requirements, engineering design standards, and other considerations that could affect the performance of the subdivision, streets, utilities, or residences. ***The recommendations contained in this report will not be valid after a period of five years from the date of this report, or after December 3, 2020.*** After this date, any additional work relying on recommendations obtained from this report will need to be re-evaluated and redone, including, but not limited to, a new geotechnical report, fieldwork, laboratory tests, and all analyses and recommendations used for design purposes.

General

Please refer to the attached report for more detailed results of our fieldwork, engineering analyses, and recommendations.

Thank you for using SK Geotechnical. If you have any questions regarding this report, please call Cory Rice at (406) 652-3930.

Sincerely,

Cory G. Rice, PE
Senior Engineer

Gregory T. Staffileno, PE
Reviewing Engineer

Attachment:
Geotechnical Evaluation Report

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A. Introduction

A.1. Project

SK Geotechnical was originally retained by Professional Consultants, Inc. (PCI), in 2006 to assist them in designing the Southern Hills Subdivision in Missoula, Montana. This project was never developed, and design of the subdivision was recently picked up by Territorial Landworks. The current name of the subdivision is Hillview Crossing – Missoula and is located in Missoula, Montana. The project is located west of the existing residence at 4607 Hillview Way. The approximate location of the subdivision is presented on the Site Location Sketch in the Appendix of this report.

A.2. Purpose of this Evaluation

The purpose of this updated geotechnical evaluation is to utilize the work originally performed for PCI and to develop an updated geotechnical evaluation to assist Territorial Landworks in the current subdivision design. This work will consist of asphalt pavement design for residential streets, utility construction, and mass earthwork constructing the proposed cut and fill slopes. This evaluation will also assist Territorial Landworks in preparing plans and specifications for construction of the proposed Hillview Crossing Subdivision. It is not the purpose of this evaluation to develop lot-specific geotechnical recommendations for the individual residences. Individual geotechnical evaluations will need to be conducted by others for these structures.

A.3. Scope

Our scope of services to update the geotechnical evaluation was summarized in our proposal to Territorial Landworks dated April 14, 2015, and consisted of the following.

- Conduct a geotechnical reconnaissance and document review to observe the current ground conditions and review our original geotechnical report as it relates to the current planned construction and to evaluate recommended changes as required.

- Conduct up to three additional slope stability analyses on typical cross sections on future fill and cut slope areas based on the proposed updated grading plan.

- Provide updated pavement design for the residential roadways.

- Develop additional geotechnical recommendations regarding utility support, backfill recommendations, and fill and cut slope construction.

- Provide an updated geotechnical report incorporating our additional slope stability analysis, pavement design, and updated recommendations for the current project owner and current design and code standards.

- **Individual residence foundations – not included in scope of services.** As indicated previously, this work will not address subgrade preparation or foundation design for individual residences, and this work is specifically excluded from our scope of services. Individual geotechnical evaluations will need to be performed by others for each individual residence to determine subgrade and foundation design parameters.

A.4. Documents Provided

To assist in our evaluation, Territorial Landworks provided us with the following documents.

- Overall Grading Plan, dated August 14, 2015
- Site cross sections for steeper slopes (approximately 2.5 horizontal:1.0 vertical), or flatter, dated August 14, 2015.
- Site cross sections for flatter slopes, approximately 3.0:1, or flatter, dated August 14, 2015.
- Preliminary Utility Layout, dated November 25, 2015.

We also utilized our original Geotechnical Evaluation Report, Project 067358, dated April 26, 2007, for available soils and laboratory information.

A.5. Boring Locations and Elevations

The original boring locations were selected by Mr. Kevin Dansie, PE, a geotechnical engineer with our firm. The locations were plotted on a Preliminary Site Plan, and a copy was provided to PCI. Boring locations were then staked in the field by PCI, and the locations of the borings were plotted on a Final Site Plan prepared by PCI. This plan was overlaid on the current Overall Grading Plan, and the approximate locations are shown on the attached Overall Grading Plan with the drawn boring locations.

B. Results

B.1. Logs

Log of Boring sheets indicating the depths and identifications of the various soil strata, the penetration resistances, laboratory test data, and water level information are attached. It should be noted the depths shown as boundaries between the strata are only approximate. The actual changes may be transitions and the depths of the changes may vary between borings. At the completion of logging and soil sampling, Borings ST-1P, ST-2P, ST-3P, ST-4P, ST-10P, and ST-12P were converted to temporary piezometers.

Geologic origins presented for each stratum on the Log of Boring sheets are based on the soil types, blows per foot, and available common knowledge of the depositional history of the site. Because of the complex glacial and post-glacial depositional environments, geologic origins are frequently difficult to ascertain. A detailed evaluation of the geologic history of the site was not performed.

B.2. Geology

Based on the geology map titled *Geologic Map of the Missoula West 30' X 60' Quadrangle*, compiled and mapped by Reed S. Lewis, 1998, the general geology at the site consists of "**Taf** – Alluvial Fan Deposits (Miocene through Pliocene) – Locally derived, poorly sorted, angular to rounded boulders, cobbles, gravel, sand, and silt. Probably equivalent to the Sixmile Formation of southwest Montana (Sears 1997)" and "**Tgc** – Gravel and Clay (Eocene through Miocene) – Channel and flood plain deposits of the ancestral Bitterroot and Clark Fork Rivers. May also be present and includes well-sorted and well-rounded cobbles, gravel, sand, clay, and volcanic ash deposits….Coarser intervals are permeable, but clay-rich zones are not. Probably equivalent to the Renova Formation of southwest Montana (Jim Sears, prs. Comm., 1997)."

B.3. Site Conditions

At the time of our original evaluation in 2006, the site was an undeveloped lot covered with native grasses. Since that time, it appears the lot has little changed. The only significant change appeared to be trails that were cut parallel to the existing slope to allow access to our drill rig during the 2006 fieldwork. On May 1, 2015, Mr. Cory Rice, PE, a senior geotechnical engineer with our firm, visited the site to observe the existing surface conditions and obtain several updated photographs. We also obtained current groundwater level readings in six PVC piezometers that were installed in 2006.

As indicated above, the site appears to be little changed with the exception of the trails cut to access the proposed boring locations. The site was still covered with native grasses. We did observe the grass on the eastern side, and primarily southwestern side, of the subdivision appeared to generally be lusher, indicating a higher level of moisture available for surface vegetation. The center and western portions of the site appeared to generally be drier with coarser gravels observed on the surface and in the shallow access road cuts. Existing slopes generally ranged from about 10 to 19 degrees from horizontal, which equate to about 5:1 to 3:1 horizontal to vertical (H:V) slopes. The existing cut slopes appeared to be stable and signs of instability were not observed. Seepage from the existing hillside was also not observed, although somewhat lusher vegetation was observed on the eastern portion of the site, as indicated above.

Some boulders with a maximum dimension of about 3 feet were observed in isolated areas. We also observed the existing cut slope near the northwest side of the subdivision near the end of Saranac Drive. This cut slope appeared to be about 20 feet in height and constructed at an angle of about 36 degrees

(1.4:1). Based on our observations, this cut slope appeared to be stable. We also observed an embankment slope to the east of the subdivision that we estimated to have a height of about 12 feet and was constructed at a slope of about 22 degrees (2.5:1). This slope also visually appeared to be stable. We also observed an 8-foot high cut slope along an access road at the northwest corner of the subdivision that was constructed at a slope of about 18 degrees (3.0:1) that also appeared to be stable. Updated photographs of the subdivision are attached. Our groundwater level measurements are discussed in more detail in Section B.5 of this report.

B.4. Soils

The soil borings performed in 2006 encountered 1 1/2 to 3 feet of topsoil and root zone at all locations. Beneath the topsoil and root zone, the general soil profile encountered at the borings was clayey sands with gravel, silty sands with gravel, and poorly graded gravel with silt and sand. Underlying these soils, lean clays with gravel, poorly graded gravel with silt and sand, and inter-bedded lean clays, silty sands and poorly graded gravel with silt and sand were encountered. These strata are described in more detail below.

B.4.a. Topsoil/Root Zone. The topsoil generally consisted of loose to medium dense clayey sand with roots. The topsoil ranged in depth from 1 1/2 feet to 3 feet. Penetration resistances generally ranged from 3 to 26 blows per foot (BPF), but generally averaged between 7 and 12 BPF.

B.4.b. Clayey Sand with Gravel Alluvium. Beneath the existing topsoil, clayey and silty-clayey sand with gravel was encountered in Borings ST-1P, ST-2P, and ST-7. Penetration resistances generally ranged from 13 to 34 BPF, indicating these soils were medium dense to dense. These soils were encountered to depths ranging from 4 to 9 feet.

B.4.c. Silty Sand with Gravel Alluvium. Underlying the topsoil in Borings ST-4P and ST-5 were silty sands with gravel. Penetration resistances generally ranged from 10 to 22 BPF, indicating these soils were loose to medium dense. These soils were generally encountered to depths ranging from 3 to 6 feet.

B.4.d. Poorly Graded Gravel with Silt and Sand Alluvium. Underlying the topsoil in Borings ST-6, and ST-8 through ST-11 were poorly graded gravels with silt and sand. These soils were encountered to depths ranging from 12 to 29 feet. Penetration resistances generally ranged from 18 to 87 BPF, indicating these soils were medium dense to very dense. The average BPF ranged from about 22 to 35.

B.4.e. Sandy Lean Clay Alluvium. Underlying the topsoil in Boring ST-12P, stiff to hard sandy lean clay was encountered to a depth of 12 feet. Penetration resistances ranged from 28 to 36, indicating these soils were hard to very hard.

B.4.f. Interbedded Alluvium Soils. Interbedded soils encountered at deeper depths in the borings generally consisted of silty clays, silty clayey sands, silty sands, clayey sands, clayey gravels with silt and sand, poorly graded gravels with silt and sand, silt with sand, and sandy lean clay. Penetration resistances generally indicated these soils ranged from medium dense to very dense and stiff to hard. Unusually very dense and moderately cemented silty clay and silty clayey sand soils and gravels were encountered in Boring ST-12P below a depth of about 12 feet. These soils had penetration resistances ranging from 74 BPF to 50 blows for 3 inches. These soils, while being very dense, could be penetrated with our hollow-stem auger drilling equipment, indicating it likely was not hard bedrock. However, these soil deposits could be older alluvial sediments that are intermediate geomaterials (IGMs), which are typically dense soils with physical characteristics between soil and harder bedrock.

B.5. Groundwater Observations

Groundwater was generally not observed in the borings at the time of drilling. The exception was a waterbearing zone observed at a depth of about 12 1/2 feet in Boring ST-1P. Six piezometers were installed in the borings (Borings ST-1P through ST-4P, ST-10P, and ST-12P) for extended water level measurements. On November 28, 2006, the piezometers were measured for groundwater, but groundwater was not encountered. Again, on April 5, 2007, the piezometers were rechecked and groundwater was not encountered. However, on May 1, 2015, groundwater was observed in three of the piezometers, ST-1P, ST-4P, and ST-10P, at depths ranging from 42.7 to 43.8 feet. Also, muddy soils were present at a depth of 33.4 feet in ST-2P, indicating water was recently present in the piezometer, but has likely since drained away. A summary of the May 1, 2015, groundwater level measurements are summarized in Table 1 below.

Table 1. Summary of Groundwater Level Measurements – 2015

Piezometer	Ground Surface	Depth to Groundwater	Groundwater Elevation
ST-1P	3365.9	42.7'	3323.2
ST-2P	3328.5	Mud – 33.4'	3295.1 – Mud
ST-3P	3252.8	N/E – 43.7'	Below 3209.1
ST-4P	3261.9	43.4'	3218.5
ST-10P	3251.4	43.8'	3207.6
ST-12P	3277.6	N/E – 39.6'	Below 3238.0

As indicated in the above table, groundwater is present at elevations ranging from about 3207 1/2 to 3323. Including the muddy soils, groundwater is also present near elevation 3295. These water levels were generally near the bottom of the piezometer and indicate groundwater may generally follow the ground surface at a depth of about 42 to 44 feet. The water levels observed also may be seasonal groundwater that became perched on less permeable silt or clay layers that then travelled laterally until the groundwater encountered the piezometer and then accumulated near the bottom of the piezometer pipe. We recommend additional groundwater level measurements be obtained, especially in the spring and fall to evaluate groundwater fluctuations.

The water level measurements indicate, at a minimum, perched groundwater does exist during wetter periods. It is our opinion the perched water is likely related to surface water that infiltrates down through the surface through sand or gravel layers and then becomes perched on less permeable silt or clay layers. This water then travels laterally until it encounters a more permeable sand or gravel layer and can infiltrate downward. Alternatively, the water can exit the slope face which may partially contribute to the more lush vegetation on the eastern side of the subdivision.

B.6. Laboratory Tests

The results of the laboratory tests completed in 2006 are summarized on the boring logs and graphs in the Appendix. Additional laboratory testing since that time has not been completed.

B.6.a. Classification Tests. Classification tests consisting of Atterberg limits and percent-finer-than-a-200-sieve were conducted on both split-spoon samples and loose bulk samples obtained from the borings. Table 2 below provides a summary of the classification tests.

Table 2. Summary of Laboratory Tests

Boring	Depth (feet)	Atterberg Limits			P_{200} (%)
		LL	PL	PI	
ST-2P	1½ to 9 (bulk sample)	24	14	10	26
ST-2 P	12 to 13	47	21	26	82
ST-4P	7 to 14 (bulk sample)	47	16	31	70
ST-6	14½ to 15½	46	21	25	67
ST-7	0 to 9 (bulk sample)	24	17	7	24

The Atterberg limits tests indicate the on-site clayey soils have a moderate potential for volume change, i.e., shrinking and swelling with changes in moisture content.

Based on the results indicated above, samples from Borings ST-2P, ST-4P, and ST-6 classify as lean clay while the sample from Boring ST-7 classified as silty clayey sand. The American Society for Testing and Materials (ASTM) symbols for these soils are CL and SC-SM, respectively.

B.6.b. Proctor Tests

Three Proctor tests were performed on larger bag samples obtained from Borings ST-2P, ST-4P, and ST-7. The results of these tests are shown on the graphs in the Appendix and are summarized in Table 3 below.

Table 3. Summary of Proctor Tests

Boring	Depth (feet)	ASTM Classification	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
ST-2P	11/2 to 9	SC	132	8
ST-4P	7 to 14	CL	106	18
ST-7	0 to 9	SC-SM	133	7

The results indicated above are typical for alluvial clays and sands with gravel, but are quite variable, indicating a high level of testing and inspection will be required during construction.

B.6.c. Corrosion Tests

Corrosion tests were conducted on two thin-walled tube samples obtained from Borings ST-4P and ST- 12P at a depth of 11 feet. Results of the corrosion testing are presented in Table 4 below.

Table 4. Summary of Corrosion Tests

Boring	Depth (feet)	Resistivity (ohm/cm)	Conductivity (mmhos)	pH	Marble pH	Sulfate (%)
ST-4P	10½ to 11½	9,250	0.1081	7.01	7.28	< 0.01
ST-12P	10½ to 11½	7,900	0.1265	8.18	7.88	< 0.01

Based on the results of the corrosion tests, the clay soils tested generally have a moderate to low potential for corrosion to steel materials. The sulfate tests indicate the clay soils would be Class S0 as defined by Table 4.2.1 of the American Concrete Institute (ACI) Manual 318-56, and will have a low risk of detrimental effect on reinforced concrete from sulfate exposure.

C. Analyses and Recommendations

C.1. Proposed Construction

The proposed subdivision will include 34 duplex townhomes and two residential streets as shown on the attached Overall Grading Plan. To create relatively level or split-level building pads for the future townhomes, two sidehill cuts will be made running roughly parallel to the existing slopes. The maximum height of these cuts will be about 45 feet measured from the top of the cut slope to the bottom. The maximum vertical cut depth measured from the existing ground to the base of the cut will be about 24 feet. The material removed from the cut slopes will generally be used to construct embankments on the downhill side of the future roadways. The fills will generally have a maximum height of about 27 feet as measured from the toe of the fill slope to the top. The maximum thickness of the fills will generally be about 12 feet as measured from the existing ground surface to the top of the embankment fill. A larger 40-foot high fill will be required for the access road coming off of Hillview Way, and this embankment will have a maximum thickness of about 23 feet. All future cut and fill slopes will be constructed at slopes of 2.5:1, or flatter. The exception will be the uphill, or left hand, embankment sideslopes for the access road off of Hillview Way that will need to be constructed at a slope of 2:1 to keep within current right-of-way limits.

The future utilities will consist of 8-inch PVC sewer main with burial depths ranging from 8 to 15 feet, and an 8-inch ductile water main with burial depths of approximately 6 1/2 feet. Stormwater infrastructure will include standard curb inlets connected to corrugated metal pipe structures ranging in size from about 18 to 30 inches. Footing and roof drains from all of the townhomes will also be directed into the stormwater system that will eventually drain into a dry creek bed between the upper and lower homes that will be routed to a detention pond near the northwest corner of the site that will eventually overflow into Wapikiya Park.

The residential roadways will be paved with asphaltic concrete and will be about 25 feet in width with concrete curb and gutter. The streets will be subjected primarily to light car and truck traffic with occasional trucks, such as moving vans, garbage trucks, and delivery vehicles.

If the proposed grades differ from the drawings provided or if there are changes to the design, we should be informed. Additional analyses and recommendations may be necessary.

C.2. Discussion

Based on the results of the soil borings and laboratory tests conducted for our 2006 work and our recent geotechnical reconnaissance, it is our opinion the on-site natural soils will generally be suitable for reuse as fill material during mass grading operations, provided they are thoroughly mixed, moisture conditioned to a moisture content near optimum, and properly compacted to specification. It is also critical the embankment fills be properly keyed into the existing sideslopes. Also, we recommend geogrid reinforcement for the embankment toes to provide a higher factor of safety for embankments with residences constructed near the top of the slopes. The soils encountered during mass grading will consist of a mixture of silt and lean clay soils along with alluvial granular soils such as sands and gravels. We recommend these soils be thoroughly mixed to improve the workability and strength of the silt and clay soils and to provide embankment fill soils that will have a minimum internal friction angle of at least 32 degrees, or higher.

Based on our updated stability analysis, it is our opinion all future fill and cut slopes should be constructed at a slope of 2.5:1 (horizontal:vertical), or flatter. The exception is the access road embankment sideslope on the uphill side (left of centerline) that can be constructed at a slope of 2.0:1, or flatter. There is some potential for seasonal groundwater seeps that could emanate from future permanent and/or temporary cut slopes. These seeps could develop into cut slope instability. Therefore, we recommend close observation of all cut slope excavations during construction, and if seeps or signs of past seepage are encountered, additional measures to control seepage from exiting on the slope surface should be implemented. A contingency should be provided for this purpose.

The future embankments will be constructed on a sideslope with clayey soils. Wetting or saturation of these embankment fill slopes could result in embankment instability that could affect future roadways, utilities, embankments, or structures. Therefore, it is critical stormwater be properly collected in a well maintained stormwater collection system. Also, all roof run-off needs to be collected in a similar system and well maintained throughout the life of the structures. Xeriscaping is strongly recommended to reduce lawn irrigation and potential uncontrolled water sources that are difficult to maintain and reliably control.

Moderately deep utility excavations will extend into the alluvial clays and silts. It has been our experience, obtaining proper compaction on these soils in utility trench excavations is very difficult and can result in several inches or even several feet of settlement if not properly compacted. A large amount of embankment material will also be placed for the future building pads. Inadequate compaction could result in excessive settlement or instability. We recommend a project-specific specification be written outlining or requiring the contractor to submit a detailed plan of how the soils will be processed to obtain a moisture content near optimum and documentation of how the material will be placed in sufficiently thin lifts, compacted to specification, and providing full-time construction inspection and testing, documenting the fill material has been properly placed and compacted to specification.

Provided the cuts and fills are constructed as recommended, it is our opinion these soils and the undisturbed native soils will generally be suitable for direct support of the proposed utilities and roadways. Evaluating the suitability of the soil or groundwater conditions for support of the individual residences was not included in our scope of services. ***Separate geotechnical evaluations will be needed***

for each individual residence to determine the specific soils at each residence and to address the specific design.

Seasonal and annual fluctuations of the groundwater table will occur due to variations in rainfall, irrigation, snow melt, and other factors not evident at the time of our original fieldwork. It appears seasonal fluctuations do occur, however, the current depths of groundwater appear to be below the future cut slope and utility depths. Careful observations should be performed during construction to identify seepage, or recent seepage, areas that require additional seepage control measures. However, careful observations during construction are recommended to control seepage from future cut slopes, if encountered.

C.3. Slope Stability

Stability analyses of the maximum cut and fill slopes along cross sections C and D, which in our opinion, are the more critical sections due to the more predominant clayey soils and steeper slopes, were performed. Our stability analysis was conducted with the SVSLOPE™ computer program for static and seismic conditions. Strength parameters utilizing the analyses were based on our past experience and published data on similar soils as those encountered at the site. Table 5 presents the strength parameters utilized in the analyses. Based on the International Building Code (IBC) 2012, it is our opinion the site is classified as Site Class "C" for very dense soil and soft rock profiles. Based on this, seismic force coefficients of 0.081 horizontal were used in the slope stability analysis for pseudo-static (seismic) conditions. Boundary loads of approximately 1,000 pounds per square foot (psf) were also utilized to represent future residential structure loads.

Several program runs were performed using the Ordinary Method and Bishop Method of determining circular failure surfaces. Initiation and termination ranges were varied until factors of safety converged on a minimum value. The calculated minimum factors of safety are presented in Table 6. The program output outlining the results of our analysis are presented in the Appendix.

The recommended a minimum factor of safety for earthfill embankments under static conditions is 1.3 for embankment slopes with only roadways above them. We recommend a minimum factor of safety between 1.4 and 1.5 for embankments with structures above them. We also recommend a minimum factor of safety between 1.4 and 1.5 for cut slopes constructed above residences. For seismic conditions, we recommend a minimum factor of safety of 1.1.

Based on our review of our original stability analysis conducted in 2006, the original analysis was based on an assumption the soil layers were generally horizontal in nature. However, based on our current review, it is our opinion it is more likely the soil layering generally follows the ground surface, which also results in a more conservative analysis.

Table 5. Material Strength Parameters

Material Type	Total Unit Weight (lbs/ft^3)	Drained		Undrained	
		Friction Angle	Cohesion (lbs/ft^2)	Friction Angle	Cohesion (lbs/ft^2)
Fill (SC-GC)	130	32	0	32	0
Clayey Sand (SC)	126	29	0	29	0
Sandy Lean Clay (CL)	115	22	250	0	3,000
Clayey Gravel (GC)	138	32	0	32	0
Gravel with Sand (GP)	140	36	0	36	0

Table 6. Slope Stability Analysis Results, Minimum Factors of Safety for Circular Failure

Cross Section/Slope	Analysis	Factor of Safety (Static)	Factor of Safety (Seismic)
2.5:1 Cut and Fill Slopes			
C –Upper Embankment	Undrained	1.4	1.2
	Drained	1.5	---
C-Middle Cut Slope/Embankment	Undrained	1.4 to 1.5	1.1
	Drained	1.4 to 1.5	---
C – Lower Embankment	Undrained	1.5	1.2
	Drained	1.5	---
D – Upper Cut Slope	Undrained	1.4	1.1 to 1.2
	Drained	1.4	---
D – Middle Embankment/Cut Slope	Undrained	1.4 to 1.5	1.1 to 1.3
	Drained	1.4 to 1.5	---
D – Lower Embankment	Undrained	1.5	1.2
	Drained	1.5	---
2.5:1 Cut Slopes and 3.0:1 Fill Slopes			
C –Upper Embankment	Undrained	1.5	1.2
	Drained	1.5	---
C-Middle Cut Slope/Embankment	Undrained	1.5	1.2
	Drained	1.7	---
C – Lower Embankment	Undrained	1.7	1.3
	Drained	1.8	---
D – Upper Cut Slope/Embankment	Undrained	1.4	1.1 to 1.2
	Drained	1.4	---
D – Middle Embankment/Cut Slope	Undrained	1.4 to 1.5	1.1 to 1.2
	Drained	1.4	---
D – Lower Embankment	Undrained	1.7	1.3 to 1.4
	Drained	1.7	---

C.4. Site Preparation and Mass Grading

C.4.a. Stripping. We recommend vegetation, topsoil, and root zone be removed from beneath all proposed embankments, roadways and foundations and slabs. The thickness of topsoil and root zone at the borings ranged from about 1 1/2 to 3 feet. Actual depth of removal across the site should be determined by observations during stripping. As indicated above, a significant volume of topsoil will be generated during the stripping operation. This topsoil can be reused as topsoil over future embankment and cut slopes and landscape areas. After final construction of the future embankment sideslopes, surplus topsoil could also be used for further flattening of fill slopes, but it is critical the topsoil be placed in a controlled manner, i.e., placed in lifts and moisture conditioned to a moisture content near optimum, and compacted to specification. Loosely placing or dumping the topsoil would result in severe erosion and failure of these fill slopes. The flattened slopes using topsoil should have slopes of 3:1 (horizontal:vertical) or flatter.

C.4.b. Embankments. All embankments should be constructed of slopes no steeper than 2.5:1 so they will be stable. The exception is the access road embankment sideslope on the uphill side, left of centerline that can be constructed as steep as 2:1 after the topsoil has been removed. All fill material should be keyed into the existing slope's natural, undisturbed soils using benches with a minimum width of at least 8 feet and maximum vertical separation between benches should not exceed 4 feet. In addition, at the toe of the proposed slope, a keyway with a minimum depth of 18 inches and a width of at least 10 feet should be keyed into the natural undisturbed soils prior to placement of fill material. We also recommend reinforcing the embankment toes that are constructed at 2.5:1 with a minimum of three layers of geogrid reinforcement as shown on the attached Embankment Construction Detail. Slopes constructed at 3:1, or flatter, should also be keyed into the existing slopes as described above, but the geogrid reinforcement can be eliminated. We wish to point out fill slopes of 3:1 are generally considered the practical maximum (steepest) for maintenance operations, erosion control, and safety.

Geogrid should be used for fill slope reinforcement. We recommend using a biaxial geogrid with a minimum Long Term Allowable Design Strength (LTDS) of at least 500 pounds per foot in the cross machine direction. Tensar BX1200 geogrid will meet this requirement. Alternative grids should meet or exceed the properties of the Tensar BX1200 geogrid.

Before fill is placed, all exposed soil surfaces should be scarified to a minimum depth of 8 inches, moisture conditioned to near or slightly above optimum moisture content, and compacted to at least 95 percent of its standard Proctor density determined in accordance with ASTM Method of Test D 698.

A combination of sandy gravel, sand, silt, or clay with a plastic index less than 20 can be used to construct the future embankments. Based on our laboratory test results, some of the natural soils have plastic limits ranging from about 20 to 30. It is our opinion these soils will not be suitable for direct use as embankment construction. If they are to be reused for embankment construction, we recommend the natural clayey soils be thoroughly mixed with the natural granular soils prior to placement so they have a plastic index less than 20 and a minimum internal friction angle of 32 degrees, or higher. If imported soils are required, we recommend importing 3-inch minus sandy gravel or sand meeting the requirements of *Montana Public Works Standard Specifications* (MPWSS), 6th Edition, April 2010, Section 02234 for 4-inch minus subbase.

All fill material should be placed in lifts not exceeding 8 inches (loose thickness) and moisture conditioned within 2 percentage points of optimum moisture content. Since the majority of the embankment fills will have maximum heights near 8 to 10 feet, we recommend all embankment fill be compacted to at least 98 percent of its standard Proctor maximum dry density. The differential fill thickness should not range by more than 8 feet across an individual building pad. If embankments below residences will have heights greater than 10 feet, the material should be compacted to 100 percent. Full-time inspection and compaction testing are recommended during placement of fills on the site. Testing frequency is addressed in Section D.3 of this report.

C.4.c. Cut Slopes. We also recommend all cut slopes be cut to slopes of 2.5:1, or flatter, so they will be stable. As indicated, there is some potential for seepage from the proposed cut slopes that could reduce cut slope stability. Therefore, we recommend closely observing the exposed cut slopes for signs of seepage or past seepage during construction. We wish to point out cut slopes of 3:1 are generally considered the practical maximum (steepest) for maintenance operations, erosion control, and safety.

If seepage is encountered, we recommend armoring the cut slope with a layer of 3- to 6-inch minus cobbles on the slope surface to collect the seepage and prevent it from exiting on the slope surface. The cobbles should be laid over a geotextile filter fabric to control the loss of fines. The cobble layer should be a minimum of 18 inches thick, and the seepage should be routed to a toe drain constructed at the toe of the cut slope. The toe drain should consist of a perforated pipe embedded in drainage aggregate and wrapped in a geotextile filter fabric. The drainage should be drained by gravity down and away from the structures and into the storm drainage collection system.

C.4.d. Setback Requirements. The slope designs and future residence designs will also need to meet the minimum foundation setback requirements as outlined in the current International Residential Code and as required by the local building official.

C.4.e. Shrinkage. The earthwork will consist of excavating a mixture of silt, clay, sand, and gravel from cut areas and placing and compacting in future embankment areas. The clays and silts will tend to shrink more and the sands and gravels less. Based on our review of the boring logs, we estimate shrinkage will range from about 15 to 20 percent from its current "bank" condition to its final "compacted in place" condition. We recommend using a value of 18 percent for design, but it should be considered approximate. The actual shrinkage value will not be known until significant earthwork is completed.

C.5. Utilities

C.5.a. Materials. Silty to clayey soils (silt with sand, sandy lean clay, and lean clay with sand and gravel) were commonly encountered by the borings. Silty and clayey soils are generally corrosive to metallic conduits. Also, based on the results of the corrosion tests, we recommend specifying non-corrosive materials or providing corrosion protection for steel materials. We also recommend polyethylene encasement for ductile iron pipe, if used.

C.5.b. Type 1 Bedding. Based on our borings, it is our opinion the alluvial clays, silts, sands, and gravels will generally not meet the requirements for Type 1 bedding. MPWSS indicates Type 1 bedding shall be 1 1/2-inch minus free draining and nonplastic material. An alternative is 3/4-inch minus well graded gravel (GW) or well graded sand (SW). It is our opinion none of the on-site soils encountered in the borings will meet these requirements, therefore, Type 1 bedding will need to be imported.

It is our opinion the MPWSS Type 1 bedding is often too openly graded and the well graded gravel with sand makes a more suitable material to place beneath the proposed sewer lines. Well graded gravel with sand contains an even distribution of sand and gravel size particles. Once placed and compacted, it does not contain excessive void spaces. Crushed base course is a typical well graded gravel with sand material, while common Type 1 bedding material is open graded. The open graded material contains void spaces between the gravel particles. Surface water infiltration, groundwater, or vibrations can cause sand, silt, and clay backfill to fill the voids, which can result in settlement of the trench backfill, above, below, and on the sides of the bedding.

Therefore, we recommend using crushed base course meeting the requirements of MPWSS Section 02235 as Type 1 bedding beneath the proposed utility pipes. The gradation requirements are shown in the MPWSS. The 1- and 3/4-inch minus materials generally contain more sand and are preferable to the 1 1/2-inch minus material, in our opinion. If open graded bedding is used, it should be wrapped in a geotextile filter fabric to reduce the risk of "piping of fines" into the open graded material. We recommend all bedding be placed in lifts and compacted to a minimum of 95 percent of its standard Proctor density.

C.5.c. Trench Backfill above Bedding. Trench settlement of deeper utility excavations is a common problem and is often difficult to avoid. Even well compacted backfill will settle, in our opinion, and we anticipate normal trench settlement will be approximately 1 percent of the total trench depth. Therefore, for a 15-foot deep trench, at least 1 1/2 inches of trench settlement should be anticipated. If the backfill is poorly compacted, excessively thick lifts are placed, or surface water infiltrates into the trench, several inches or several feet of settlement can occur. This can obviously adversely affect roadways or nearby utilities or structures within the influence of the trench. In areas where up to 2 inches of trench settlement cannot be tolerated, we recommend replacing the on-site clays and silts with imported 4-inch minus sandy gravels that can be more readily compacted to specification. Sandy gravel should be used until the backfill is within at least 5 feet of the final surface.

In areas where the on-site soils are to be used as backfill, a larger amount of work will be required to properly place and compact these soils to specification. The on-site silts and clays will need to be moisture conditioned to obtain a moisture content near or slightly above optimum moisture content, which is necessary to achieve the specified compaction.

We recommend all trench backfill be compacted to a minimum of 98 percent of its standard Proctor density. The material should also be placed at a moisture content within plus or minus 2 percent of optimum moisture content. The material should also be placed in maximum loose lift thicknesses ranging from 4 to 8 inches, depending on the compaction equipment being used. Recommendations for compaction and inspection control are discussed in Section D of this report. Full-time inspection and compaction testing are recommended during placement of trench backfill. Testing frequency is addressed in Section D.3 of this report.

C.5.d. Trench Backfill and Bedding Plugs. It is our opinion low permeability trench backfill plugs should be used along the utility alignments at frequencies to be determined by the civil engineer in accordance with MPWSS Section 02222. At a minimum, we recommend trench backfill plugs be installed at each service entrance and at a minimum horizontal interval of 200 feet along the utility alignments. Trench backfill plugs should be installed in accordance with MPWSS to reduce the risk of piping and water transfer along the pipe bedding. Again, they should be inspected during placement and testing to confirm they meet specifications, especially permeability of 1×10^{-7} cm/sec or less.

C.6. Pavement

C.6.a. Subgrade Preparation. Where residential streets are located in cut areas, after mass grading, we recommend the upper 6 inches of the resulting subgrade be scarified, moistened to a moisture content near optimum, and compacted to a minimum of 95 percent of its standard Proctor maximum dry density. In addition, when residential streets are located in fill areas, after mass grading, we recommend the fill be placed and compacted as described in Section C.4 of this report.

C.6.b. Pavement Sections. The required flexible pavement sections for the residential roadways were evaluated using the software program DARwin™ developed by the Federal Highway Administration (FHWA) based on the 1993 American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures*. The following parameters were used in the DARwin program for calculating the pavement, crushed base, and subbase thicknesses. We also compared our design to the Minimum Local/Residential Street Standards required by the City of Missoula – Engineering Division.

Table 7. Pavement Design Parameters

Parameter	Value
18-kip ESAL	67,991*
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level (%)	85
Overall Standard Deviation	0.45
Roadbed Modulus (M_R)	9,480**

*Calculated using DARWin program.
**Calculated using an estimated resistance value, R-value, of 15.

Using the parameters listed in Table 7 and the DARWin program, a structural number of 1.96 was calculated to determine the minimum pavement section. The minimum City of Missoula Standard for Local/Residential Streets with a "medium" subgrade is 3 inches of asphalt pavement over 6 inches of 3/4-inch crushed gravel base over 8 inches of 3-inch minus subbase. The City minimum pavement section correlates to a structural number of 2.63, which exceeds the minimum calculated value of 1.96. Therefore, it is our opinion the City minimum Standard for Local/Residential Streets with a medium subgrade can be used for design. This section is summarized in Table 8 below.

Table 8. Residential Street Pavement Sections

Alternative	Subbase Section
Asphalt Surface ¾" or 1 1/2" Crushed Base 3" Sandy Gravel Subbase	3" 6" 8"

C.6.c. Materials and Compaction. We recommend specifying crushed gravel base and sandy gravel subbase courses meeting the requirements of MPWSS Sections 02235 and 02234. We recommend the gravel base and subbase be compacted to a minimum of 95 percent of its standard Proctor maximum dry density. We recommend the asphaltic concrete meet the requirements of Section 02503. We recommend the asphaltic concrete pavement be compacted to an average density of 93 percent or greater of the maximum density as determined by ASTM D 2041 (Rice's) and no individual sample shall be less than 92 percent.

C.7. Drainage

Proper control of surface water, roof run-off, and subsurface drainage will be critical for proper performance of the future slopes, roadways, and residences. We recommend all surface water run-off in the roadways be collected by a properly constructed series of curb and gutter, and storm sewer manholes and inlets. All roof run-off from the residences should also be collected by high quality gutters, downspouts, and piping systems, and this water routed to defined collection ditches to carry surface water down and away from the subdivision. We recommend any ditches constructed above future residences be lined with an impermeable PVC or HDPE liner to prevent surface water from infiltrating into the ground surface and affecting adjacent homes.

C.8. Concrete

We recommend using cement meeting the requirements of ASTM C 150 Type II to provide moderate resistance to sulfate attack. We recommend specifying 5 to 7 percent entrained air for exposed concrete to provide resistance to freeze-thaw deterioration. We recommend using a water-cement ratio of 0.50 or less for exposed concrete and a water-cement ratio of 0.45 or less for concrete exposed to deicers.

D. Construction

D.1. Excavation

It is our opinion the majority of the soils encountered by the borings can be excavated with a backhoe, front-end loader, or scraper. The very dense soils, if encountered, at Boring ST-12P may require larger excavating equipment with ripping attachments. Blasting is not anticipated. Due to the variable soil conditions, it is our opinion all soils should be considered Type C soils under Department of Labor Occupational Safety and Health Administration (OSHA) guidelines. All earthwork and construction should be performed in accordance with OSHA guidelines.

During fill placement, the work surface should be graded to direct run-off away from fill areas to prevent saturation of the exposed surface of fill material during a precipitation event. The contractor should also provide positive drainage away from all excavations. No frozen fill shall be placed and no fill shall be placed on frozen ground, on standing water, or on yielding soil. The compaction of fill should be completed under continuous engineering inspection and testing as outlined in Sections C.4 and D.3 of this report.

D.2. Observations

We recommend all stripping, embankment, and pavement subgrades be observed by a geotechnical engineer or an engineering technician working under the direction of a geotechnical engineer to see if the subgrade soils are similar to those encountered by the borings, identify areas of seepage, if any, and determine adequate stripping has been completed. The mixture of on-site soils should also be observed to determine the mixed soils are a uniform mixture of silty clayey sand and/or gravels, will have an internal friction angle of at least 32 degrees, and a plasticity index less than 20. We anticipate this can be performed by a qualified soils inspector based on visual and manual procedures.

D.3. Compaction and Inspection Control of Embankments and Trench Backfill

It is our opinion a detailed site specific specification should be written addressing how embankment and trench backfill shall be placed, tested, and inspected, and how failing tests will be treated so all failed areas are removed and properly replaced. In particular, we recommend the following.

- On-site clays and silts that are found to be excessively wet should be transported to a larger designated processing area where they can be spread out, mixed, and dried with tractors and discs to obtain a uniform material near optimum moisture content. Additional moisture may need to be added depending on weather conditions. If additional moisture is required, the moisture should be added with trucks and spray bars and applied uniformly, and then thoroughly mixed with discs. After the material has been uniformly mixed and moisture conditioned to a moisture content plus or minus 2 percent of optimum, it can be transported back to the utility alignment or fill area, placed, and compacted.

- All trench backfill above bedding should be placed in maximum loose lift thicknesses between 4 to 8 inches and compacted to a minimum of 98 percent of its standard Proctor density.

- Embankment fill should be thoroughly mixed and be uniform material, placed in maximum loose lifts of 8 inches. It should be compacted as follows per standard Proctor.

    - 98 percent for fills less than 10 feet thick
    - 100 percent for fills 10 feet or greater

- Full-time quality control (QC) testing should be provided for each crew working on the utility alignments and embankments to document the specified lift thickness has not been exceeded, the material has been properly mixed and is uniform, and compacted to specification.

- Daily quality assurance (QA) testing should also be performed by a separate independent testing agency (not the QC testing firm) to avoid potential conflict of interest and to determine the QC testing is representative.

- Full-time inspection should also be provided for each crew performing earthwork. QC and QA test results should be reported to the inspector on site. Any discrepancies between QC and QA test results should be resolved before proceeding with any additional earthwork.

- The contractor and inspector should be required to prepare daily production reports of the amount and rate of material placement. At the onset of construction, the contractor's production rate should be established for a zone of properly compacted and tested backfill. This production rate should then be compared on a daily basis to the contractor's production. If the production exceeds the normal production rate, additional testing and inspection should be performed to verify all of the material is being placed and compacted to specification.

- If a compaction test fails, the failed lift should be removed both horizontally and vertically to the point where previous passing tests were obtained. This is the best approach, in our opinion, to make sure adequate compaction effort is applied to every lift. Simple recompaction of the immediate testing area should ***not*** be allowed. The contractor should be made aware of this requirement during the bidding process.

- The surface of the trench backfill should be crowned to allow surface water to drain off of the trench excavation and to allow for some trench settlement.

- Compaction tests should be performed on each 1 1/2-foot vertical lift of trench backfill and one test for every 100 lineal feet of trench. For mass grading areas, compaction tests should be performed on each 1 1/2-foot vertical lift of fill and for every 2,500 square feet of embankment.

- The QC and QA testing firms should prepare a continuous plan and profile plot of the compaction test results and include this with their daily reports. This will allow the project inspector to evaluate the specified testing frequency is being met.

- The contractor should be required to provide safe trench entrances and exits to allow testing personnel to safely enter the bottom of the excavation and perform compaction tests.

D.4. Moisture Conditioning

The majority of site soils that will be excavated and reused as backfill and fill material appeared to be below optimum moisture content. We anticipate it will be necessary to moisture condition these soils to achieve a moisture content near or slightly above optimum. Silt and clay layers were generally above optimum, and these soils will need to be spread out and dried or mixed with drier soils to obtain a moisture content near optimum. It should also be anticipated imported fill and backfill materials will be below optimum moisture content and additional moisture will be necessary to achieve a moisture content near or slightly above optimum.

D.5. Subgrade Disturbance

The borings indicated the surficial subgrade will be clayey sands, sandy lean clays, and clayey gravels. These fine-grained soils are considered to be moisture sensitive and are easily disturbed when wet. We therefore recommend good drainage of surface water be provided during construction to help avoid ponding areas. Ponding water will result in saturation of the clayey soils, creating soft spots. Construction traffic driving across these soft spots can create large ruts and excessively disturb the areas. It is then very difficult to recompact these areas to specification, and they can result in construction delays.

D.6. Subgrade Stabilization

There is a possibility that some excessively soft subgrade areas may be encountered and/or created due to improper drainage, inclement weather, or other unforeseen conditions or site features currently present. Excessively soft soils can also be created during construction due to heavy construction traffic. Excessively soft areas can be identified by proof-rolling with a loaded tandem-axle dump truck. Where deflection of 3/4 inch or more occurs beneath the rubber tires, the areas can be considered excessively soft, and corrective earthwork will be required.

Several alternatives are available to repair excessively soft areas. The least expensive method is to avoid the area and allow it to dry. Consideration can be given to scarifying the subgrade to promote drying. Eventually, the area will likely stabilize, the subgrade can be recompacted, and the pavement sections constructed on top of it. This method, however, can take several weeks or longer and is dependant on weather conditions.

Another alternative to more quickly repair excessively soft subgrades is to use geotextiles and geogrids. For these areas, we recommend subexcavating the unstable soils and adding an additional 12 inches of subbase to the sections indicated in Table 7.

The subbase should be placed in one lift by end-dumping methods over the geotextile/geogrid, depending on the section selected. The crushed base course and asphaltic pavement can then be placed above the subbase. The fabric should be placed in accordance with the manufacturer's guidelines. We suggest contract documents contain a bid item for this stabilization approach.

Numerous other alternatives for stabilizing excessively soft subgrades are also available. The contractor may have a preferred method, which should be considered when determining the actual method of stabilization.

We also recommend specifying either 1) Tensar BX1200 geogrid over a 4-ounce, or heavier, non-woven geotextile filter fabric, or 2) a Mirafi RS530i woven geotextile. The geotextile fabrics and geogrid, if utilized, should be installed in accordance with the manufacturer's recommendations.

Tensar and Mirafi have been providing geosynthetics for subgrade stabilization for many years and have the research data, case histories, and performance to support their products. Both products also have geotechnical software based on the AASHTO 1993 Pavement Design Guide, which can be used to evaluate required thicknesses to support the anticipated traffic. Alternative products can be submitted at least two weeks in advance of the bid date and must include the following.

1. A pavement section design signed and sealed by a registered professional engineer in the state of Montana.

2. A thickness design analysis (software or calculations) based on the AASHTO 1993 Pavement Design Guide. The analysis should include equivalency factors and/or modified layer coefficients based on full scale laboratory or field testing. A report documenting the full-scale laboratory or field testing must also be included.

D.7. Testing

We recommend full-time testing and inspection be performed during the construction of fills and backfills required for the embankment fill slopes, pavements, and utilities. Testing and inspection requirements for individual residences will need to be determined by the geotechnical engineer of record for each of the individual residences. We recommend density testing of the compacted pavement subgrade and gravel base course. We recommend slump, temperature, air content, and strength tests on Portland cement concrete.

We recommend density testing of the asphaltic concrete pavement (cores and nuclear density gauge). The maximum density of the asphaltic concrete mix should be determined by ASTM D 2041 (Rice). We also recommend Marshall tests of the asphalt mix to evaluate strength and air voids.

D.8. Cold Weather Construction

If site grading and construction is anticipated during cold weather, we recommend good winter construction practices be observed. All snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on soils that have frozen or contain frozen material. No frozen soils should be used as fill.

Concrete delivered to the site should meet the temperature requirements of ASTM C 94. Concrete should not be placed on frozen soils or soils that contain frozen material. Concrete should be protected from freezing until the necessary strength is attained. Frost should not be permitted to penetrate below footings bearing on frost-susceptible soil since such freezing could heave and crack the footings and/or foundation walls.

E. Procedures

E.1. Drilling and Sampling

The penetration test borings were performed with our CME 550 ATV core and auger drill. Sampling for the borings was conducted in accordance with ASTM D 1586, "Penetration Test and Split-Barrel Sampling of Soils." Using this method, we advanced the borehole with hollow-stem auger to the desired test depth. Then a 140-pound hammer falling 30 inches drove a standard, 2-inch OD, split-barrel sampler a total penetration of 1 1/2 feet below the tip of the hollow-stem auger. The blows for the last foot of penetration were recorded and are an index of soil strength characteristics.

Twelve 3-inch diameter thin-walled tube samples were taken in clayey and silty soils in general accordance with ASTM D 1587, "Thin-walled Tube Sampling of Soils." The tubes were slowly pushed into undisturbed soils below the hollow-stem auger. After they were withdrawn from the boreholes, the ends of the tubes were sealed and the tubes were carefully transported to our laboratory.

Five of the borings encountered very hard clays and very dense clayey gravels below 20 feet. When the sampler could not be driven 6 inches with 50 blows of the hammer, the distance the sampler was advanced with 50 blows was recorded. When this situation occurred during the first 6 inches of the drive, it was noted as occurring within the "set."

E.2. Soil Classification

The drill crew chief visually and manually classified the soils encountered in the borings in accordance with ASTM D 2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)." A summary of the ASTM classification system is attached. All samples were then returned to our laboratory for review of the field classifications by a geotechnical engineer. Representative samples will remain in our office for a period of 60 days to be available for your examination.

E.3. Groundwater Observations

About 10 minutes after taking the final sample in the bottom of a boring, the driller probed through the hollow-stem auger to check for the presence of groundwater. Immediately after withdrawal of the auger, the driller again probed the depth to water or cave-in. The boring was then generally backfilled.

Prior to withdrawing the hollow-stem auger from Borings ST-1P, ST-2P, ST-3P, ST-4P, ST-10P, and ST-12P, PVC pipe with a well-screen section at the bottom was placed in the borings to permit long-term monitoring of the groundwater level.

F. General Recommendations

F.1. Basis of Recommendations

The analyses and recommendations submitted in this report are based upon the data obtained from the soil borings performed at the locations indicated on the attached sketch. Often, variations occur between these borings, the nature and extent of which do not become evident until additional exploration or construction is conducted. A reevaluation of the recommendations in this report should be made after performing on-site observations during construction to note the characteristics of any variations. The variations may result in additional foundation or site preparation costs, and it is suggested a contingency be provided for this purpose.

F.2. Review of Design

This report is based on the design of the proposed subdivision as related to us for preparation of this report. It is recommended we be retained to review the geotechnical aspects of the designs and specifications. With the review, we will evaluate whether any changes in design have affected the validity of the recommendations, and whether our recommendations have been correctly interpreted and implemented in the design and specifications.

F.3. Groundwater Fluctuations

We made water level observations in the borings at the times and under the conditions stated on the boring logs. These data were interpreted in the text of this report. The period of observation was relatively short, and fluctuation in the groundwater level may occur due to rainfall, flooding, irrigation, spring thaw, drainage, and other seasonal and annual factors not evident at the time the observations were made. Design drawings and specifications and construction planning should recognize the possibility of fluctuations.

F.4. Use of Report

This report is for the exclusive use of Territorial Landworks to use to design the proposed subdivision (excluding the residences) and prepare construction documents. It is not to be used for design of the proposed residential structures. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other structures or purposes. We recommend parties contemplating other structures or purposes contact us.

This updated geotechnical report is based on the current site observations and design information provided. Over time, surface and/or subsurface conditions can change along with code requirements, engineering design standards, and other considerations that could affect the design of the subdivision, streets, utilities, or residences. The recommendations contained in this report will not be valid after a period of five years from the date of this report, or after December 3, 2020. After this date, any additional work relying on recommendations obtained from this report will need to be re-evaluated and redone, including, but not limited to, a new geotechnical report, fieldwork, laboratory tests, and/or analyses.

F.5. Level of Care

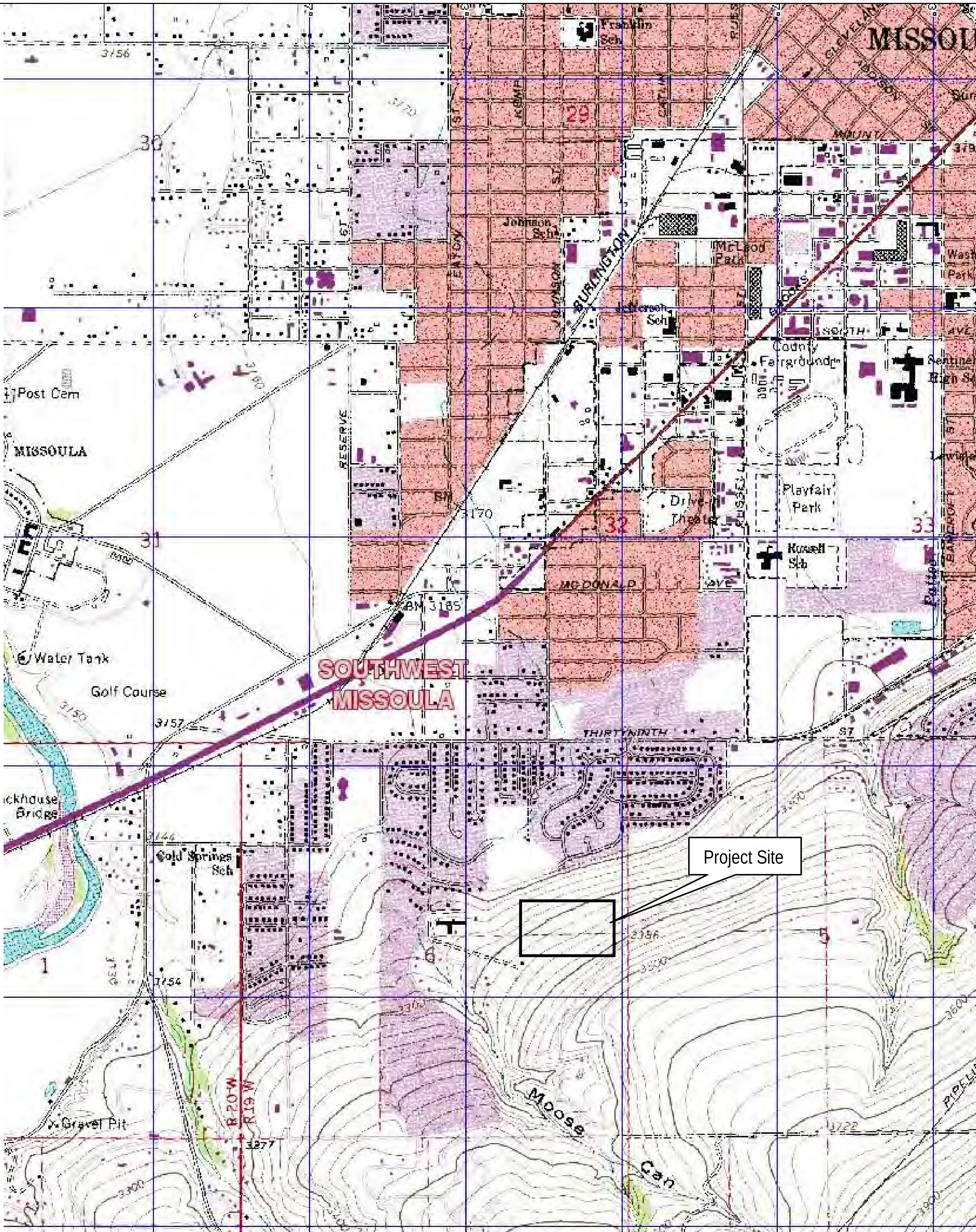
Services performed by SK Geotechnical Corporation personnel for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is made.

Professional Certification
I hereby certify that this report was prepared by me and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.

MONTANA CORY G. RICE 9914PE PROFESSIONAL ENGINEER

Cory G. Rice, PE
Senior Engineer
License Number 9914PE
December 3, 2015

Appendix



SITE LOCATION SKETCH
Geotechnical Evaluation
Southern Hills Subdivision
Missoula, Montana

Drawn by:	KLD/SKG	Date	04/18/07
Project:	06-7358		
Scale:	N/A		FIGURE
Sheet	1 of 1		

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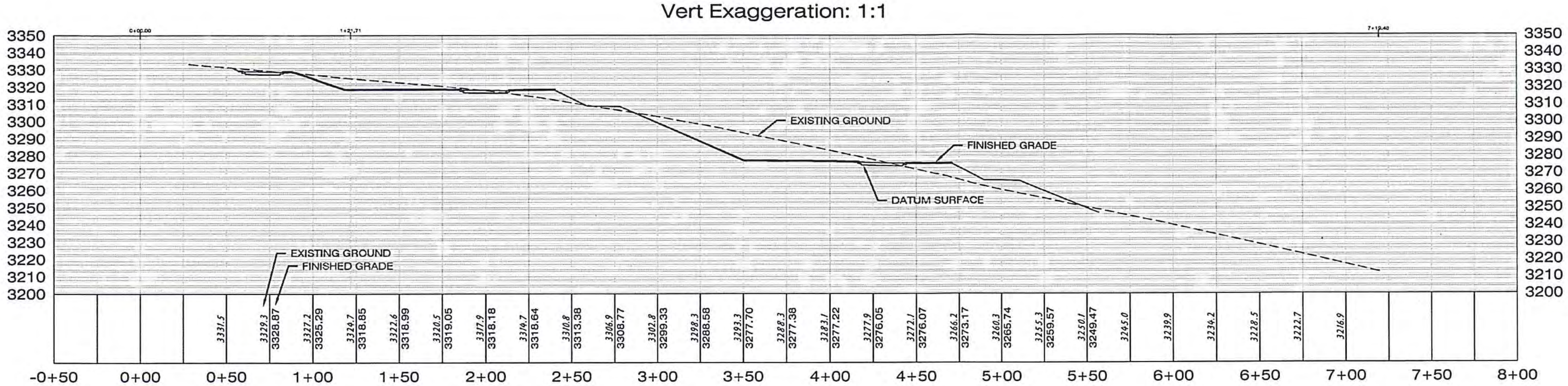
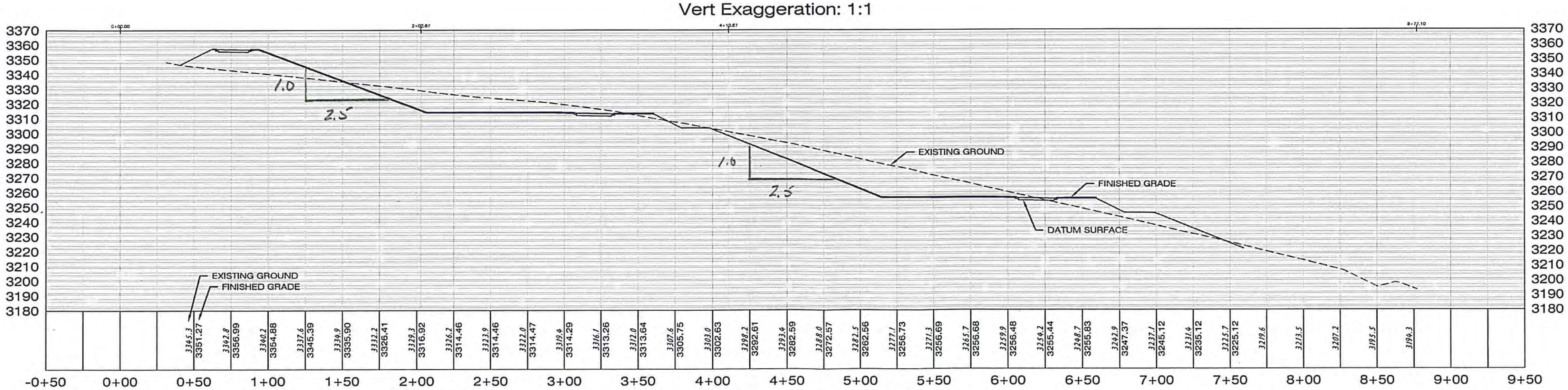
REVISIONS
DATE
DESIGNED: NL
DRAFTED: BD
CHECKED:
DATE: 08/14/2015
LOCATION: CITY OF MISSOULA
12N, 19W, S6
MISSOULA COUNTY, MONTANA
PREPARED FOR: DJ HOLDINGS
PROJECT NAME: HILLVIEW CROSSING - MISSOULA
SHEET TITLE: OVERALL GRADING
PROJECT NO. 14-3592
SHEET: 1 OF 3
PRELIMINARY
SCALE IN FEET
25.63 ACRES
WAPIKIYA NO. 1
SARANAC DRIVE
PARK
CONCRETE DRAINAGE STRUCTURE
ST-1P
ST-2P
ST-3P
ST-4P
ST-5
ST-6
ST-7
ST-8
ST-9
ST-10P
ST-11
ST-12P
SEWER MANHOLE
RIM=3365.22
INV. NE=3254.4
INV. SW=3254.4
SEWER MANHOLE
RIM=3371.98
LOT 9
DIRT ROAD
EASEMENT
COS 4649
S88°46'27" W 1322.39'
S00°08'42" W 1128.35'
N65°44'58" E 1451.74'
N00°08'01" E 560.37'

Steeper

Alignment: SECTION A
Profile: SECTION A167
Vert Exaggeration: 1:1



Alignment: SECTION B
Profile: SECTION B168
Vert Exaggeration: 1:1



40 0 40 80
SCALE IN FEET

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PLOT DATE: 8/14/2015 3:52 PM

REVISIONS	DATE

DESIGNED: NL
DRAFTED: BD
CHECKED:
DATE: 08/14/2015

LOCATION: CITY OF MISSOULA
12N, 19W, S6
MISSOULA COUNTY, MONTANA

PREPARED FOR: DJ HOLDINGS

PROJECT NAME: HILLVIEW CROSSING - MISSOULA

SHEET TITLE: SITE CROSS SECTIONS

PROJECT NO. 14-3592

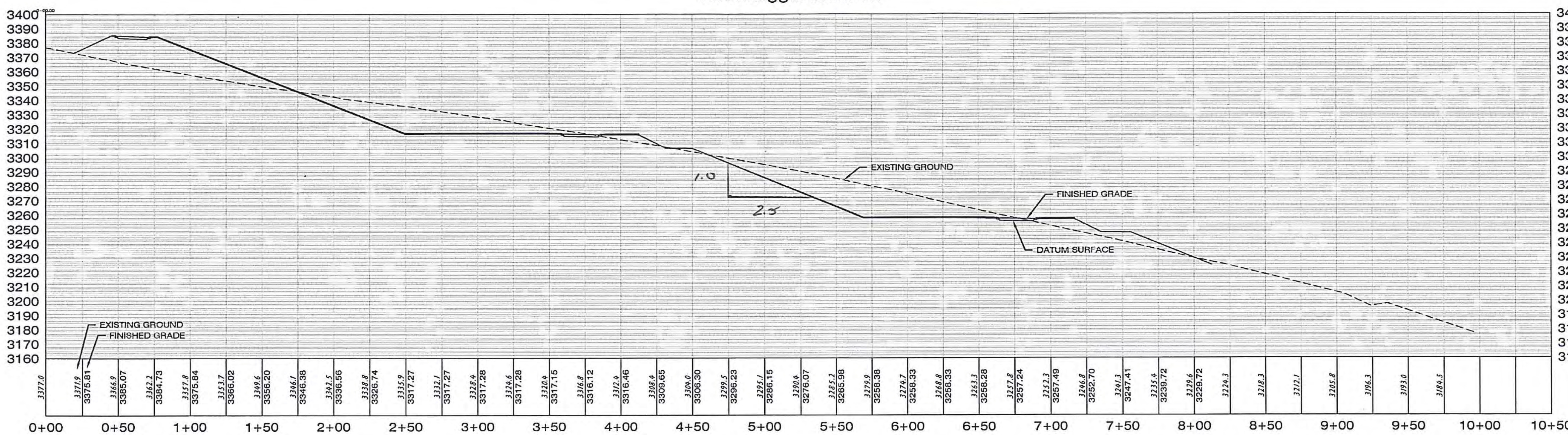
SHEET: 2 OF 3

PRELIMINARY

DWG LOCATION: T:\1_ACTIVE FILES\2014 PROJECTS\3592 - DJ HOLDINGS HILLVIEW S HILLS DEVELOPMENT\8_DRAFTING\8.1_DRAWINGS\AUTOCAD\EXHIBITS\EXH-14-3592_SITE CROSS SECTIONS_STEEPER SLOPES.DWG

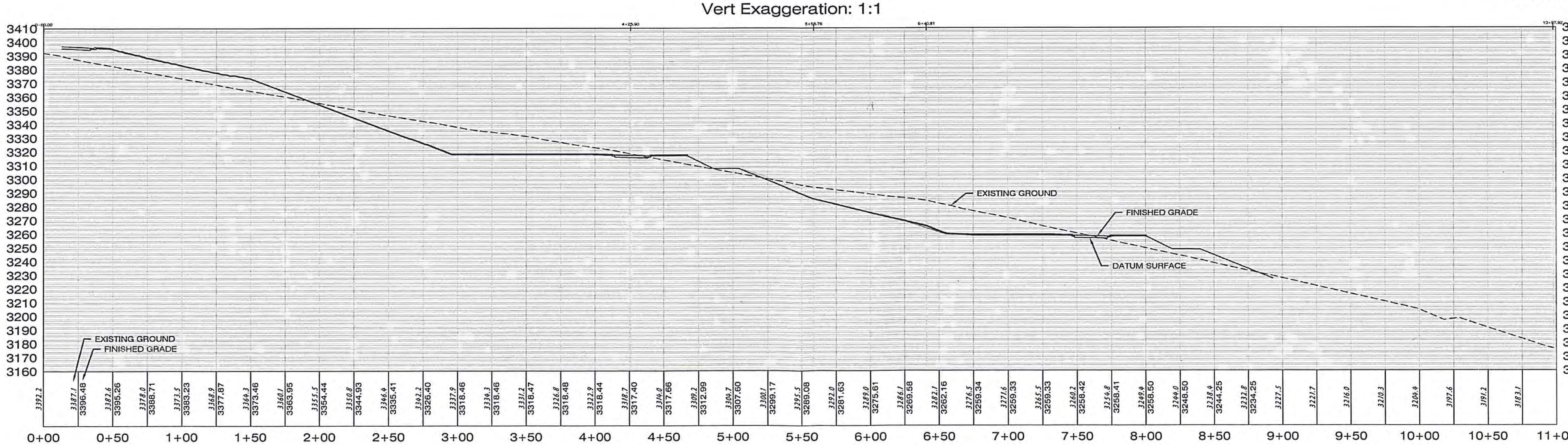
Steeper

Alignment: SECTION C
Profile: SECTION C169
Vert Exaggeration: 1:1



Alignment: SECTION D
Profile: SECTION D170
Vert Exaggeration: 1:1

40 0 40 80
SCALE IN FEET



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Missoula, MT 59806
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REVISIONS	DATE

DESIGNED: HL
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DATE: 08/14/2015

LOCATION: CITY OF MISSOULA
12N, 19W, S6
MISSOULA COUNTY, MONTANA

PREPARED FOR: DJ HOLDINGS

PROJECT NAME: HILLVIEW CROSSING - MISSOULA

PROJECT NO. 14-3592

SHEET TITLE: SITE CROSS SECTIONS

SHEET: 3 OF 3

PRELIMINARY

Descriptive Terminology

Standard D 2487
Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Group Name [B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [C]	$C_U \ge 4$ and $1 \le C_C \le 3$ [E]	GW	Well graded gravel [F]
			$C_U < 4$ and/or $1 > C_C > 3$ [E]	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines [D]	$C_U \ge 6$ and $1 \le C_C \le 3$ [E]	SW	Well graded sand [I]
			$C_U < 6$ and/or $1 > C_C > 3$ [E]	SP	Poorly graded sand [I]
		Sands with Fines More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OL	Organic clay [K, L, M, N] Organic silt [K, L, M, O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OH	Organic clay [K, L, M, P] Organic silt [K, L, M, Q]
Highly Organic Soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

A Based on the material passing the 3" (75 mm) sieve.
B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
C Gravels with 5 to 12% fines require dual symbols
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
D Sands with 5 to 12% fines require dual symbols.
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
E $C_U = D_{50} / D_{10}$
$C_C = (D_{30})^2 / (D_{10} \times D_{50})$
F If soil contains ≥ 15% sand, add "with sand" to group name.
G If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
H If fines are organic, add "with organic fines" to group name.
I If soil contains ≥ 15% gravel, add "with gravel" to group name.
J If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
L If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
M If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.
N PI ≥ 4 and plots on or above "A" line.
O PI < 4 or plots below "A" line.
P PI plots on or above "A" line.
Q PI plots below "A" line.

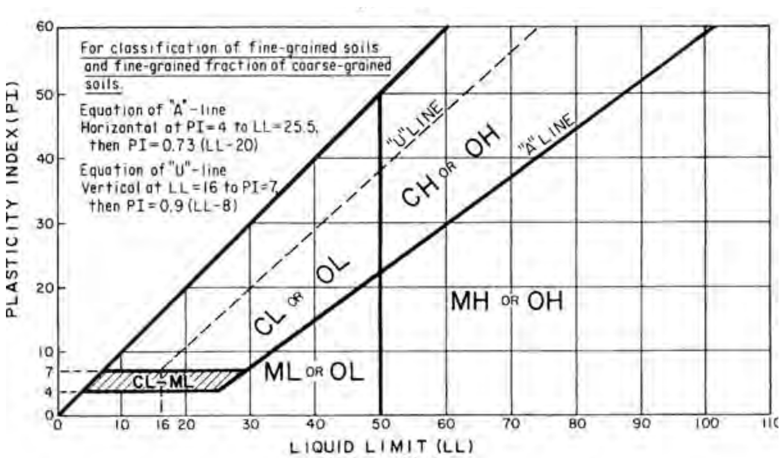

FIG. 4 Plasticity Chart

Laboratory Tests

DD	Dry density, pcf	OC	Organic content, %
WD	Wet density, pcf	P_{200}	% passing 200 sieve
LL	Liquid limit	PL	Plastic limit
PI	Plasticity index	MC	Natural moisture content, %
qu	Unconfined compressive strength, psf		
qp	Pocket penetrometer strength, tsf		

Particle Size Identification

Boulders .... over 12"
Cobbles ....3" to 12"
Gravel
  coarse .... 3/4" to 3"
  fine .... No. 4 to 3/4"
Sand
  coarse ....No. 4 to No. 10
  medium ....No. 10 to No. 40
  fine ....No. 40 to No. 200
Silt ....No. 200 to .005 mm
Clay ....less than .005 mm

Relative Density of Cohesionless Soils

very loose ....0 to 4 BPF
loose ....5 to 10 BPF
medium dense ....11 to 30 BPF
dense ....31 to 50 BPF
very dense ....over 50 BPF

Consistency of Cohesive Soils

very soft ....0 to 1 BPF
soft..2 to 3 BPF
rather soft ....4 to 5 BPF
medium ....6 to 8 BPF
rather stiff...................................9 to 12 BPF
stiff ....13 to 16 BPF
very stiff ....17 to 30 BPF
hard ....over 30 BPF

Moisture Content (MC) Description

rather dry	MC less than 5%, absence of moisture, dusty
moist	MC below optimum, but no visible water
wet	Soil is over optimum MC
waterbearing	Granular or low plasticity soil with free water, typically near or below groundwater table
saturated	Cohesive soil, typically near or below groundwater table

Drilling Notes

Standard penetration test borings were advanced by 3¼" or 4¼" ID hollow-stem augers, unless noted otherwise. Standard penetration test borings are designated by the prefix "ST" (split tube). Hand auger borings were advanced manually with a 2 to 3" diameter auger to the depths indicated. Hand auger borings are indicated by the prefix "HA."

Sampling. All samples were taken with the standard 2" OD split-tube sampler, except where noted. TW indicates thin-walled tube sample. CS indicates California tube sample.

BPF. Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they were separated by backslash (/). In very dense/hard strata, the depth driven in 50 blows is indicated.

WH. WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

Note. All tests were run in general accordance with applicable ASTM standards.

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-1P**

LOCATION:
See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/16/06 | SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
3365.9	0.0						
3364.4	1.5	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, few Gravels, dark brown, moist, loose. (Topsoil and Root Zone)	10			Bag sample 1'-5'
3361.9	4.0	SC	CLAYEY SAND with GRAVEL, fine- to coarse-grained, low plasticity, brown, moist, medium dense. (Alluvium)	26			
3356.9	9.0	CL	SANDY LEAN CLAY with GRAVEL, fine- to coarse-grained, medium plasticity, brown, moist, very stiff. (Alluvium)	26 22			
3346.9	19.0	CL	LEAN CLAY with SAND and GRAVEL, fine- to coarse-grained, medium plasticity, brown, moist, rather stiff to stiff. (Alluvium) -waterbearing, layer observed at 12 1/2'.	12 13 10			An open triangle in the water level (WL) column indicates the depth at which groundwater was first observed while drilling. Groundwater levels fluctuate. Please refer to the discussion in our report.
3337.4	28.5	CL	LEAN CLAY, medium plasticity, brown, moist, very stiff. (Alluvium) -light brown below 25'.	22 TW 25			
		GC	CLAYEY GRAVEL with SAND, fine- to coarse-grained, brown, moist, very dense. (Alluvium)	50 - 5"			

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-1P (cont.)** LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG — METHOD: CME 550	DATE: 11/16/06 — SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
		GC	CLAYEY GRAVEL with SAND continued.				
3331.9	34.0	GP	POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, brown, moist, very dense. (Alluvium)	50 - 3"			
				50 - 2"			
3320.5	45.4		END OF BORING	50 - 5.5"			

Water down 14' with 14' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 29.6' immediately after withdrawal of auger.

A 2" PVC piezometer was installed in the boring.

Groundwater not observed when rechecked on 11/28/06.

Groundwater not observed when rechecked on 04/05/07.

gw - 42.7', 5/1/15

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-2P** LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG METHOD: CME 550	DATE: 11/8/06 SCALE: 1" = 4'

Elev. 3328.5	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
3326.5	2.0	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, few Gravels, dark brown, moist, very loose, few Roots. (Topsoil and Root Zone)	3			MC = 20.6%
3324.5	4.0	SC	CLAYEY SAND with GRAVEL, fine- to coarse-grained, brown, dry, dense. (Alluvium)	34			Bag sample 1.5' - 9. LL=24, PL=14, PI=10, P_{200}=26.2%
3319.5	9.0	GC	CLAYEY GRAVEL with SAND, fine- to coarse-grained, low plasticity, brown, dry, very dense. (Alluvium)	54			MC = 4.3%
							MC = 5.1%
			-dense below 7'.	30			
3313.0	15.5	CL	LEAN CLAY with SAND, fine-grained, medium plasticity, dark brown, moist, rather stiff. (Alluvium)	10			
			-brown below 11'.	TW			LL=47, PL=21, PI=26, P_{200}=82.2%, MC=27.3%
			-stiff to very stiff below 12'.	16			
			-medium to high plasticity, light brown, below 14'.	24			
3304.5	24.0	GC	CLAYEY GRAVEL with SAND, fine- to coarse-grained, low plasticity, brown, moist, very dense. (Alluvium)	69			MC = 63%
				50 - 5"			
		GP	POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, trace Clay, brown, moist, very dense. (Alluvium)	50 - 5"			MC = 4.4%
				50 - 3"			

LOG OF BORING 7358.GPJ LAGNNN06.GDT 4/26/07

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-2P (cont.)** LOCATION: See attached sketch.

DRILLED BY: CTL&JSF/SKG	METHOD: CME 550	DATE: 11/8/06	SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
3294.5	34.0	GP	POORLY GRADED GRAVEL with SAND continued.				
			END OF BORING Water not observed with 34' of hollow-stem auger in the ground when checking borehole after 10 minutes. Water down 15' immediately after withdrawal of auger. A 2" PVC piezometer was installed in the boring. Groundwater not observed when rechecked on 11/28/06. Groundwater not observed when rechecked on 04/05/07. NLE Mod. @ 33.4, 5/1/14, free water not observed				

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-3P**

LOCATION:
See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/14/06 | SCALE: 1" = 4'

Elev. 3252.8	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
3250.8	2.0	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, few Gravels, dark brown, moist, medium dense. (Topsoil and Root Zone)	26			MC = 2.9%
3246.8	6.0	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, medium dense. (Alluvium)	20 12			MC = 18.7% MC = 4.9%
3243.3	9.5	SM	SILTY SAND, fine- to coarse-grained, brown, moist, medium dense. (Alluvium) -loose below 7'	10 TW			
3241.8	11.0	SM	SILTY SAND with GRAVEL, fine- to coarse-grained, brown, moist, medium dense. (Alluvium)	27			
3238.3	14.5	SC SM	SILTY-CLAYEY SAND, fine- to medium-grained, low plasticity, light brown, moist, medium dense. (Alluvium)	15			
3231.8	21.0	SM	SILTY SAND, fine- to medium-grained, some Gravel, light brown to grey, moist, dense. (Alluvium)	49 39			MC = 5.4%
		GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, light brown, moist, dense. (Alluvium) -very dense below 24'.	50 - 5" 50 - 5"			MC = 3.8%

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-3P (cont.)** LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG — METHOD: CME 550	DATE: 11/14/06 — SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
		GP GM	POORLY GRADED GRAVEL with SILT and SAND continued.				
3218.8	34.0	CL	LEAN CLAY, low plasticity, trace Gravel light brown, wet, very stiff. (Alluvium)	22			MC = 36.4%
3217.3	35.5	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, trace Clay, light brown, moist, very dense. (Alluvium)	66			MC = 4.6%
3208.0	44.8		END OF BORING	50 - 3"			

Water not observed with 44' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 24' immediately after withdrawal of auger.

A 2" PVC piezometer was installed in the boring.

Groundwater not observed when rechecked on 11/28/06.

Groundwater not observed when rechecked on 04/05/07.

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-4P**

LOCATION:
See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/15/06 | SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
3261.9	0.0						
3260.4	1.5	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, few GravelS, dark brown to black, moist, loose. (Topsoil and Root Zone)	9			
3255.9	6.0	SM	SILTY SAND with GRAVEL, fine- to coarse-grained, brown, moist, medium dense to loose. (Alluvium) -trace Clay below 5'.	12 10			MC = 2.8%
3253.9	8.0	GP	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, very dense. (Alluvium)	50 - 3"			MC = 2.4%
3246.9	15.0	CL	SANDY LEAN CLAY, fine-grained, low to medium plasticity, brown, wet, rather stiff to stiff. (Alluvium)	9 15			MC = 21.2% Bag sample 7 - 14'. LL=47, PL=16, PI=31, P_{200}=64.6%.
3241.9	20.0	SM	SILTY SAND, fine-grained, brown, moist, medium dense. (Alluvium)	20			MC = 11.9%
3236.9	25.0	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, very dense. (Alluvium)	60			
		ML	SILT with SAND, fine-grained Sand, low plasticity, yellowish brown, moist to wet, stiff to hard. (Alluvium) -hard below 29'.	15 55			MC = 6.2% MC = 20.8% MC = 31.3%

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-4P (cont.)** LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG — METHOD: CME 550	DATE: 11/15/06 — SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
		ML	SILT with SAND continued.	28			MC = 31.8%
				34			
3216.4	45.5			24			MC = 24.9
			END OF BORING Water not observed with 44' of hollow-stem auger in the ground when checking borehole after 10 minutes. Water not observed when probing boring immediately after withdrawal of auger. A 2" PVC piezometer was installed in the boring. Groundwater not observed when rechecked on 11/28/06. Groundwater not observed when rechecked on 04/05/07. N/E 43.4' - 5-1-15				

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-5**

LOCATION:
See attached sketch.

DRILLED BY: CTL&JSF/SKG

METHOD: CME 550

DATE: 11/14/06

SCALE: 1" = 4'

Elev. 3253.6	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
3252.1	1.5	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, dark brown to black, moist. (Topsoil and Root Zone)	7			
3250.6	3.0	SM	SILTY SAND with GRAVEL, fine- to coarse-grained, dark brown, moist, medium dense. (Alluvium)	22			
		GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, few Cobbles, brown, moist, medium dense to dense. (Alluvium)	34			
			-low plasticity, Clayey below 7'.	17			
				24			
				27			
				39			
3233.1	20.5		END OF BORING Water not observed with 19' of hollow-stem auger in the ground when checking borehole after 10 minutes. Water not observed to dry cave-in depth of 11' immediately after withdrawal of auger. Boring then backfilled.	19 - 20.5'2			

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-6**
LOCATION: See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/16/06 | SCALE: 1" = 4'

Elev. 3313.4	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
3311.4	2.0	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, few Gravels, dark brown to black, wet, loose. (Topsoil and Root Zone)	6			MC = 26.7%
3301.4	12.0	GP GM	POORLY GRADED GRAVEL wtih SILT and SAND, fine- to coarse-grained, brown, moist, dense to very dense.	45 59 87 49			MC = 3.1%
3294.4	19.0	CL	SANDY LEAN CLAY, fine-grained, medium plasticity, light brown, moist, very stiff to stiff. (Alluvium)	18 15 TW			MC = 22.6%, LL=46, PL=21, PI=25, P_{200}=67%
3292.9	20.5	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, very dense. (Alluvium)	64			MC = 3.3%

END OF BORING

Water not observed with 19' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 9.6' immediately after withdrawal of auger.

Boring then backfilled.

SK GEOTECHNICAL
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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-7**
LOCATION: See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/16/06 | SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
3281.8	0.0						
3279.8	2.0	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, trace Gravel, dark brown to black, moist, medium dense. (Topsoil and Root Zone)	11			MC = 17.2%
3272.8	9.0	SC SM	SILTY CLAYEY SAND with GRAVEL, fine- to coarse-grained, brown, moist, medium dense to dense. (Alluvium)	29 13 31			Bag sample 0 - 9'. LL=24, PL=17, PI=7, P_{200}=24.2% MC = 5.7%
3270.3	11.5	CL	LEAN CLAY, medium plasticity, trace Sand and Gravel, brown, moist. (Alluvium)	14			MC = 12.7%
3261.3	20.5	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, dense to medium dense. (Alluvium) -trace Clay below 15'.	34 28 36			MC 4.8%

END OF BORING

Water not observed with 19' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 9.8' immediately after withdrawal of auger.

Boring then backfilled.

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-8** LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG METHOD: CME 550	DATE: 11/13/06 SCALE: 1" = 4'

Elev. 3251.3	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
		SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, dark brown to black, moist, loose to medium dense. (Topsoil and Root Zone)	11			MC = 11.2%
3249.3	2.0	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, dense. (Alluvium)	46			
			-medium dense below 5'.	24			MC = 3.1%
				22			
			-Clayey below 10'.	25			MC = 6.8%
				28			
3237.3	14.0	CL	LEAN CLAY, medium plasticity, trace Sand and Gravel, brown, moist, rather stiff. (Alluvium)	9			MC = 18.2%
3232.8	18.5	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, dense. (Alluvium)	40			MC = 6.0%
3230.8	20.5		END OF BORING				

Water not observed with 19' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 11.7' immediately after withdrawal of auger.

Boring then backfilled.

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LOG OF BORING

PROJECT: 067358 GEOTECHNICAL EVALUATION Southern Hills Subdivision Missoula, Montana	BORING: ST-9 LOCATION: See attached sketch.

DRILLED BY: CTL&JSF/SKG	METHOD: CME 550	DATE: 11/13/06	SCALE: 1" = 4'

Elev. 3247.2	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
		SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, trace Gravel, dark brown to black, moist, loose. (Topsoil and Root Zone)	5			
3244.7	2.5	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, medium dense to dense. (Alluvium)	18			
				34			
				42			
			-trace Clay below 10'.	26			
				25			
				25			
				39			
3226.7	20.5		END OF BORING				

Water not observed with 19' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 11.2' immediately after withdrawal of auger.

Boring then backfilled.

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LOG OF BORING

PROJECT: 067358 **GEOTECHNICAL EVALUATION** Southern Hills Subdivision Missoula, Montana	BORING: **ST-10P** LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG — METHOD: CME 550	DATE: 11/13/06 — SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
3251.4	0.0						
		SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, dark brown to black, moist, medium dense. (Topsoil and Root Zone)	11			
3249.4	2.0	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, medium dense. (Alluvium)	21			
				27			
				25			
			-dense to very dense below 9'.	35			
				38			
				31			
			-Clayey below 20'.	40			
				50 - 3"			
3222.4	29.0	GC	CLAYEY GRAVEL with SAND and SILT, fine- to coarse-grained, low to medium plasticity, brown, moist, dense. (Alluvium)	31			

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-10P (cont.)**
LOCATION: See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/13/06 | SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
		GC	CLAYEY GRAVEL with SAND and SILT continued.	29			
				33			
3206.4	45.0	GP-GM		46			
3205.9	45.5		POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, dense. (Alluvium)				
			END OF BORING				

Water not observed with 44' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 25.5' immediately after withdrawal of auger.

A 2" PVC piezometer was installed in the boring.

Groundwater not observed when rechecked on 11/28/06.

Groundwater not observed when rechecked on 04/05/07.

GW – 43.8', 5-1-15

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-11**
LOCATION:
See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/14/06 | SCALE: 1" = 4'

Elev. 3229.4	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
3227.4	2.0	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, few Gravel, dark brown to black, moist. (Topsoil and Root Zone)	12			
		GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, medium dense to very dense. (Alluvium)	38			
				24			
				23			
			-Clayey below 9'.	30			
				39			
			-Cobbles, very dense below 14'.	57			
3208.9	20.5			59			

END OF BORING

Water not observed with 19' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 8.3' immediately after withdrawal of auger.

Boring then backfilled.

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LOG OF BORING

PROJECT: 067358 GEOTECHNICAL EVALUATION Southern Hills Subdivision Missoula, Montana	BORING: ST-12P LOCATION: See attached sketch.
DRILLED BY: CTL&JSF/SKG — METHOD: CME 550	DATE: 11/15/06 — SCALE: 1" = 4'

Elev. 3277.6	Depth 0.0	Symbol	Description of Materials	BPF	WL	qp	Remarks
		SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, dark brown to black, moist, loose to medium dense. (Topsoil and Root Zone)	12			MC = 17.1%
				10			
3274.6	3.0	CL	SANDY LEAN CLAY, fine- to coarse-grained, low plasticity, light brown, moist, stiff to very stiff. (Alluvium)	28			MC = 15.6%
			-hard below 7'.	36			
				34			MC = 24.0%
3265.6	12.0	CL ML	SILTY CLAY, fine-grained, low plasticity, yellowish brown, moist, very hard, cemented. (Alluvium)	74			
				81 - 11.5"			
3258.6	19.0	SC SM	SILTY CLAYEY SAND, fine-grained, low to medium plasticity, light brown, moist, very dense, moderately cemented. (Alluvium)	98 - 9"			MC = 27.4%
				87 - 9"			
				81			

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LOG OF BORING

PROJECT: 067358
GEOTECHNICAL EVALUATION
Southern Hills Subdivision
Missoula, Montana

BORING: **ST-12P (cont.)**

LOCATION: See attached sketch.

DRILLED BY: CTL&JSF/SKG | METHOD: CME 550 | DATE: 11/15/06 | SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	qp	Remarks
		SC SM	SILTY CLAYEY SAND continued.				
3243.6	34.0	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, very dense. (Alluvium)	50 - 3" 50 - 5"			
3233.6	44.0		END OF BORING				

Water not observed wtih 44' of hollow-stem auger in the ground when checking borehole after 10 minutes.

Water not observed to dry cave-in depth of 19' immediately after withdrawal of auger.

A 2" PVC piezometer was installed in the boring.

Groundwater not observed when rechecked on 11/28/06.

Groundwater not observed when rechecked on 04/05/07.

4/E - 39.6' - 5-1-15


SE corner of site, looking west


SE corner of site, looking downhill, note lusher vegetation


East side of site, looking west


NE corner of site, looking west, note drainage swale cut into slope

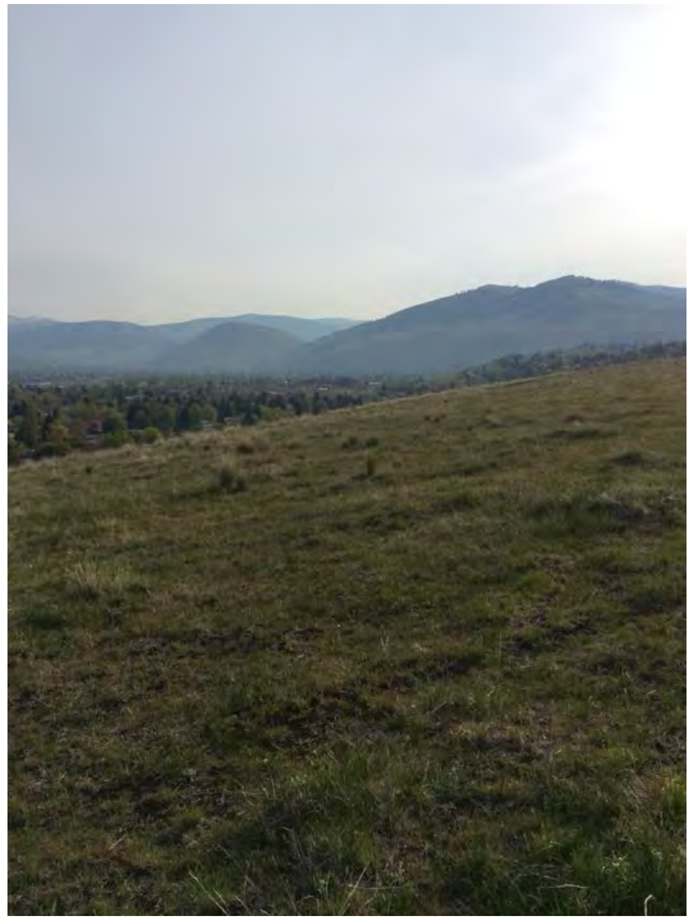

NW corner of site, looking east, note drainage swale cut into slope


North center portion of site, note 8-foot high cut for drainage swale


36-degree cut, 20 feet high near end of Saranac Drive


Existing home site, ~12' high embankment, ~22-degree slope

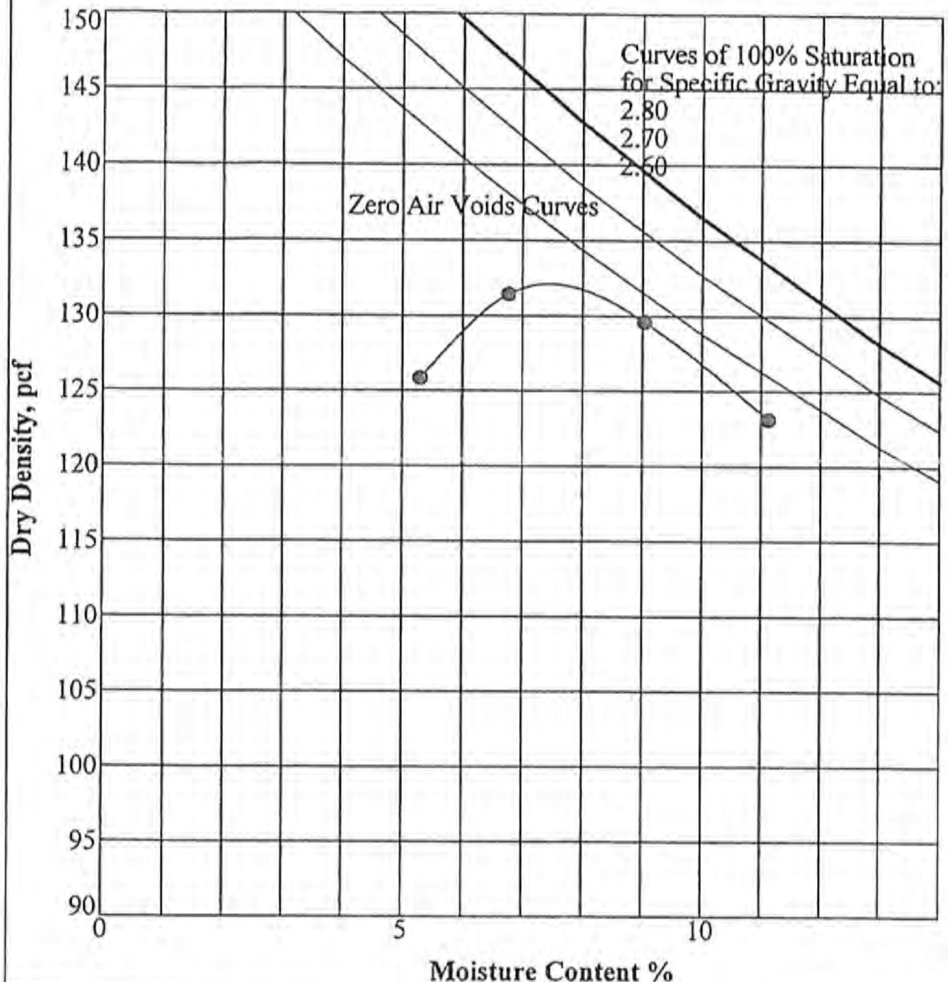
Boulder on west side of site



SW corner of site, looking NE, 14-degree slope, drier ground

Piezometer ST-1P, groundwater at 42.7 feet

Center of site, looking west



AASHTO T99 Method D

Maximum Dry Density, pcf	Optimum Moisture Content %
132	8

Rammer Type: Manual
Preparation Method: Wet

Soil Description

CLAYEY SAND with GRAVEL (SC)

Sieve Size	% Retained
3/4"	3
3/8"	17
#4	38

Sample No:	ST-2
Lab Sample No:	P-1
Date Received:	11/16/06
Sampled By:	CTL&JSF/SKG
Date Sampled:	11/16/06
Sampled From:	ST-2
Depth:	1.5' - 9'
Performed by:	CTL&JSF/SKG
Date Performed:	11/22/06

Comments

Additional Remarks

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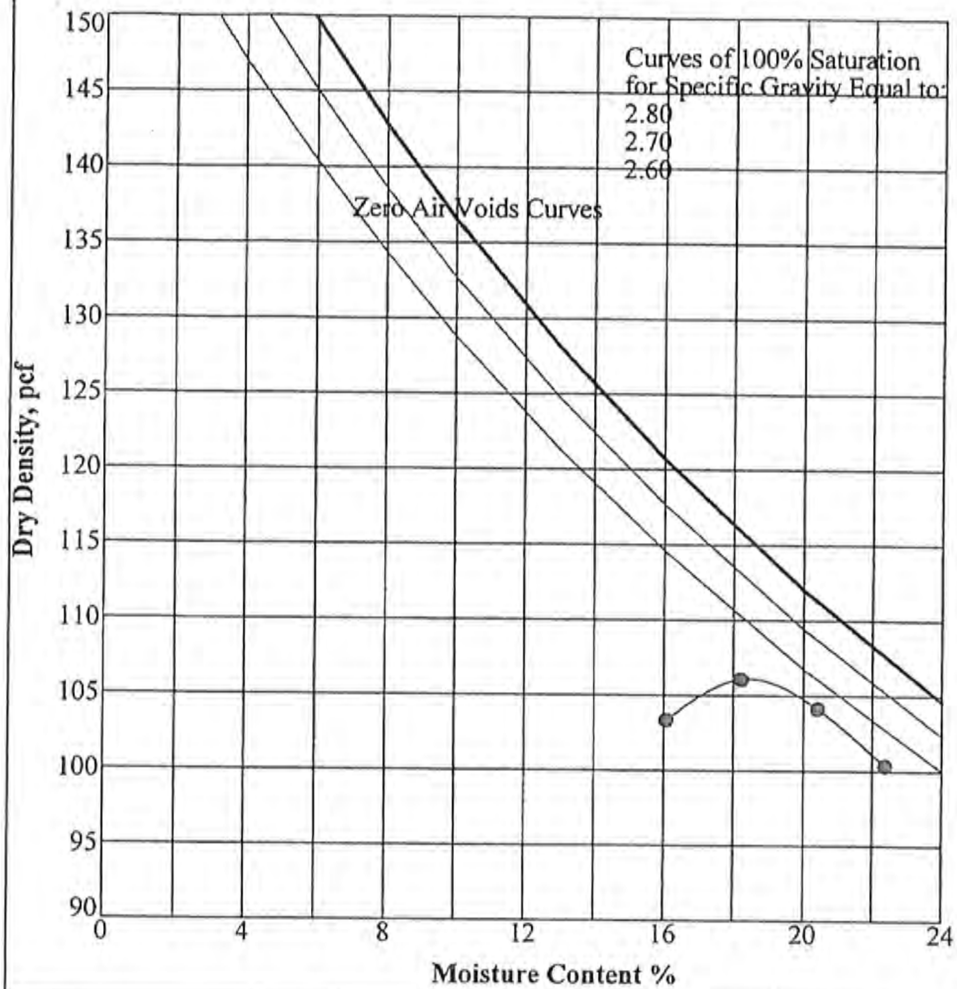
Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 067358
Southern Hills Subdivision
Missoula, Montana

PROCTOR

P-1

4/26/07



AASHTO T99 Method A

Maximum Dry Density, pcf	Optimum Moisture Content %
106	18

Rammer Type: Manual
Preparation Method: Wet

Soil Description

SANDY LEAN CLAY (CL)

Sieve Size	% Retained
3/4"	1
3/8"	2
#4	2

Sample No:	ST-4
Lab Sample No:	P-2
Date Received:	11/15/06
Sampled By:	CTL&AMS/SKG
Date Sampled:	11/15/06
Sampled From:	ST-4
Depth:	7' - 14'
Performed by:	CTL&JSF/SKG
Date Performed:	11/22/06

Comments

Additional Remarks

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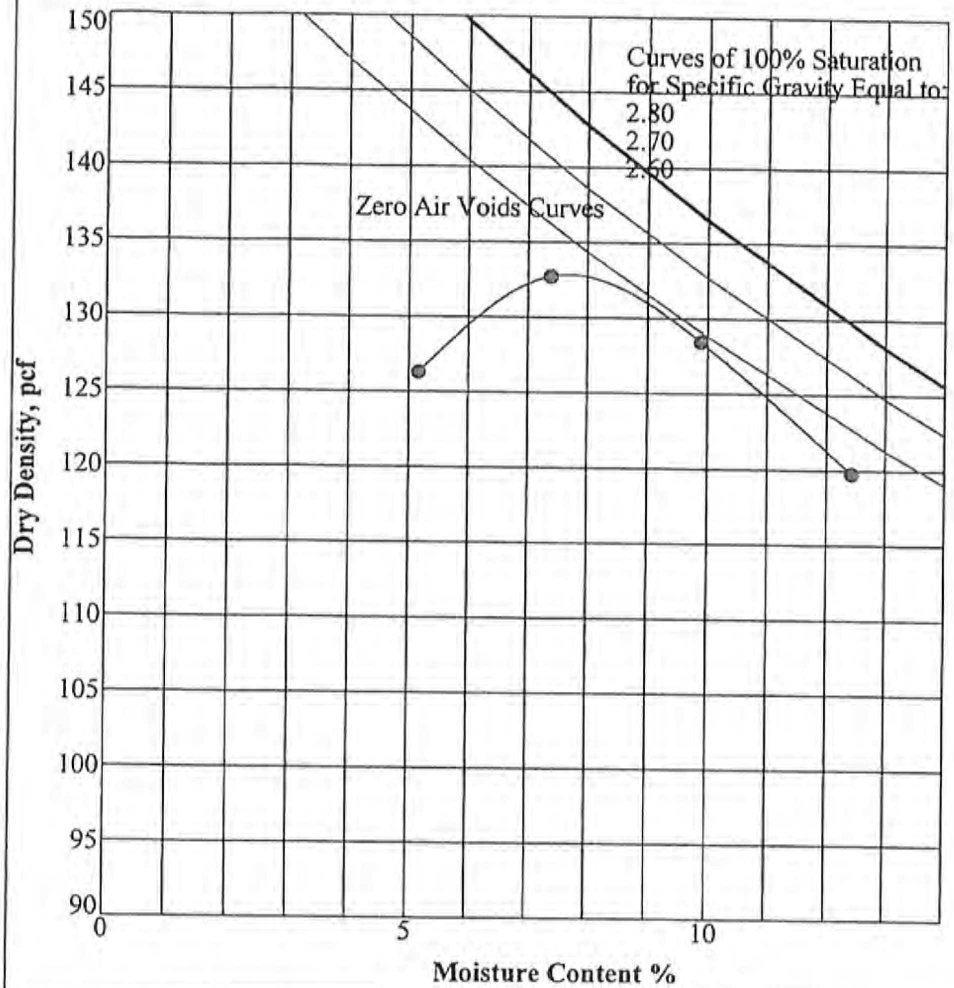
Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 067358
Southern Hills Subdivision
Missoula, Montana

PROCTOR

P-2

4/26/07



AASHTO T99 Method D

Maximum Dry Density, pcf	Optimum Moisture Content %
133	7

Rammer Type: Manual
Preparation Method: Wet

Soil Description

SILTY CLAYEY SAND (SC-SM)

Sieve Size	% Retained
3/4"	4
3/8"	18
#4	40

Sample No:	ST-7
Lab Sample No:	P-3
Date Received:	11/16/06
Sampled By:	CTL&JSF/SKG
Date Sampled:	11/16/06
Sampled From:	ST-7
Depth:	0 - 9'
Performed by:	AMS/SKG
Date Performed:	11/21/06

Comments

Additional Remarks

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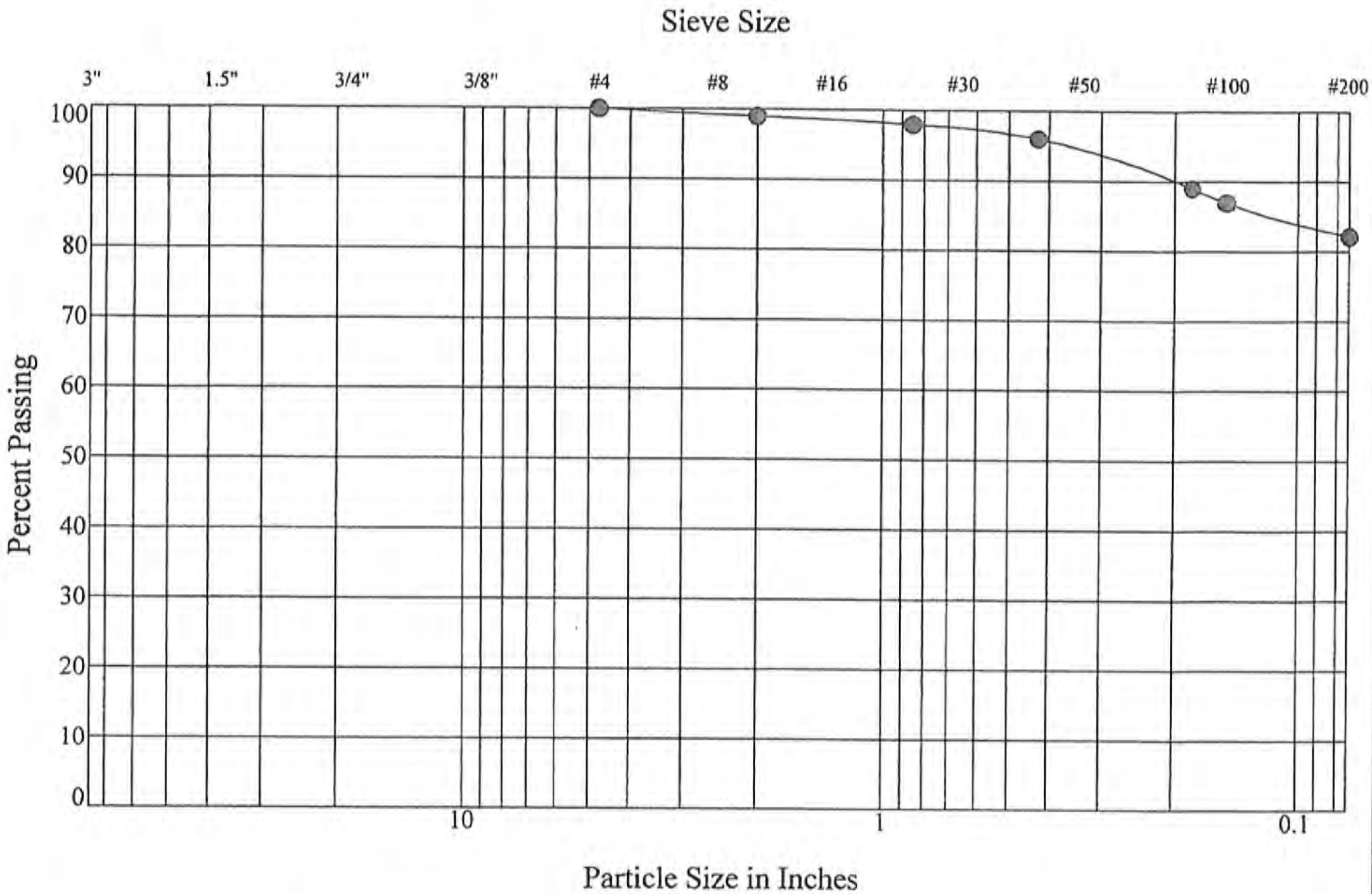
Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 067358
Southern Hills Subdivision
Missoula, Montana

PROCTOR

P-3

4/26/07



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
				100	99	98	97	93	87	82.2

Boring No.: ST-2P
Lab No.: ST-2
Depth (m): #6 Bag

Date Received: 11/16/06
Comments:

Approved By:

Percent Gravel: 0.0
Percent Sand: 17.8
Percent Silt + Clay: 82.2
ASTM Group Name: Lean Clay With Sand
AASHTO Classification: A-7-6

Liquid Limit:	47
Plastic Limit:	21
Plasticity Index:	26
Classification:	CL
Moisture Content:	

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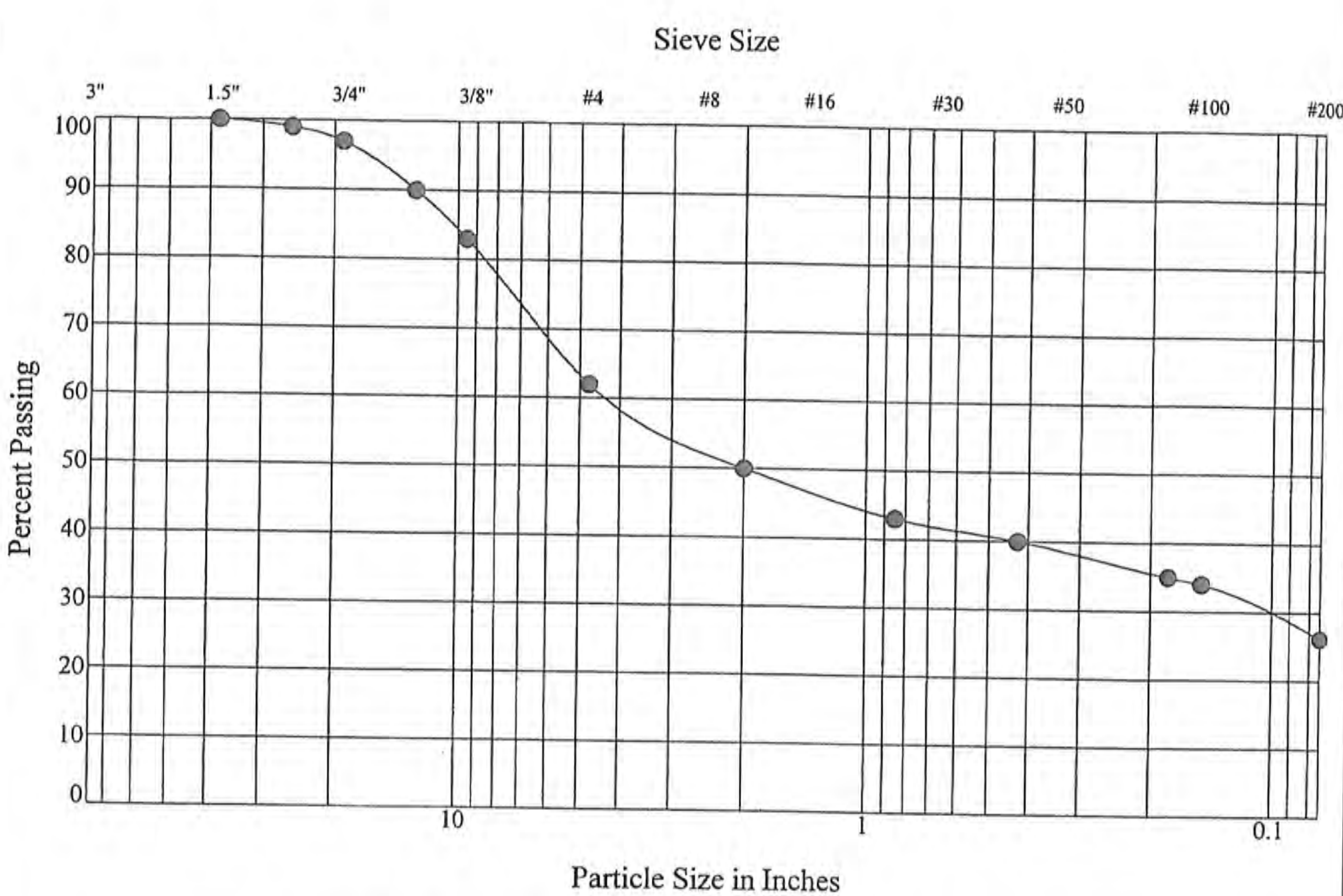
Sieve Analysis

Project Number: 067358

Project Name: Southern Hills Subdivision

Project Location: Missoula, Montana

4/27/07



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
	100	97	83	62	52	46	41	38	34	26.2

Boring No.: ST-2P
Lab No.: ST-2
Depth (m): 1.5' - 9.0'

Date Received: 11/16/06
Comments:

Approved By:

Liquid Limit:	24
Plastic Limit:	14
Plasticity Index:	10
Classification:	GC
Moisture Content:	

Percent Gravel: 38.0
Percent Sand: 35.8
Percent Silt + Clay: 26.2
ASTM Group Name: Clayey Gravel With Sand
AASHTO Classification: A-2-4

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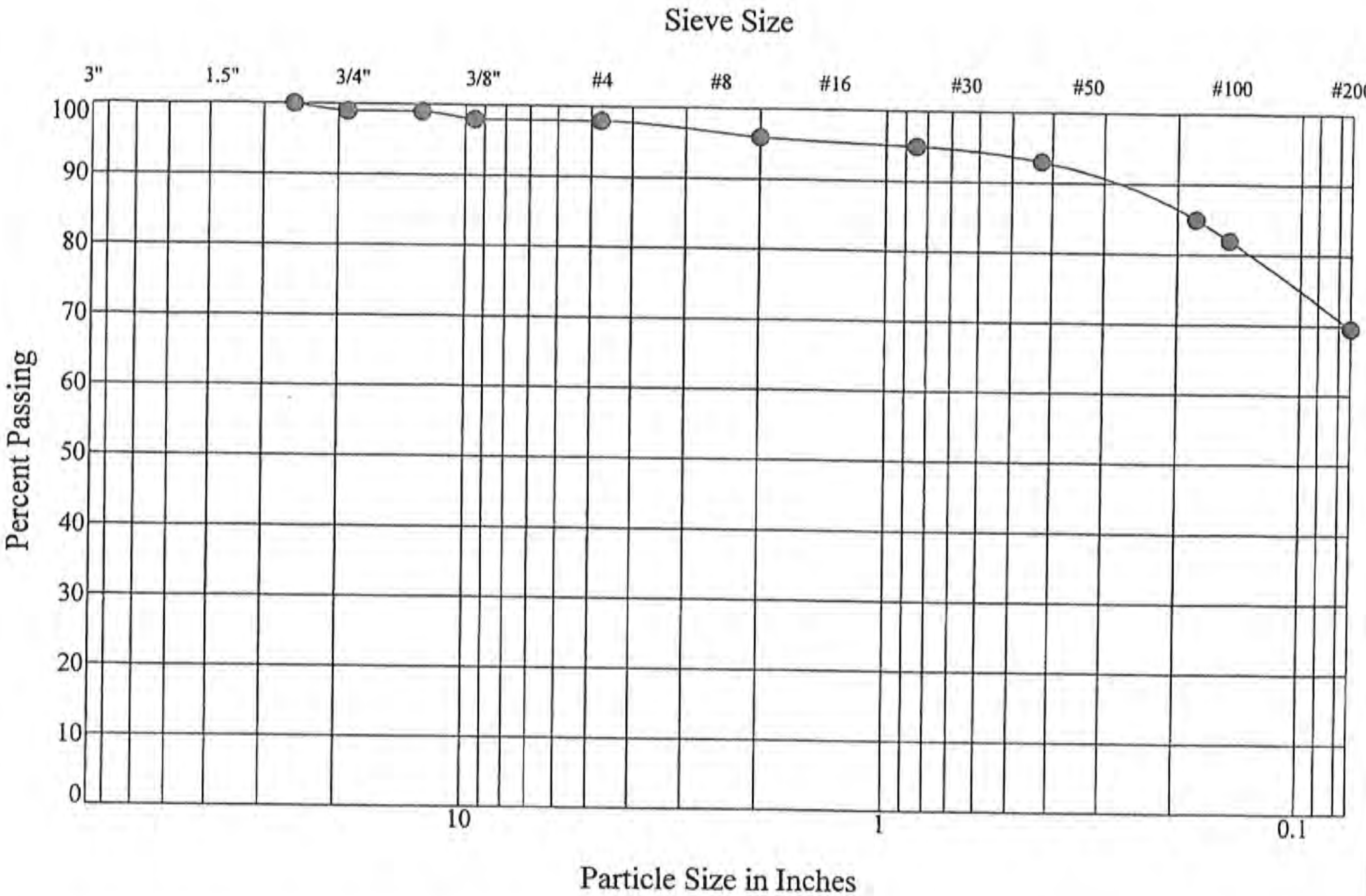
Sieve Analysis
Project Number: 067358
Project Name: Southern Hills Subdivision
Project Location: Missoula, Montana

4/27/07



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
		99	98	98	96	95	94	90	82	69.6

Boring No.: ST-4P
Lab No.: ST-4
Depth (m): 7' - 14'

Date Received: 11/15/06
Comments:

Approved By:

Liquid Limit:	47
Plastic Limit:	16
Plasticity Index:	31
Classification:	CL
Moisture Content:	

Percent Gravel: 2.0
Percent Sand: 28.4
Percent Silt + Clay: 69.6
ASTM Group Name: Sandy Lean Clay
AASHTO Classification: A-7-6

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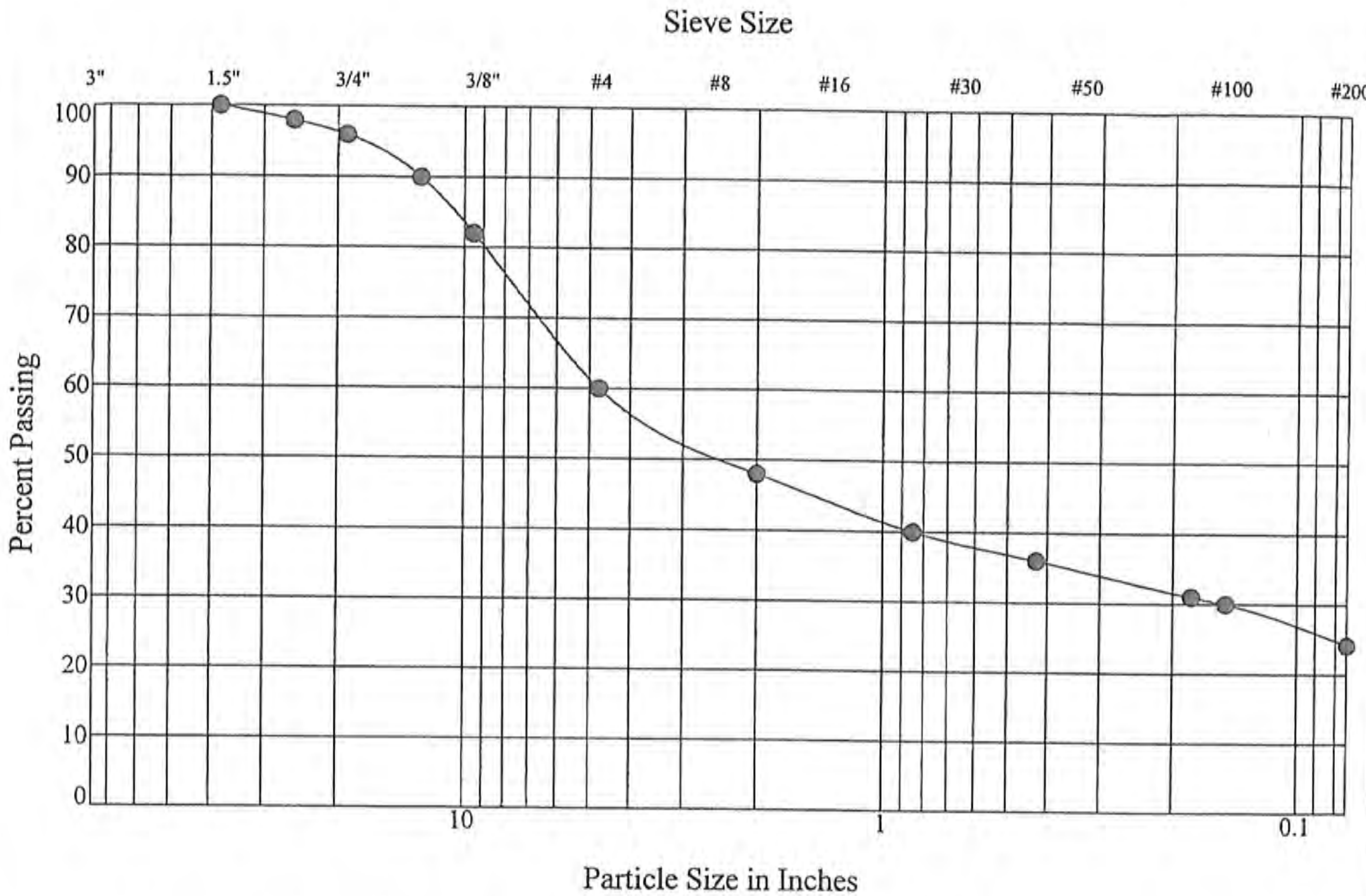
Sieve Analysis

Project Number: 067358
Project Name: Southern Hills Subdivision
Project Location: Missoula, Montana

4/27/07



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
	100	96	82	60	50	43	38	34	30	24.2

Boring No.: ST-7
Lab No.: ST-7
Depth (m): 0 - 9'

Date Received: 11/16/06
Comments:

Approved By:

Liquid Limit:	24
Plastic Limit:	17
Plasticity Index:	7
Classification:	GC-GM
Moisture Content:	

Percent Gravel: 40.0
Percent Sand: 35.8
Percent Silt + Clay: 24.2
ASTM Group Name: Silty, Clayey Gravel With Sand
AASHTO Classification: A-2-4

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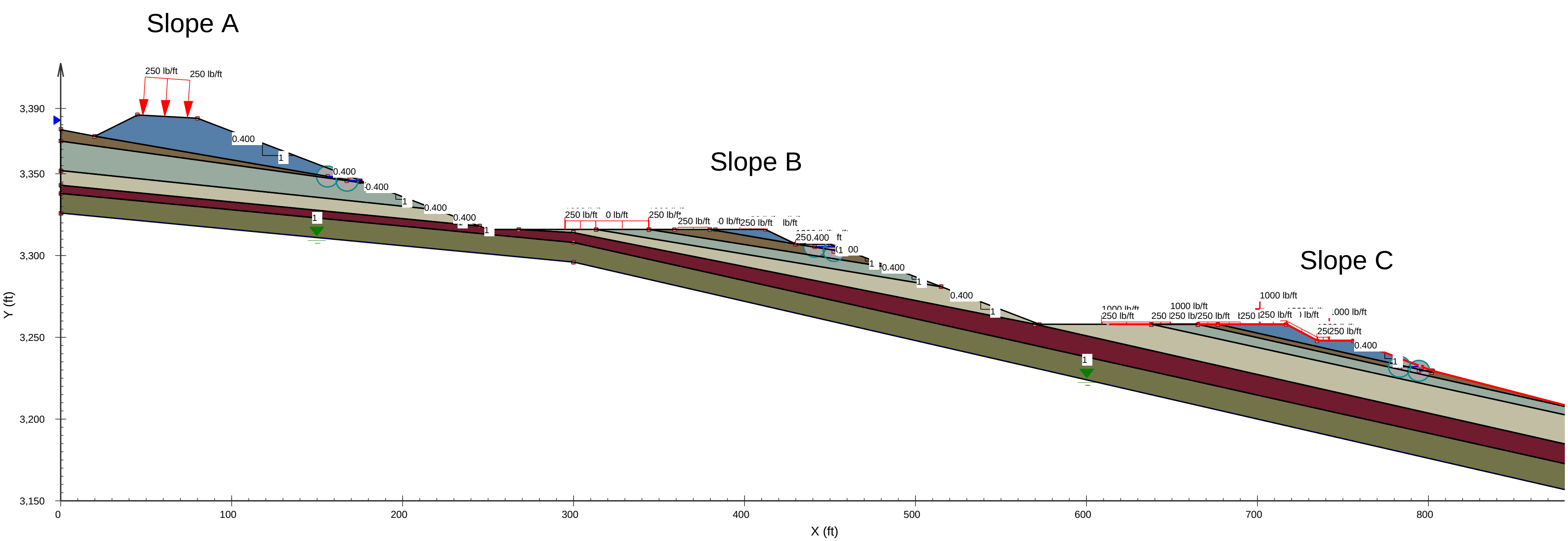
Sieve Analysis
Project Number: 067358
Project Name: Southern Hills Subdivision
Project Location: Missoula, Montana

4/27/07

Materials				
SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
Fill SCGC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GCwS	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS 2	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPwS	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)



SVSLOPE®

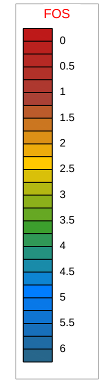
PROJECT	
Hillview Crossing-Missoula	
TITLE	
Cross Section C	
PROJECT No. 15-3338G	File No.
Author D.Hutzenbiler	FIGURE
Date 11/30/2015	

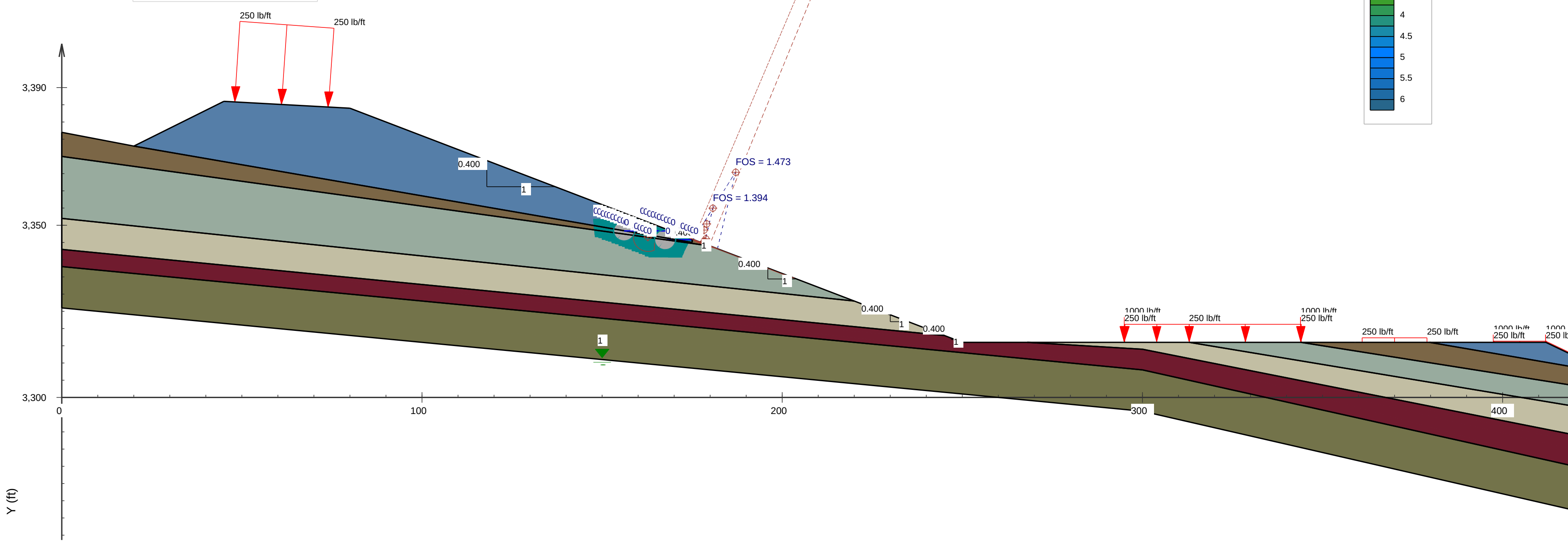
SK GEOTECHNICAL

Materials

SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
Fill SCGC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GCwS	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS 2	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPwS	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.386
Total Weight: 2.367E+000 lb
Total Volume: 2.244E-002 ft^3
Total Activating Moment: 3.563E+002 lbsf
Total Resisting Moment: 4.937E+002 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb

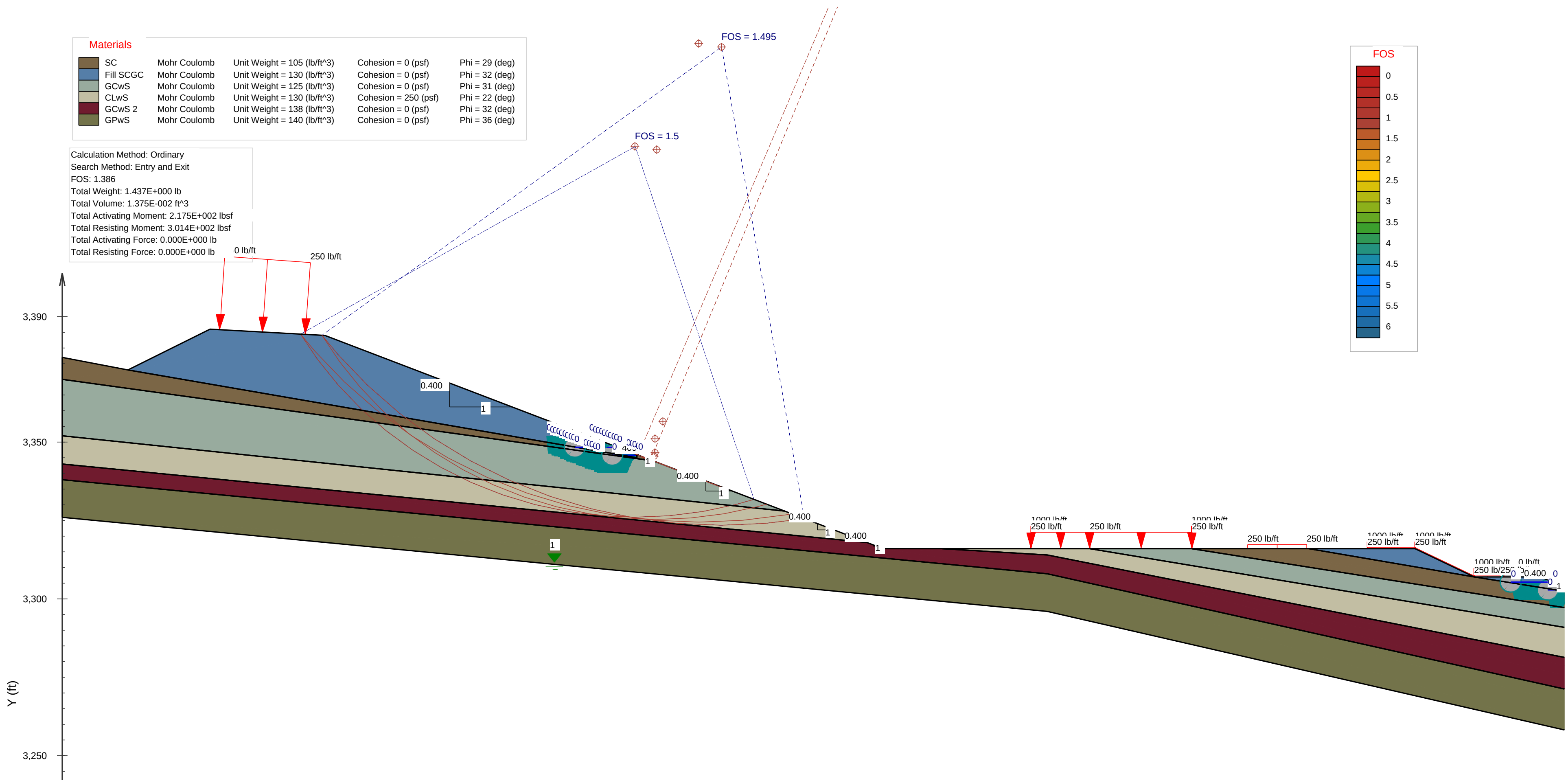




2.5:1 Cut and Fill Slope

PROJECT	Hillview Crossing-Missoula	
TITLE	Cross Section C, Undrained Condition, Slope A	
SK GEOTECHNICAL	PROJECT No. 15-3338G Author D.Hutzenbiler Date 11/17/2015	File No. FIGURE

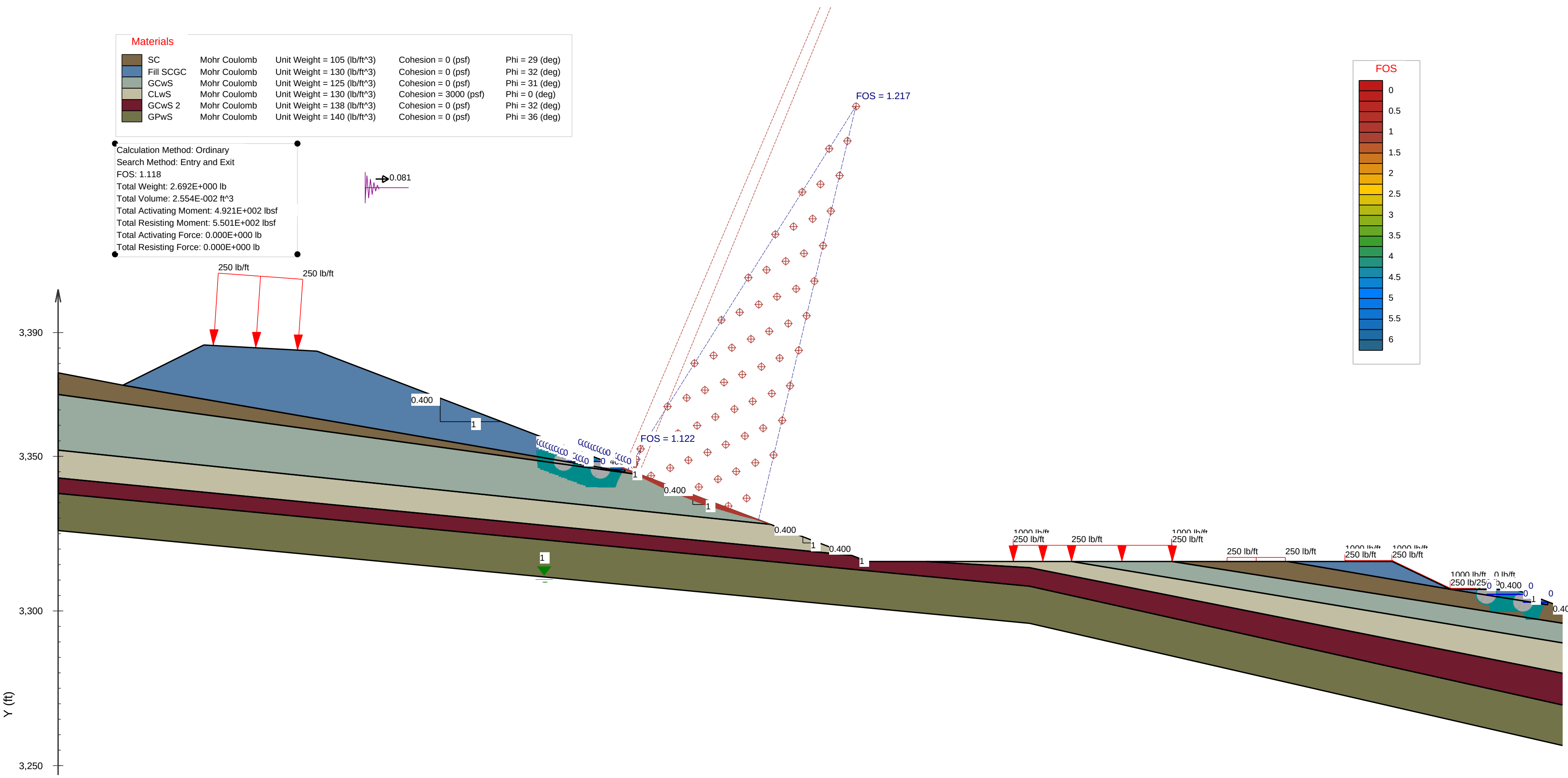
SVSLOPE®



SVSLOPE®

2.5:1 Cut and Fill Slope

PROJECT	Hillview Crossing-Missoula	
TITLE	Cross Section C, Drained Condition, Slope A	
SK GEOTECHNICAL	PROJECT No. 15-3338G	File No.
	Author D.Hutzenbiler	FIGURE
	Date 11/30/2015	



2.5:1 Cut and Fill Slope

PROJECT	Hillview Crossing-Missoula
TITLE	Cross Section C, Undrained-Seismic Condition, Slope A

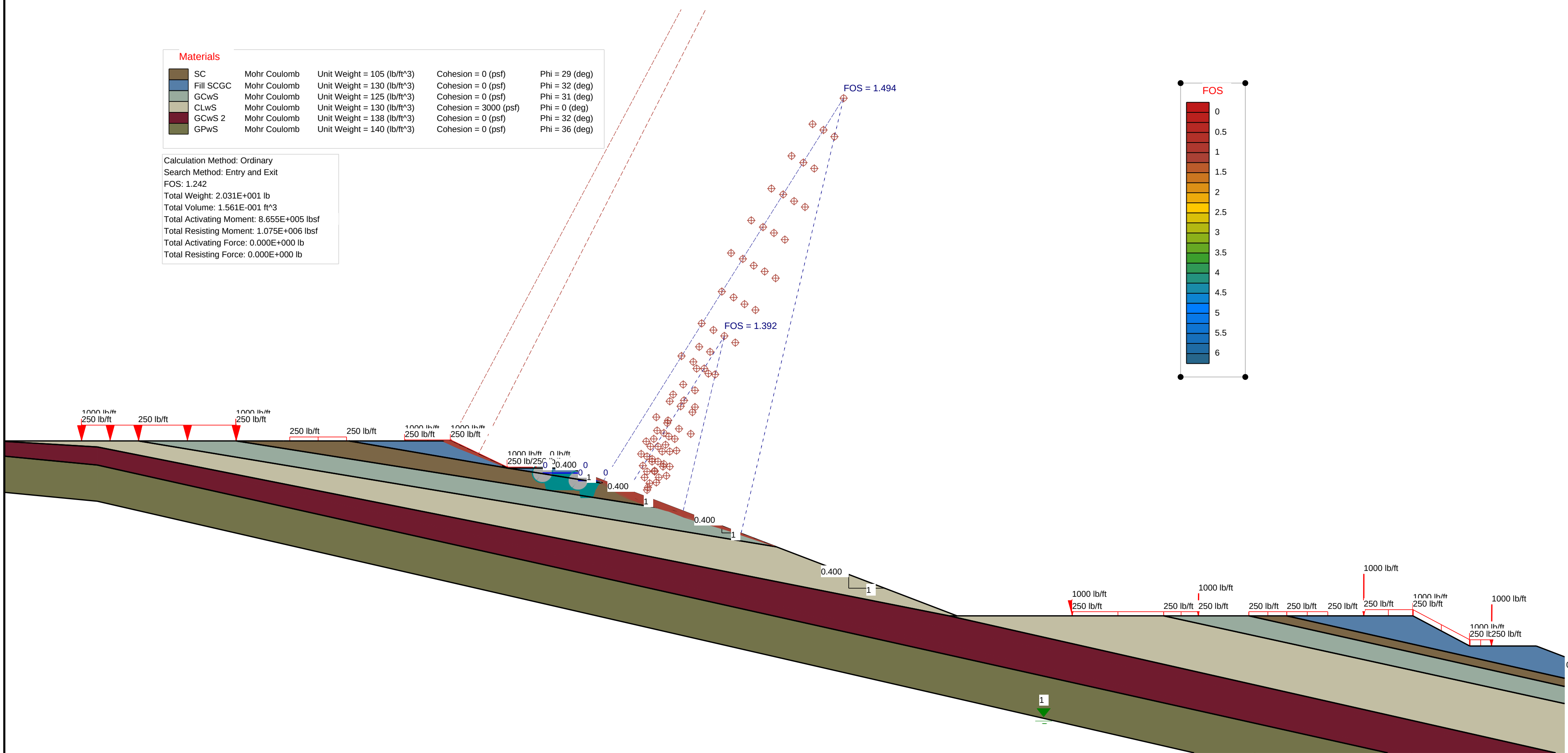
SK GEOTECHNICAL	PROJECT No. 15-3338G	File No.
	Author D.Hutzenbiler	FIGURE
	Date 11/30/2015	

SVSLOPE®

Materials

SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
Fill SCGC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GCwS	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS 2	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPwS	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.242
Total Weight: 2.031E+001 lb
Total Volume: 1.561E-001 ft^3
Total Activating Moment: 8.655E+005 lbsf
Total Resisting Moment: 1.075E+006 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb



2.5:1 Cut and Fill Slope

PROJECT	Hillview Crossing-Missoula
TITLE	Cross Section C, Undrained Condition, Slope B
PROJECT No.	15-3338G
Author	D.Hutzenbiler
Date	11/30/2015
File No.	
FIGURE	

SK GEOTECHNICAL

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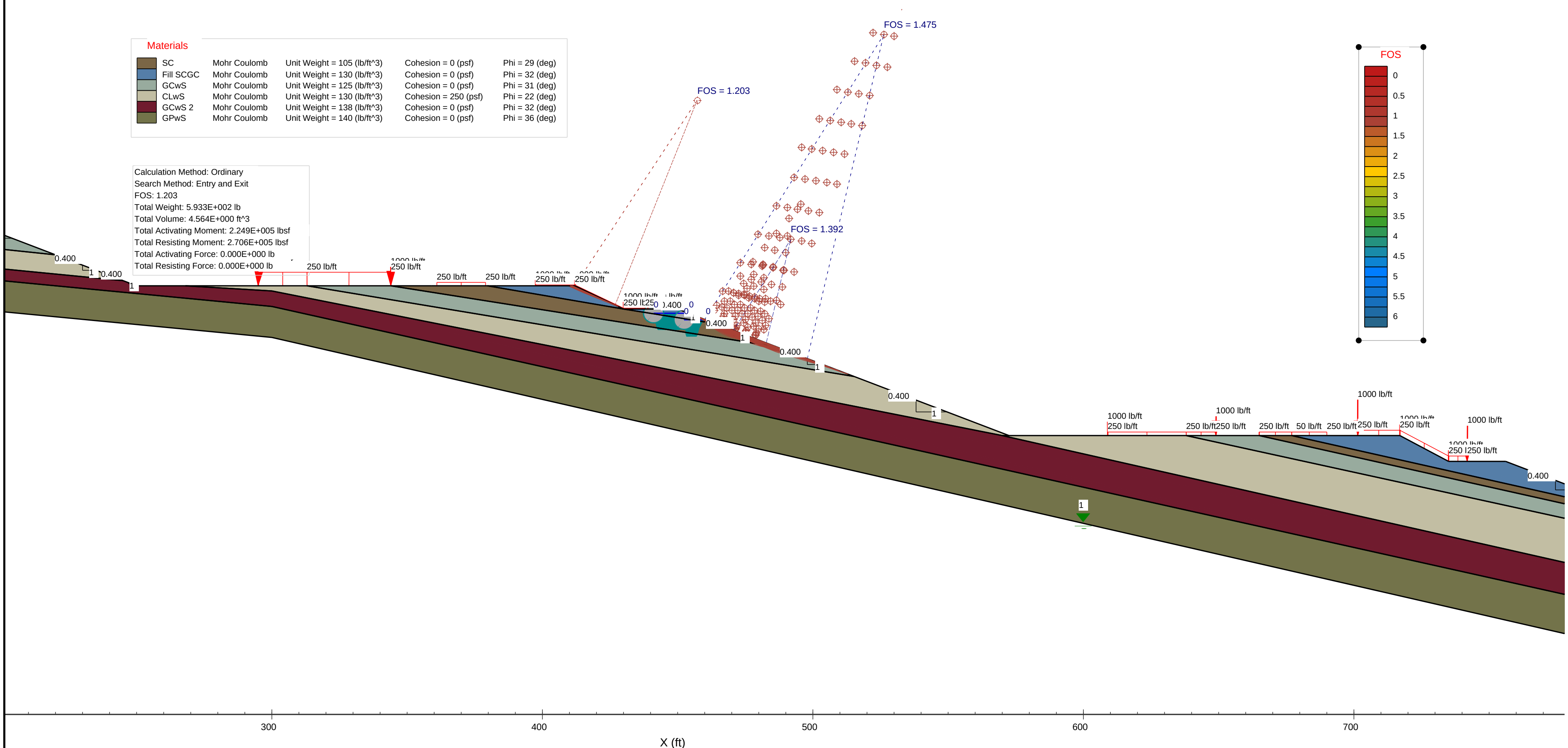


2.5:1 Cut and Fill Slope

PROJECT

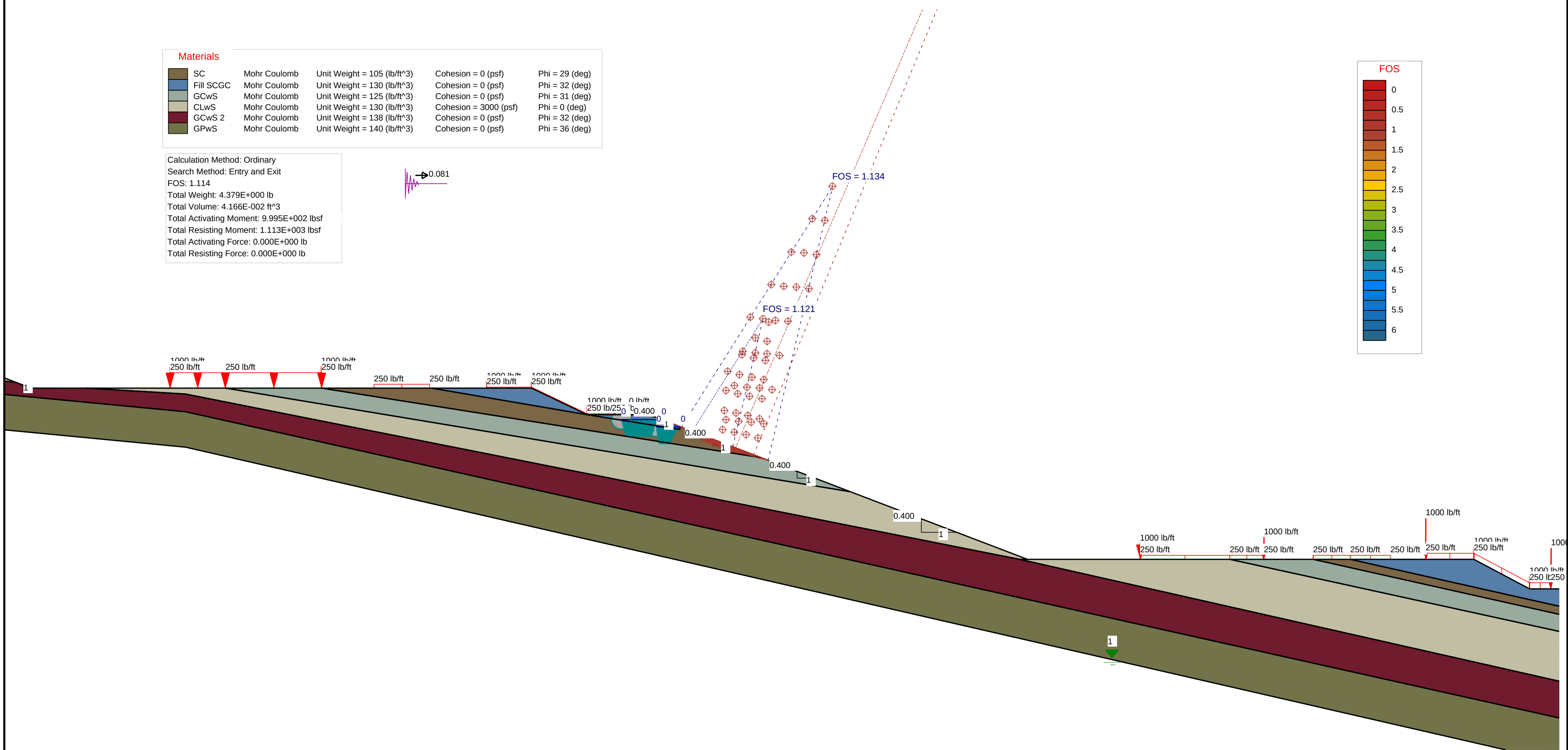
Hillview Crossing-Missoula

TITLE

Cross Section C, Drained Condition, Slope B

SVSLOPE®

PROJECT No.	15-3338G	File No.
Author	D.Hutzenbiler	FIGURE
Date	11/30/2015	



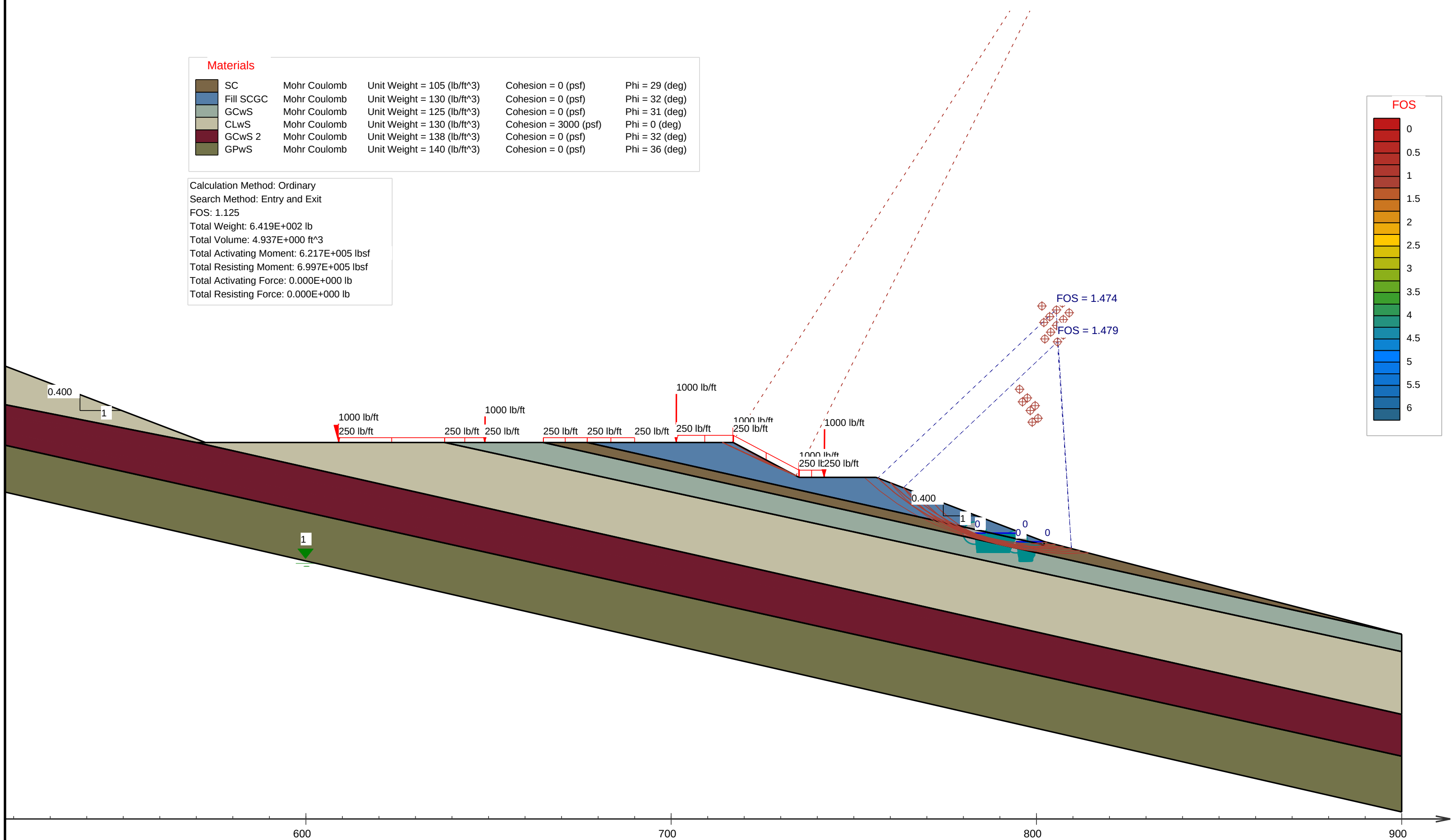
2.5:1 Cut and Fill Slope

PROJECT	Hillview Crossing-Missoula
TITLE	Cross Section C, Undrained-Seismic Condition, Slope B
PROJECT No.	15-3338G
File No.	
Author	D.Hutzenbiler
Date	11/30/2015
FIGURE	

SVSLOPE®

Materials				
SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
Fill SCGC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GCwS	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS 2	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPwS	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.125
Total Weight: 6.419E+002 lb
Total Volume: 4.937E+000 ft^3
Total Activating Moment: 6.217E+005 lbsf
Total Resisting Moment: 6.997E+005 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb



2.5:1 Cut and Fill Slope

PROJECT
Hillview Crossing-Missoula

TITLE
Cross Section C, Undrained Condition, Slope C

PROJECT No.	15-3338G	File No.
Author	D.Hutzenbiler	FIGURE
Date	11/30/2015	

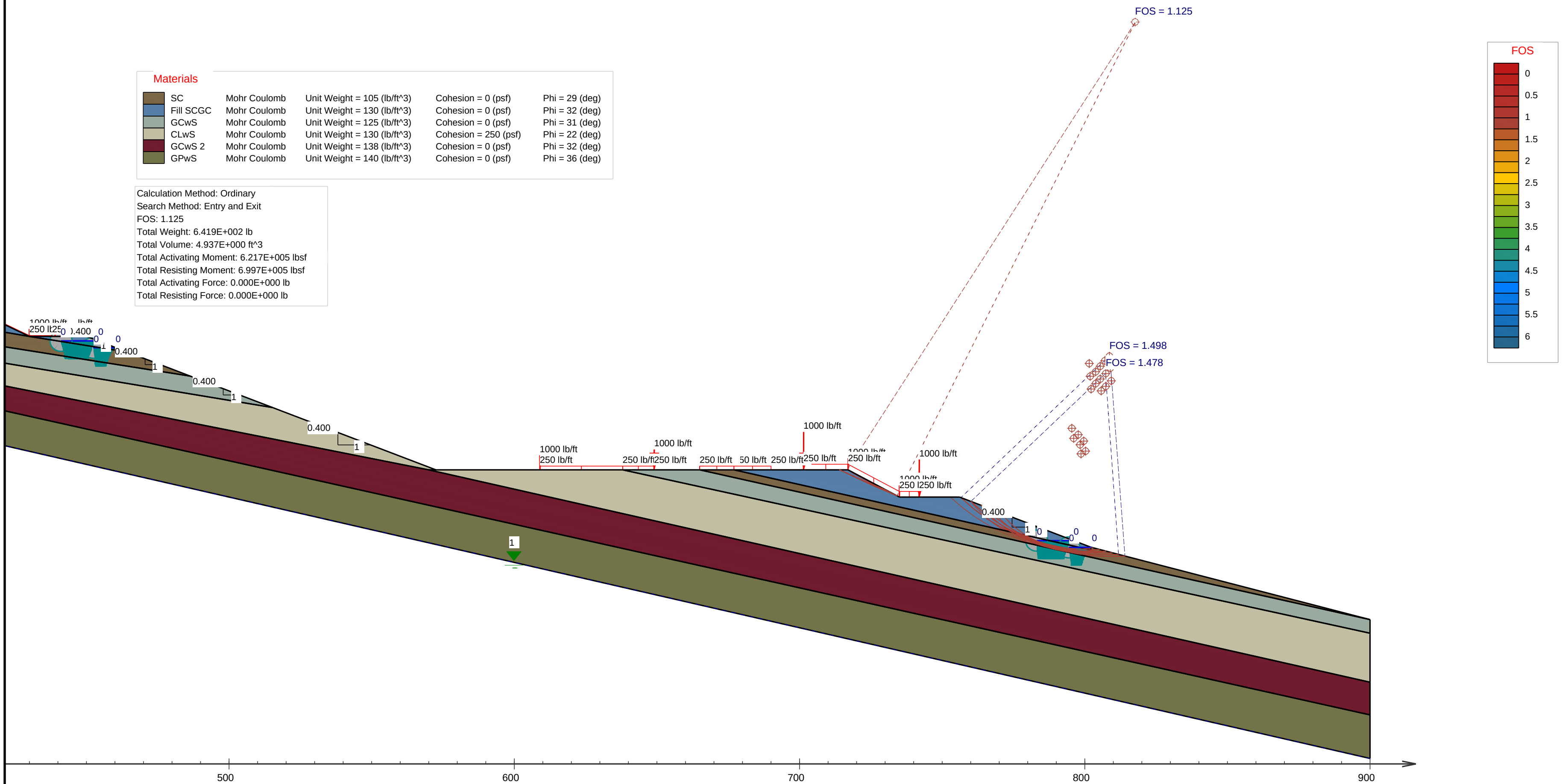
SK GEOTECHNICAL

SVSLOPE®

Materials

SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
Fill SCGC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GCwS	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 250 (psf)	Phi = 22 (deg)
GCwS 2	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPwS	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

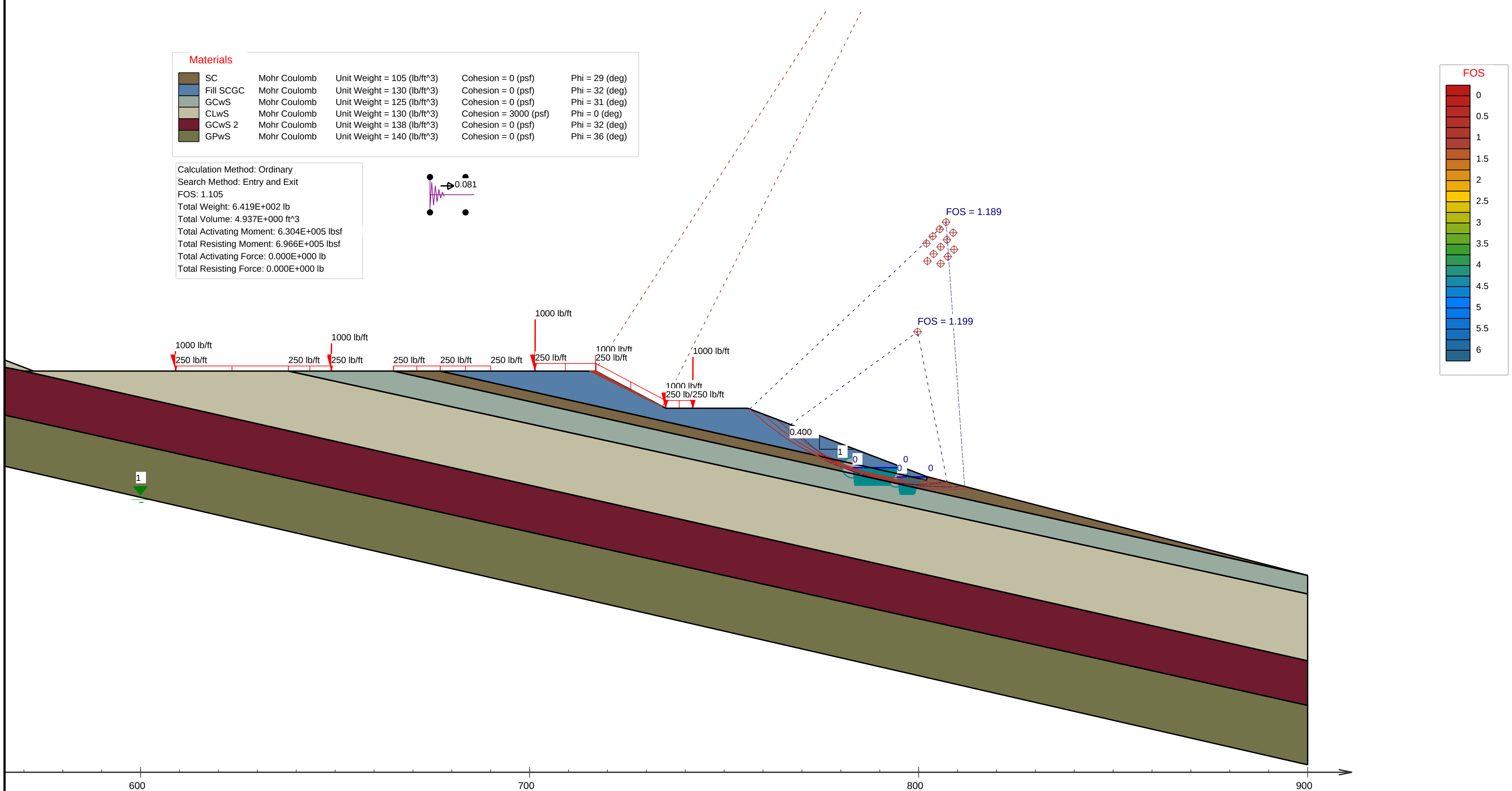
Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.125
Total Weight: 6.419E+002 lb
Total Volume: 4.937E+000 ft^3
Total Activating Moment: 6.217E+005 lbsf
Total Resisting Moment: 6.997E+005 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb



SVSLOPE®

2.5:1 Cut and Fill Slope

PROJECT	Hillview Crossing-Missoula
TITLE	Cross Section C, Drained Condition, Slope C
PROJECT No.	15-3338G
Author	D.Hutzenbiler
Date	11/30/2015
File No.	
FIGURE	



SVSLOPE®

2.5:1 Cut and Fill Slope

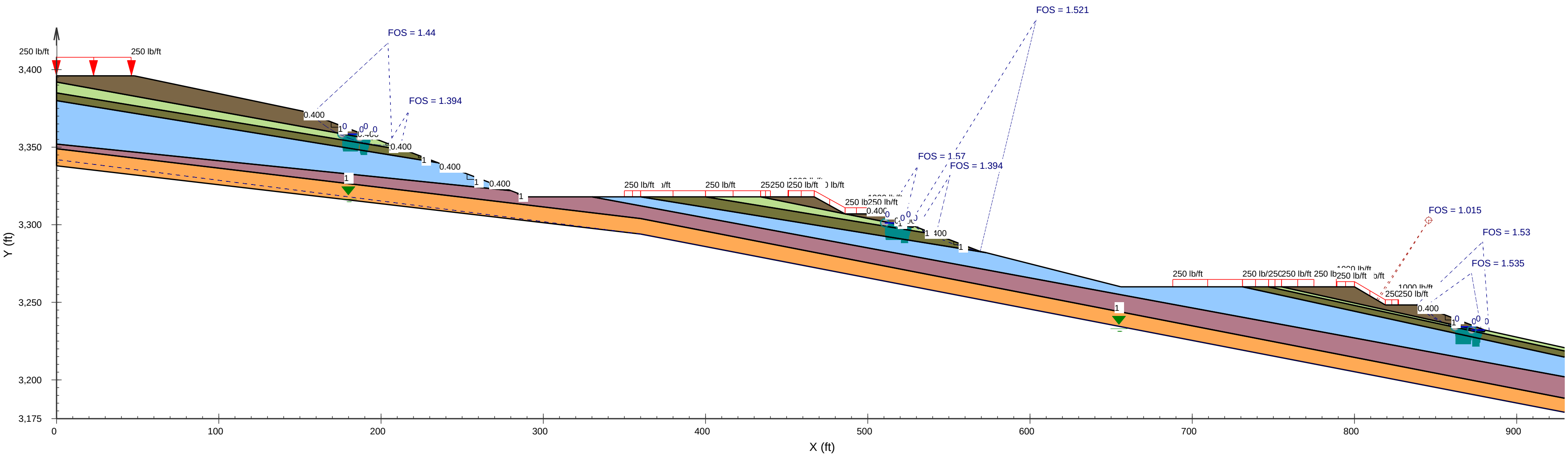
PROJECT	Hillview Crossing-Missoula
TITLE	Cross Section C, Undrained-Seismic Condition, Slope C

SK GEOTECHNICAL

PROJECT No. 15-3338G	File No.	
Author D.Hutzenbiler	FIGURE	
Date 11/30/2015		

Materials				
Fill SC GC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
GC CL	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPGM	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.015
Total Weight: 2.303E-001 lb
Total Volume: 1.786E-003 ft^3
Total Activating Moment: 8.713E+003 lbsf
Total Resisting Moment: 8.842E+003 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb



2.5:1 Cut and Fill Slope

PROJECT
Hillview Crossing - Missoula

TITLE
Cross Section D, Undrained Condition

SVSLOPE®

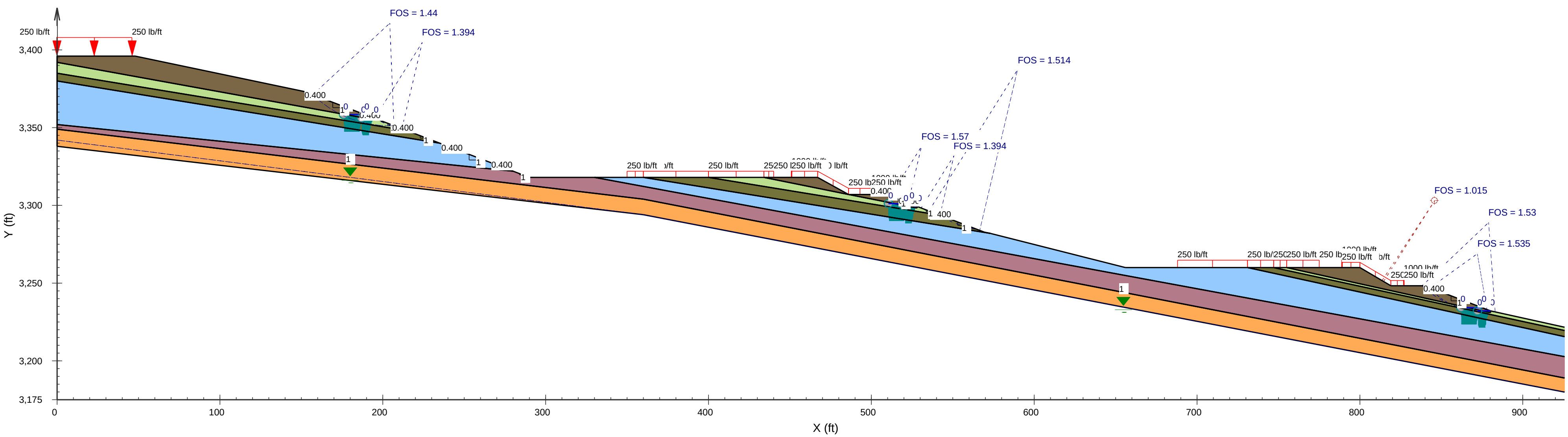
SK GEOTECHNICAL

PROJECT No. 15-3338G		File No.
Author	D.Hutzenbiler	FIGURE
Date	11/18/2015	

Materials

Fill SC GC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
GC CL	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 250 (psf)	Phi = 22 (deg)
GCwS	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPGM	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.015
Total Weight: 2.303E-001 lb
Total Volume: 1.786E-003 ft^3
Total Activating Moment: 8.713E+003 lbsf
Total Resisting Moment: 8.842E+003 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb



2.5:1 Cut and Fill Slope

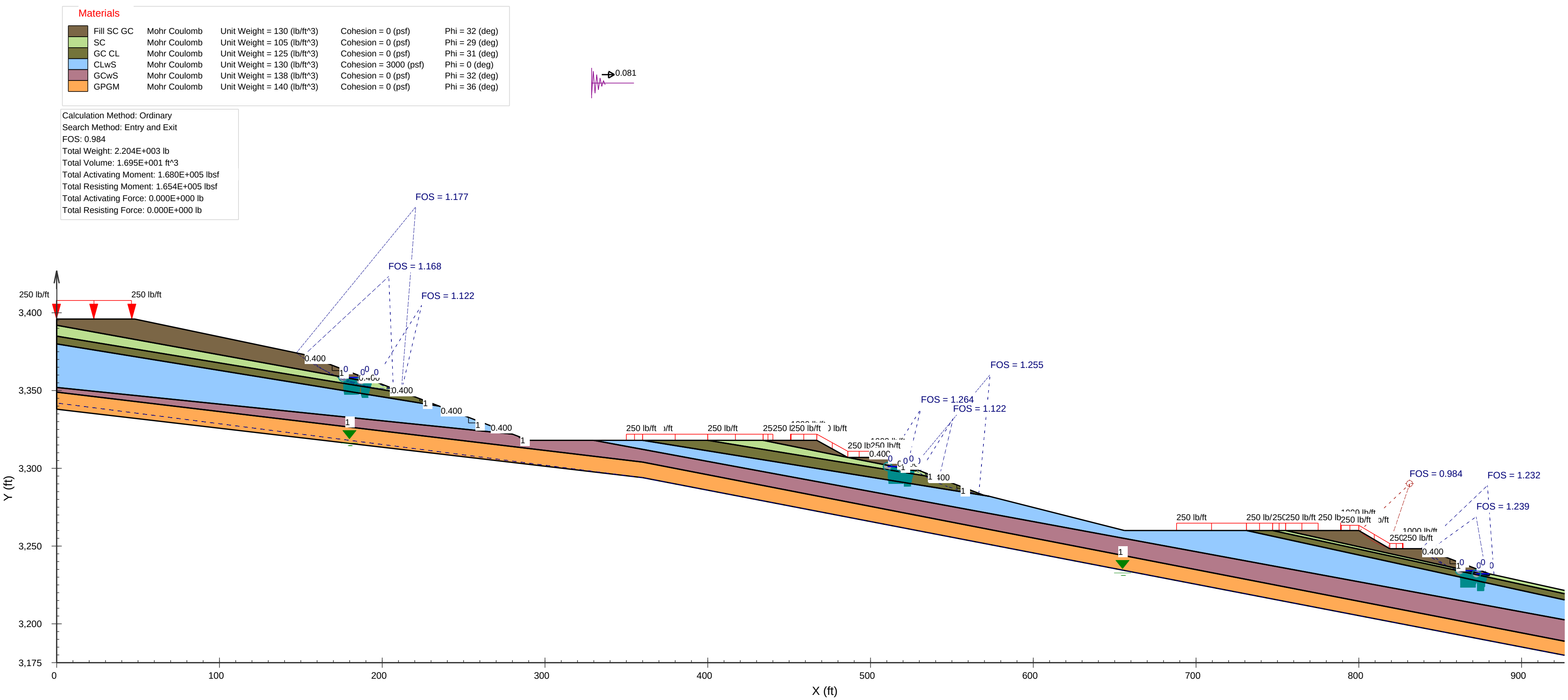
PROJECT
Hillview Crossing - Missoula

TITLE
Cross Section D, Drained Condition

SK GEOTECHNICAL

PROJECT No.	15-3338G	File No.
Author	D.Hutzenbiler	FIGURE
Date	11/18/2015	

SVSLOPE®



2.5:1 Cut and Fill Slope

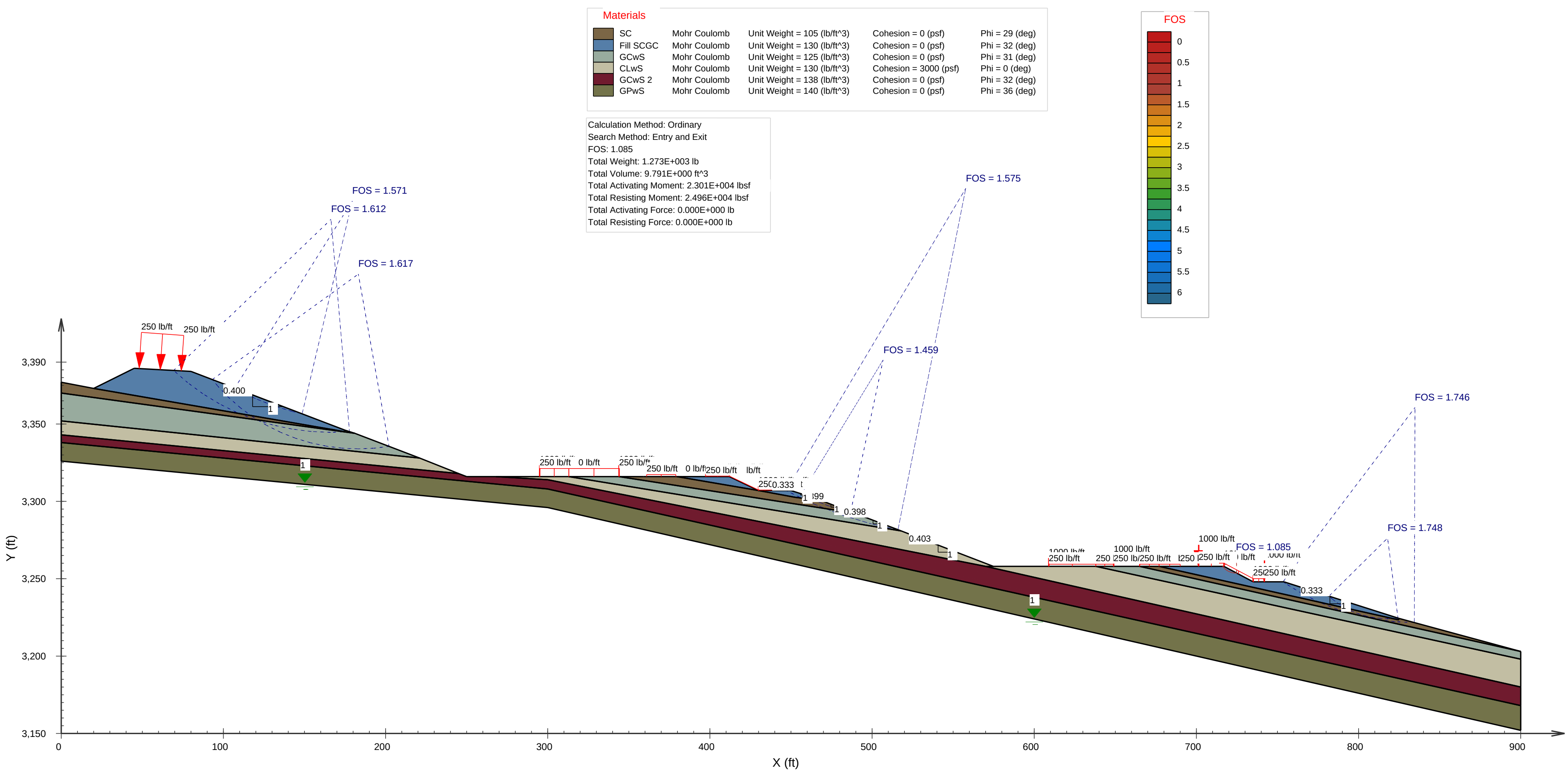
PROJECT

Hillview Crossing - Missoula

TITLE

Cross Section D, Undrained-Seismic Condition

PROJECT No.	15-3338G	File No.
Author	D.Hutzenbiler	FIGURE
Date	11/18/2015	

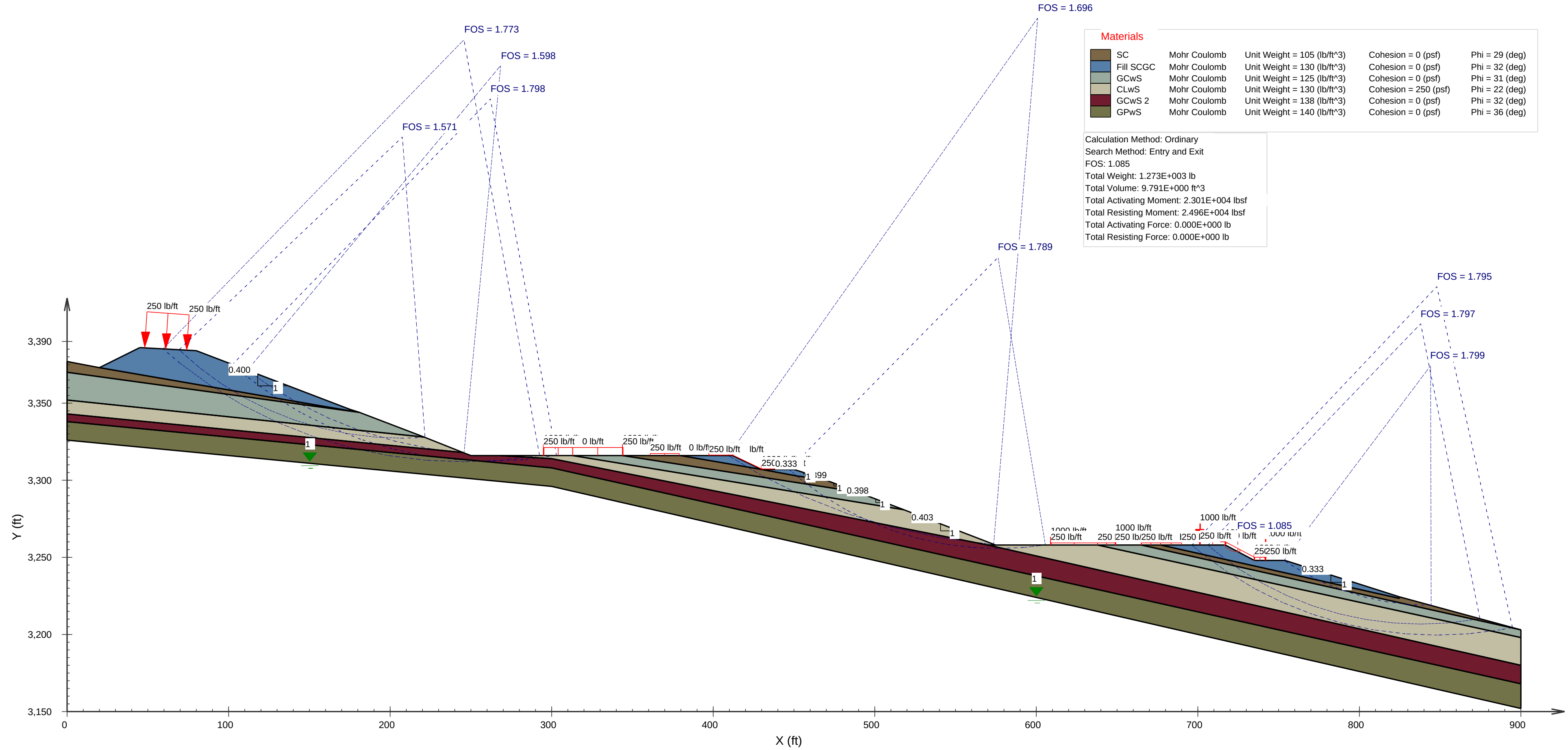


3:1 Fill Slopes and 2.5:1 Cut Slopes

PROJECT	Hillview Crossing-Missoula
TITLE	Cross Section C, Undrained Condition

PROJECT No. 15-3338G	File No.	
Author D.	FIGURE	
Date 11/17/2015		

SVSLOPE®



3:1 Fill Slopes and 2.5:1 Cut Slopes

PROJECT

Hillview Crossing-Missoula

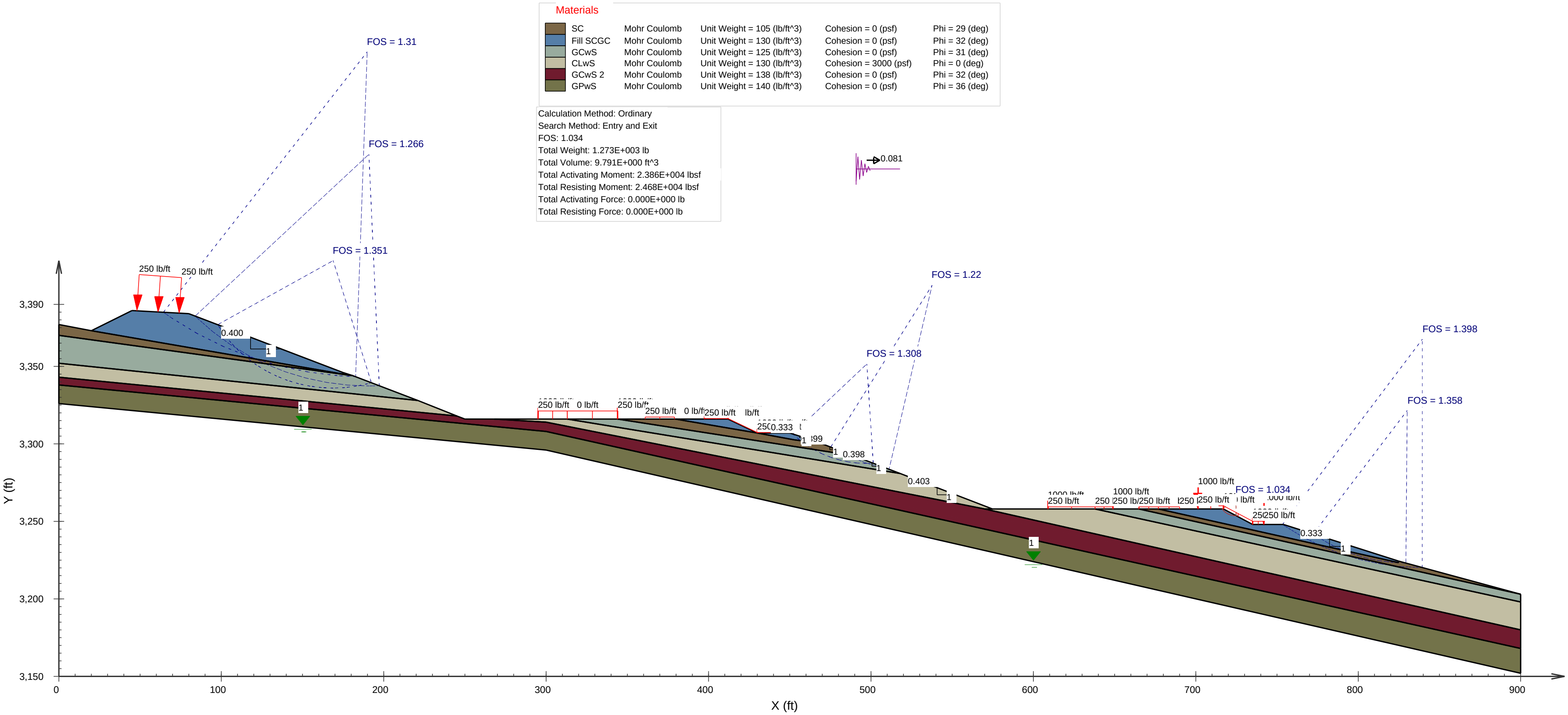
TITLE

Cross Section C, Drained Condition

SK GEOTECHNICAL

PROJECT No.	15-3338G	File No.
Author	D.	FIGURE
Date	11/17/2015	

SVSLOPE®



SVSLOPE®

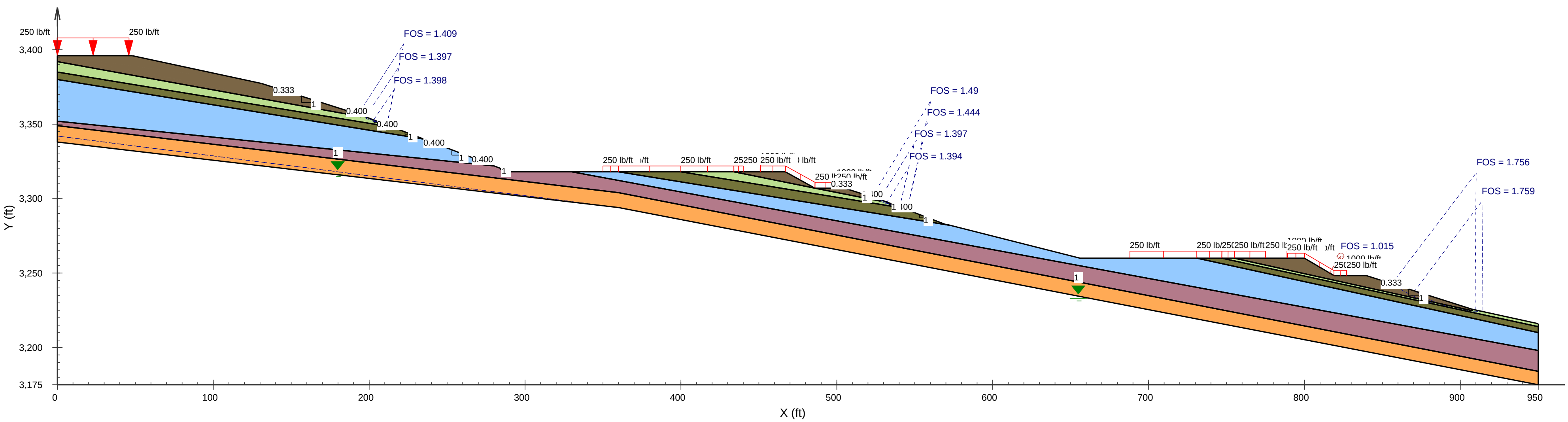
3:1 Fill Slopes and 2.5:1 Cut Slopes

PROJECT	Hillview Crossing-Missoula	
TITLE	Cross Section C, Undrained-Seismic Condition	
SK GEOTECHNICAL	PROJECT No. 15-3338G	File No.
	Author D.	FIGURE
	Date 11/17/2015	

Materials

Fill SC GC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
GC CL	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPGM	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 1.015
Total Weight: 9.805E-002 lb
Total Volume: 7.507E-004 ft^3
Total Activating Moment: 8.670E+002 lbsf
Total Resisting Moment: 8.797E+002 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb



SVSLOPE®

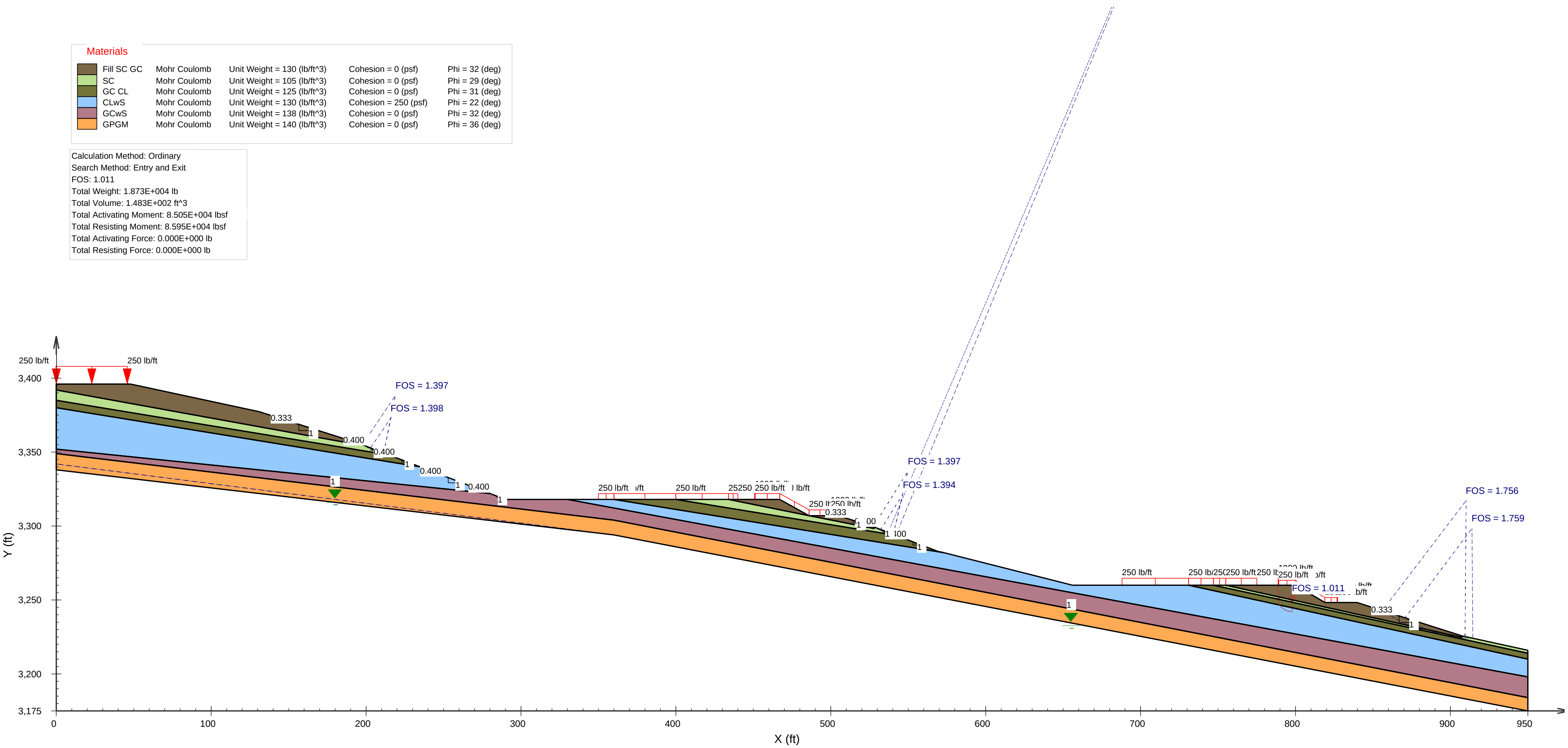
3:1 Fill Slopes and 2.5:1 Cut Slopes

PROJECT
Hillview Crossing - Missoula

TITLE
Cross Section D, Undrained Condition

SK GEOTECHNICAL

PROJECT No. 15-3338G		File No.
Author	D.Hutzenbiler	FIGURE
Date	11/18/2015	



3:1 Fill Slopes and 2.5:1 Cut Slopes

PROJECT	Hillview Crossing - Missoula
TITLE	Cross Section D, Drained Condition
PROJECT No.	15-3338G
Author	D.Hutzenbiler
Date	11/18/2015
File No.	
FIGURE	

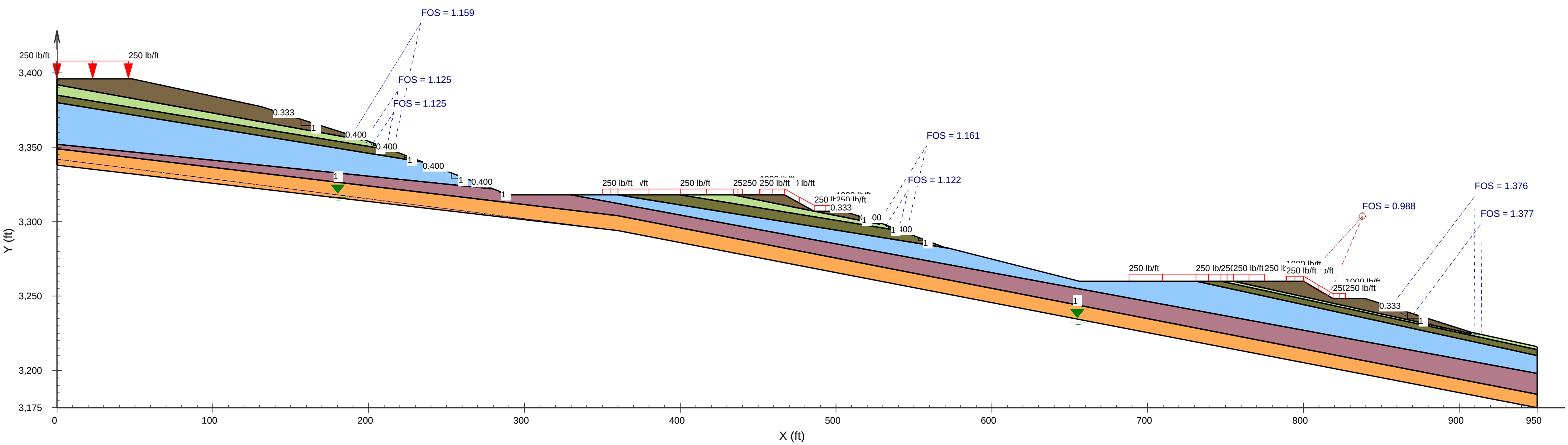
SVSLOPE®

Materials

Fill SC GC	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
SC	Mohr Coulomb	Unit Weight = 105 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 29 (deg)
GC CL	Mohr Coulomb	Unit Weight = 125 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 31 (deg)
CLwS	Mohr Coulomb	Unit Weight = 130 (lb/ft^3)	Cohesion = 3000 (psf)	Phi = 0 (deg)
GCwS	Mohr Coulomb	Unit Weight = 138 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 32 (deg)
GPGM	Mohr Coulomb	Unit Weight = 140 (lb/ft^3)	Cohesion = 0 (psf)	Phi = 36 (deg)

0.081

Calculation Method: Ordinary
Search Method: Entry and Exit
FOS: 0.988
Total Weight: 1.299E+003 lb
Total Volume: 9.989E+000 ft^3
Total Activating Moment: 1.869E+005 lbsf
Total Resisting Moment: 1.846E+005 lbsf
Total Activating Force: 0.000E+000 lb
Total Resisting Force: 0.000E+000 lb

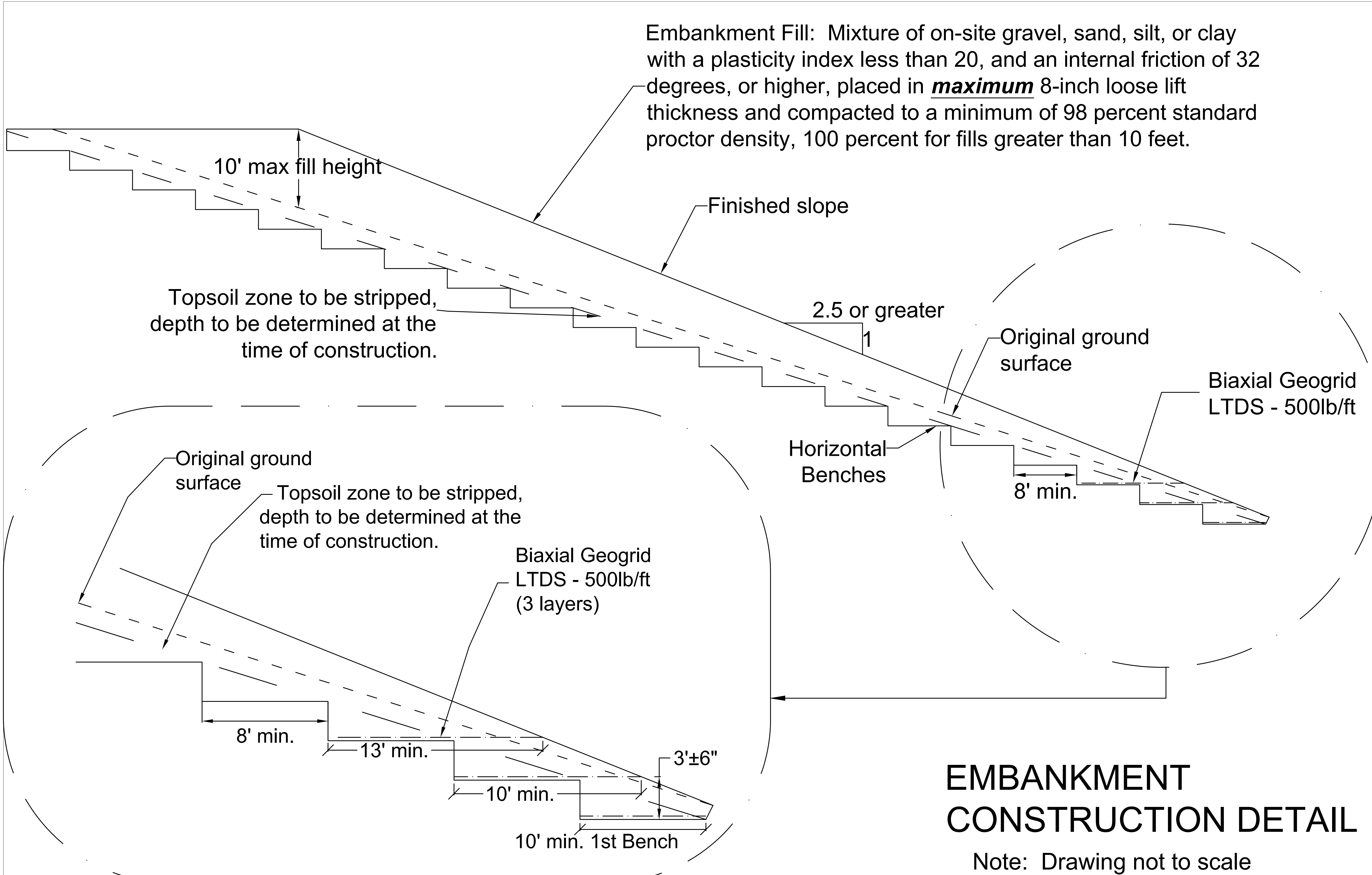


3:1 Fill Slopes and 2.5:1 Cut Slopes

PROJECT	**Hillview Crossing - Missoula**
TITLE	**Cross Section D, Undrained-Seismic Condition**

PROJECT No.	15-3338G
Author	D.Hutzenbiler
Date	11/18/2015
File No.	

FIGURE



EMBANKMENT CONSTRUCTION DETAIL

Note: Drawing not to scale