ZipperGeo
Geoprofessional Consultants

Project No. 1961.01
June 19, 2018

Dawn Drive Association
OBO Dawn Vista Owners
c/o Zane Shiras
9258 SE 46th Street
Mercer Island, WA 98040

Subject: Geotechnical Report
Dawn Drive Landslide Stabilization
Tract A, Parcel No. 192300TR-A
Mercer Island, Washington

Dear Mr. Shiras:

INTRODUCTION

This report documents the surface and subsurface conditions encountered at the site and our geotechnical engineering recommendations for work to stabilize a landslide that occurred along Dawn Drive near the intersection of Dawn Drive with SE 46th Street in Mercer Island, Washington. The project description, site conditions, and our geotechnical conclusions and design recommendations are presented in the text of this report. Supporting data including detailed exploration logs and field exploration procedures, results of laboratory testing and other supporting information are presented as appendices.

Our geotechnical engineering scope of services for the project included a literature review, site reconnaissance, subsurface exploration, laboratory testing, geotechnical engineering analysis, and preparation of this report.

BACKGROUND AND PROJECT DESCRIPTION

Based on our conversations with you, a visit to the site, and information provided by other home owners in the area, we understand that on December 10, 2017 a water main located beneath SE 46th Street broke resulting in water running over and under the surface of SE 46th Street. The water flowed southeast down SE 46th Street and then turned east across Dawn Drive. The water flowed over and under Dawn Drive and down a steep slope apparently causing a landslide. The debris flow from the landslide traveled downslope to the east, across a property located at 4691 East Mercer Way, then onto East Mercer Way. The approximate extents of the landslide are shown on the attached Figure 1, Site and Exploration Plan. The property on which the slide occurred is an undeveloped tract of land collectively owned by residents of Dawn Vista. The project will consist of stabilizing the landslide and repairing damage apparently caused by the failed water main.

SURFACE CONDITIONS

The project site consists of an undeveloped, 0.97 acre parcel of land located near the intersection of SE 46th Street and Dawn Drive in Mercer Island, Washington. The site generally occurs as a steep, east-facing hillside covered with dense deciduous brush and scant deciduous trees. The site is bordered to the north and west by Dawn Drive; to the east by developed residential properties; and to the south by SE 46th Street. The subject landslide begins at the east edge of Dawn Drive near the intersection of Dawn Drive with SE 46th Street. The main body of the landslide covers about 2,000 square feet of area. The debris flow that occurred as a result of the landslide extends about 100 to 150 feet east of the slide toe. Existing surface conditions are further illustrated on the attached Figure 1, Site and Exploration Plan.

SUBSURFACE CONDITIONS

Soil Conditions

Subsurface soil conditions at the site were evaluated by completing three geotechnical test borings at the approximate locations shown on the attached Site and Exploration Plan, Figure 1. Soils observed in the borings were visually classified in general accordance with the Unified Soil Classification System. Descriptive logs of the subsurface explorations and the procedures utilized in the subsurface exploration program are presented in *Appendix A*. A generalized description of soil conditions encountered in the borings is presented below. Detailed descriptions of soils encountered are provided on the descriptive logs in *Appendix A*.

Boring B-1 was completed near the south edge of the landslide head scarp. Subsurface soil conditions observed in boring B-1 generally consisted of soft to medium stiff silt and very loose silty sand (colluvium) extending from the ground surface to about 17 feet below existing site grade. Below the colluvium, the boring encountered stiff to very stiff, finely bedded/laminated silt (older sand) extending to about 30 feet below existing site grade. Below the older sand, the boring encountered very dense, silty sand (glacial till) extending to the completion depth of about 41 feet below existing site grade.

Boring B-2 was completed near the north edge of the landslide head scarp. The stratographic sequence observed in boring B-2 was similar to that of boring B-1 with the colluvium extending to about 13.5 feet below existing site grade; older sand below the colluvium extending to about 21 feet; and glacial till below the older sand extending to the completion depth of about 35.5 feet below existing site grade.

Boring B-3 was completed down-slope from the head scarp, near the north center of the main body of the landslide. The stratographic sequence observed in boring B-3 was similar to that of boring B-1 with the colluvium extending to about 8 feet below existing site grade; older sand below the colluvium extending to about 11 feet; and glacial till below the older sand extending to the completion depth of about 14 feet below existing site grade.

Groundwater Conditions

Slight, perched groundwater was observed at about 25.5 feet below existing grade in boring B-1 at the time of drilling. No groundwater was observed in boring B-2 at the time of drilling. Slight, perched groundwater was observed at about 9 feet below existing site grade in boring B-3 at the time of drilling. Fluctuations in groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the explorations were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher than indicated on the logs.

CONCLUSIONS AND RECOMMENDATIONS

General

The landslide has resulted in an over-steepened slope that extends into and below Dawn Drive. It is our opinion the landslide can be stabilized through a combination of removing some loose slide debris and constructing a rock buttress keyed into dense soils at the toe of the slide. The following sections of this report provide recommendations for stabilizing the landslide through construction of a rock buttress.

Temporary Erosion and Sediment Control

The success of this project will highly depend on control of surface water runoff into the work area to prevent erosion and further destabilization of slope. In general, the surface of Dawn Drive slopes down towards the landslide area. During construction, the contractor should pay particular attention to the control of surface water runoff into the work area from Dawn Drive. Surface water runoff should be diverted away from the work area through the use of an asphalt berm.

Grading for this project will require creating steep temporary cut slopes within the landslide area. The exposed cut slopes must be protected from exposure to direct rainfall and surface water runoff to the extent possible during construction. If wet weather is expected (defined as forecast rainfall greater than 0.25 inches in a 12 hour period), at the end of each work day, we recommend the slope be covered with anchored plastic sheeting. Areas of the site that will be un-worked for more than two days should be covered with anchored plastic sheeting. Depending on the construction progress, there may be a need to temporarily delay work at the site if heavy rainfall is forecast. We recommend temporary work delays during construction be evaluated on a case-by-case basis through observation of site conditions by Zipper Geo Associates in coordination with the contractor.

Silt fencing should be installed along the downhill side of the work area.

Landslide Stabilization Recommendations

In order to stabilize the landslide, we recommend loose debris at the head scarp and along the edges of the landslide be removed. After removal of the loose debris, we recommend a rock buttress be constructed. The rock buttress should be keyed into dense native soils at the toe of the landslide. The rock buttress material should consist of 6- to 8-inch quarry spalls. After completion of the rock buttress, we recommend all areas disturbed as a result of construction be restored using native plants. In order to promote growth of native

species, we recommend the voids within the upper 1 to 2 feet of the quarry spall buttress be filled with blown-in topsoil. To provide subsurface drainage for the buttress, we recommend installing a 4-inch diameter perforated drainage pipe near the toe of the buttress in a transverse direction. The perforate drain pipe should connect to a 4-inch diameter solid wall PVC pipe that discharges to a quarry spall splash pad downslope of the buttress.

In concurrence with preparation of this report, an engineered design of rock buttress and associated grading to stabilize the landslide was completed by Zipper Geo Associates, LLC. Additional geotechnical recommendations, plans, and calculations for the work are provided with this report. The design for the buttress was based on soil design parameters developed by ZGA as listed below. The values are based on correlations to blow count data derived from the subsurface explorations, codes and reports referenced, and engineering judgement.

- Colluvium:
  - Soil description: Soft to medium stiff SILT
  - Unit Weight, γ: 120 pcf
  - Effective Soil Friction Angle, $\emptyset$': 32°
  - Soil Cohesion, c: 50 psf
- Probable Colluvium:
  - Soil description: Medium stiff SILT
  - Unit Weight, γ: 125 pcf
  - Effective Soil Friction Angle, $\emptyset$': 34°
  - Soil Cohesion, c: 100 psf
- Older Sand:
  - Soil description: Stiff to very stiff SILT
  - Unit Weight, γ: 130 pcf
  - Effective Soil Friction Angle, $\emptyset$': 36°
  - Soil Cohesion, c: 250 psf
- Glacial Till:
  - Soil description: Dense to very dense silty SAND
  - Unit Weight, γ: 138 pcf
  - Effective Soil Friction Angle, $\emptyset$': 45°
  - Soil Cohesion, c: 1500 psf
- Seismic:
  - Per USGS for site latitude and longitude assuming AASHTO LRFD Bridge Design Manual as code reference, As = 0.47g, M=7.5
  - Calculated yield acceleration, k_y = 0.22g
  - Per Newmark Displacement Charts assuming amax = 0.47g and k_y = 0.22g, estimated seismic lateral displacement is approximately 2 inches. Which is acceptable for this slope.

Statement of Risk

Per Section 19.073060(D) of the Mercer Island Unified Land Development Code, the City of Mercer Island requires a "Statement of Risk" by the geotechnical engineer for work in a geologic hazard area. It is Zipper Geo Associates' opinion that the proposed work would render the development as safe as if it were not located in a geologic hazard area provided that the recommendations in this report are followed and that any recommendations by Zipper Geo Associates during construction are followed.

CLOSURE

The conclusions and recommendations presented in this report are based, in part, or subsurface soil and groundwater conditions observed in the borings completed at isolated locations. It is possible that the actual subsurface soil and groundwater conditions at areas other than the isolate boring locations may vary. The recommendations provided in this report may need to be modified during construction. It is therefore our recommendation that Zipper Geo Associates provided periodic observation of the work during construction in order to observe conditions and provide additional recommendations as needed.

This report has been prepared for the exclusive use of the Dawn Drive Association, and their agents, for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. Site safety, temporary excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Zipper Geo Associates, LLC reviews the changes and either verifies or modifies the conclusions of this report in writing.

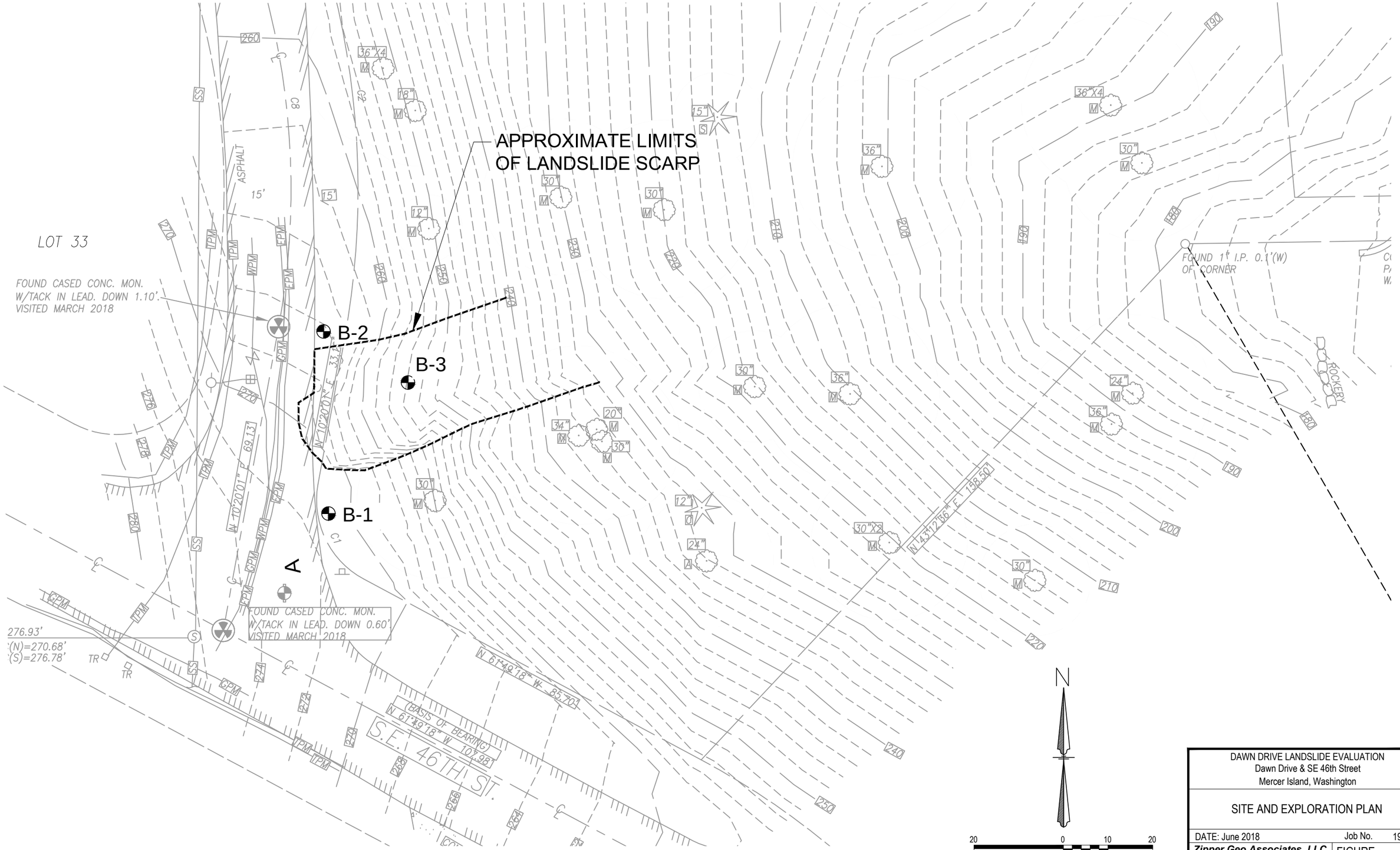
Respectfully submitted,
Zipper Geo Associates, LLC

6/19/18

ROBERT A. ROSS
STATE OF WASHINGTON
38384
REGISTERED
PROFESSIONAL ENGINEER

Robert A. Ross, P.E.
Principal

Attachments: Figure 1, Site and Exploration Plan
Appendix A: Subsurface Exploration Procedures and Logs
Plans and Calculations



DAWN DRIVE LANDSLIDE EVALUATION
Dawn Drive & SE 46th Street
Mercer Island, Washington

SITE AND EXPLORATION PLAN

DATE: June 2018 Job No. 1961.01

Zipper Geo Associates, LLC
19019 36th Ave. W.,Suite E
Lynnwood, WA

FIGURE 1
SHT.1 of 1

APPENDIX A

SUBSURFACE EXPLORATION PROCEDURES & LOGS

APPENDIX A
SUBSURFACE EXPLORATION PROCEDURES AND LOGS

Field Exploration Description

Our field exploration for this project included three geotechnical test borings completed on March 28, 2018. The approximate exploration locations are shown on the Site and Exploration Plan, Figure 1. Exploration locations were surveyed by Pacific Coast Surveys, Inc. The approximate ground surface elevation at the exploration locations was determined by interpolating from topographic information shown on a topographic survey provided by Pacific Coast Surveys, Inc.. The exploration locations and elevations should be considered accurate only to the degree implied by the means and methods used to define them. The vertical datum for the referenced survey is NAVD 88.

Boring Procedures

The borings were advanced using a drill rig operated by an independent drilling company working under subcontract to ZGA. The borings were advanced using hollow stem auger drilling methods. An engineering geologist or geotechnical engineer from our firm continuously observed the borings, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further evaluation and testing. Samples were obtained by means of the Standard Penetration Test at 2.5- to 5-foot intervals throughout the drilling operation.

The Standard Penetration Test (ASTM: D-1586) procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "blow count" (N value). If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

The enclosed boring logs describe the vertical sequence of soils and materials encountered in each boring, based primarily upon our field classifications. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the boring. If groundwater was encountered in a borehole, the approximate groundwater depth, and date of observation, are depicted on the log.

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 Inches	**B-1**
Top Elevation: NA	Drilling Method: Hollow Stem Auger	Hammer Type: Cathead	
Date Drilled: 3/28/2018	Drill Rig: Mini-track	Logged by: JPG	

Depth (ft)	SOIL DESCRIPTION	Sample Number	SAMPLES Recovery (in)	Ground Water	PENETRATION RESISTANCE (blows/foot) ▲ Standard Penetration Test △ Hammer Weight and Drop: 0 20 40 60	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.						
0	Very loose, wet, dark brown, silty SAND, with organics (Topsoil)						
	Soft, wet, mottled gray-brown, SILT, with sand, inclusions of stiff angular silt, disturbed blocky texture, iron oxide staining (Colluvium)	S-1	14"			3	
5		S-2	14"			3	GSA
		S-3	16"			3	
10	Very loose, wet, gray, silty SAND to soft, sandy SILT, inclusions of stiff angular silt, disturbed blocky texture (Colluvium)	S-4	14"			3	
	Medium stiff, moist to wet, tan, finely laminated SILT, some clay, trace to some fine sand (Probable Colluvium)	S-5	16"			8	
15	3-inch zone of disturbed block texture observed at 16 feet	S-6	18"			8	
	Stiff grading to very stiff, moist, tan, finely laminated SILT, trace to some fine sand and clay. (Older Sand)	S-7	18"			13	
20		S-8	18"			14	
		S-9	18"			19	
25							

SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- ▼ 11/2/12 Groundwater level at time of drilling (ATD) or on date of measurement.

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

Att. = Atterberg Limits

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ⊢—○—⊣ Liquid Limit

Natural Water Content

Dawn Drive Landslide
Dawn Drive & SE 46th Street
Mercer Island, Washington

Date: April 2018 Project No.: 1961.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 Inches	**B-1**
Top Elevation: NA	Drilling Method: Hollow Stem Auger	Hammer Type: Cathead	
Date Drilled: 3/28/2018	Drill Rig: Mini-track	Logged by: JPG	

Depth (ft)	SOIL DESCRIPTION	Sample Number	SAMPLES Recovery	Ground Water	PENETRATION RESISTANCE (blows/foot)	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.				▲ Standard Penetration Test △ Hammer Weight and Drop: ____ 0 20 40 60		
25	Medium dense, wet to saturated, gray-brown, finely bedded SAND, with silt (Older Sand)	S-10	18"	ATD		21	
	Stiff, moist, tan, finely laminated SILT, trace to some fine sand and clay (Older Sand)	S-11	16"			14	
30	Very dense, moist, gray, silty SAND, with gravel to SAND, with silt and gravel (Glacial Till)	S-12	16"			55	
35		S-13	16"			83	
40		S-14	12"			50/6"	
	Boring terminated at about 41 feet. Slight perched groundwater observed at about 25.5 feet at time of drilling.						
45							
50							

SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ⊣—○—⊢ Liquid Limit

Natural Water Content

TESTING KEY

GSA = Grain Size Analysis

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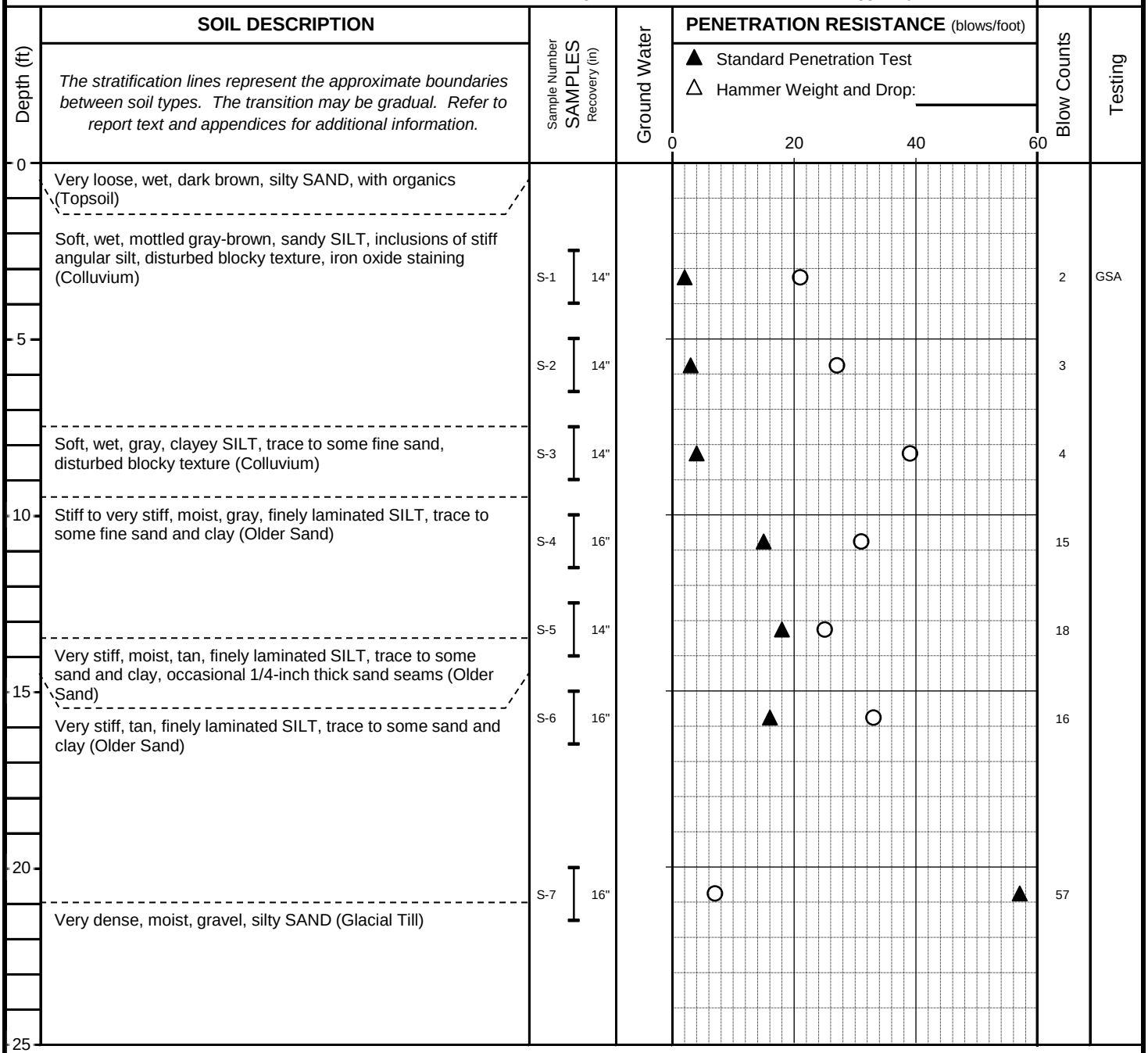
Dawn Drive Landslide
Dawn Drive & SE 46th Street
Mercer Island, Washington

Date: April 2018 Project No.: 1961.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 Inches	**B-2**
Top Elevation: NA	Drilling Method: Hollow Stem Auger	Hammer Type: Cathead	
Date Drilled: 3/28/2018	Drill Rig: Mini-track	Logged by: JPG	



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

TESTING KEY

GSA = Grain Size Analysis

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Consol. = Consolidation Test

Att. = Atterberg Limits

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit — Natural Water Content — Liquid Limit

Dawn Drive Landslide
Dawn Drive & SE 46th Street
Mercer Island, Washington

Date: April 2018 Project No.: 1961.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-2

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 Inches	**B-2**
Top Elevation: NA	Drilling Method: Hollow Stem Auger	Hammer Type: Cathead	
Date Drilled: 3/28/2018	Drill Rig: Mini-track	Logged by: JPG	

Depth (ft)	SOIL DESCRIPTION	Sample Number	SAMPLES Recovery	Ground Water	PENETRATION RESISTANCE (blows/foot)	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.				▲ Standard Penetration Test △ Hammer Weight and Drop:		
25		S-8	18"			79	
30	Very dense, moist, gray, SAND, trace to some silt and gravel (Glacial Outwash)	S-9	18"			46	
35	Very dense, moist, gray, SAND, with silt and gravel (Glacial Till)	S-10	6"			50/6"	
	Boring terminated at about 35.5 feet. No groundwater observed at time of drilling.						
40							
45							
50							

PENETRATION RESISTANCE scale: 0, 20, 40, 60

SAMPLE LEGEND
- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND
- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ⊢—○—⊣ Liquid Limit

Natural Water Content

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

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Dawn Drive Landslide
Dawn Drive & SE 46th Street
Mercer Island, Washington

Date: April 2018 Project No.: 1961.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-2

Boring Location: See Figure 1, Site and Exploration Plan		Drilling Company: Geologic Drill	Bore Hole Dia.: 6 Inches	**B-3**
Top Elevation: NA		Drilling Method: Hollow Stem Auger	Hammer Type: Cathead	
Date Drilled: 3/28/2018		Drill Rig: Mini-track	Logged by: JPG	

Depth (ft)	SOIL DESCRIPTION	Sample Number	SAMPLES Recovery (in)	Ground Water	PENETRATION RESISTANCE (blows/foot)	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.				▲ Standard Penetration Test △ Hammer Weight and Drop: ____ 0 20 40 60		
0	Very loose, moist to wet, mottled gray-brown, silty SAND to sandy SILT, trace to some gravel, moderate iron oxide staining (Colluvium)	S-1	16"			4	
5	Very loose, wet, gray, silty SAND, trace to some gravel, disturbed blocky texture (Colluvium)	S-2	18"			7	
	Loose, wet, mottled gray-brown, silty SAND to sandy SILT, trace to some gravel, moderate iron oxide staining (Colluvium)	S-3	18"	ATD		17	
10	Very stiff, wet to saturated, tan, finely laminated SILT, trace to some fine sand (Older Sand)	S-4	18"			24	
	Medium dense grading to very dense, moist, gray, silty SAND, some gravel (Glacial Till)	S-5	18"			58	
15	Boring terminated at about14 feet. Slight perched groundwater observed at about 9 feet at time of drilling.						
20							
25							

SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

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Plastic Limit ⊢—○—⊣ Liquid Limit

Natural Water Content

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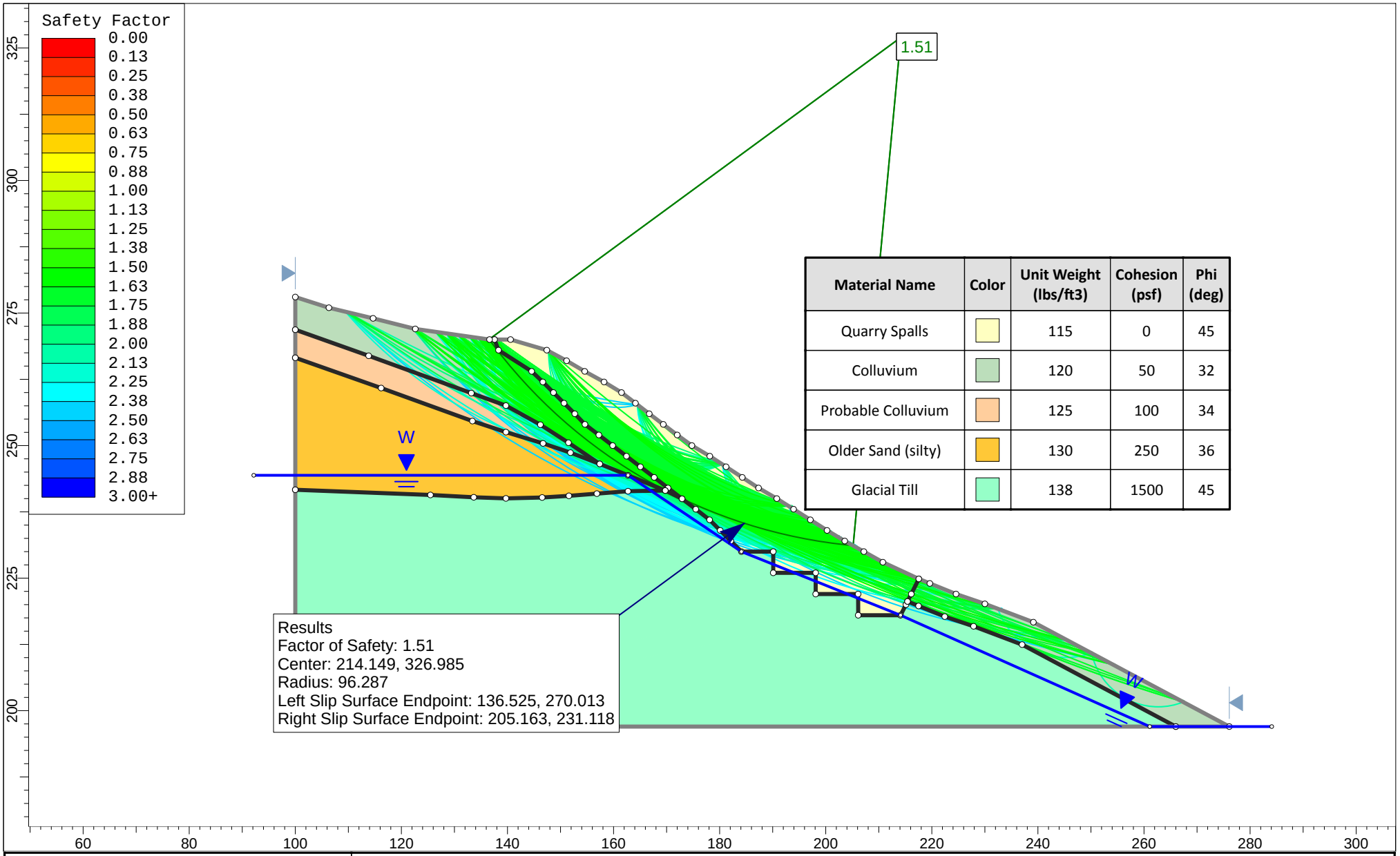
Dawn Drive & SE 46th Street
Mercer Island, Washington

Date: April 2018 Project No.: 1961.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

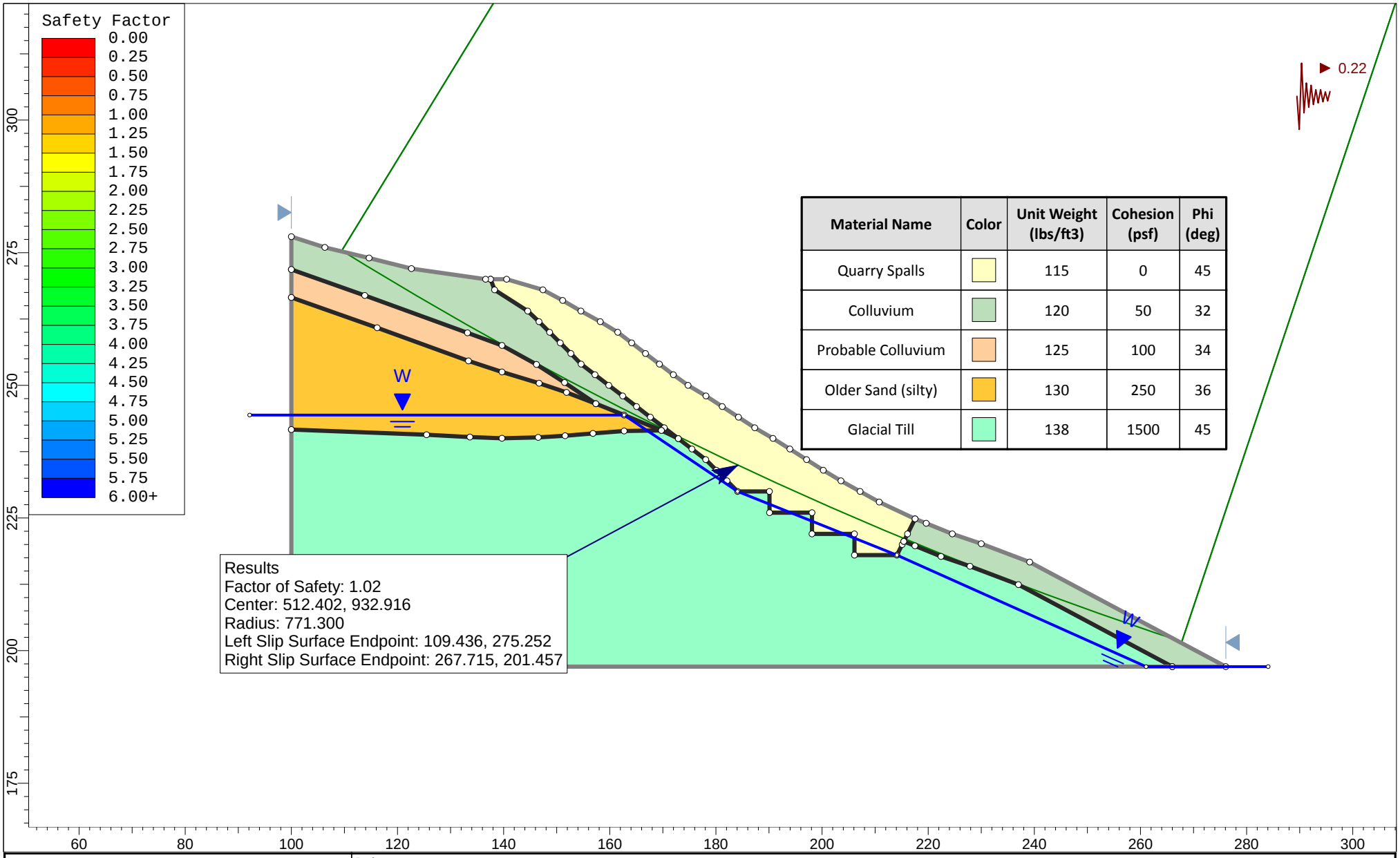
BORING LOG: B-3



ZipperGeo
Geoprofessional Consultants

SLIDEINTERPRET 6.039

Project	Dawn Drive Landslide Stabilization			
Analysis Description	Static Conditions			
Drawn By	RAR	Scale	1:300	Company ZGA
Date	4/27/2018, 11:57:44 AM			File Name SLIDE RAR.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Quarry Spalls		115	0	45
Colluvium		120	50	32
Probable Colluvium		125	100	34
Older Sand (silty)		130	250	36
Glacial Till		138	1500	45

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Geoprofessional Consultants

SLIDEINTERPRET 6.039

Project	Dawn Drive Landslide Stabilization		
Analysis Description	Seismic Yield Acceleration Determination		
Drawn By	RAR	Scale 1:300	Company ZGA
Date	4/27/2018, 11:57:44 AM		File Name SLIDE RAR.slim