MBGS
Mud Bay Geotechnical Services, LLC
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October 12, 2020 Job: 1328-KIT

Subject: 9781 Enchantment Ave NW,
Silverdale, Washington 98383
Foundation Settlement Geotechnical Report
Parcel #5201-000-032-0008

Dear Toby Weston,

This report presents the results of our geotechnical investigation and contains geotechnical recommendations for mitigation of the foundation settlement at the address of 9781 Enchantment Ave NW, Silverdale, Washington. The analyses, conclusions, and recommendations in this report are based on the information available. These informational resources include: two hand augured borings, published geologic information for the site, and our experience with similar soil conditions. The exploratory borings are assumed to be representative of the subsurface conditions where the work will occur. If during construction, subsurface conditions differ from those described in the explorations, we should be advised immediately so we may reevaluate our recommendations.

**Site Conditions and Project Description**

The parcel #5201-000-032-0008 consists of a total of 0.22 acres in Silverdale, WA. The parcel boundaries and site location are identified on the attachment included as Figure 1. The property is located to the northwest of the intersection of Enchantment Ave NW and NW Discovery Ridge Ct and accessed via a driveway extending westward from Enchantment Ave NW. The parcel slopes gently to the northwest with the grass yard on the south side of the home spanning an elevation difference of roughly 5 feet. A landscape-block retaining wall approximately 4 feet in height exists near the central, southern area of the parcel. This feature was seen to be in good condition at the time of exploration with no tilting, sloughing, or sliding noted.

The home structure is situated in the northeastern corner of the parcel with landscaped grasses surrounding the home to the south and west. The home itself is a two-story, single-family residence with a high-clearance crawl space stepped into the slope and accessed from the southwestern corner of the home. The crawl space is underlain by native glacial sediments with no poured concrete. Most of the eastern portion of the soils have been covered by plastic sheeting

as a moisture barrier for the stored possessions in the space. The soils underneath the sheeting were noted to be moist to wet with seepage emerging from the foundation footing in several spots along the southern and eastern walls. Additionally, the soils in the crawl space subgrade exhibited signs of erosion where active seepage occurs and where the footings and soils are stepped into the slope with a vertical elevation of approximately 12-inches. A small circular depression roughly 12-inches in diameter was noted in the center of the crawl space though the placement of sheeting and landscaping blocks over the depression made further investigation of the feature difficult. The wooden joists and posts in the crawl space were seen to be in good condition with no rot or major fracturing noted.

Based on conversations with the client and TerraFirma Foundation Systems, it is our understanding that the home's foundation is experiencing foundation and fracturing, predominantly along the south and southeastern edges of the crawlspace. To address the settlement issues, TerraFirma has proposed the installation of 8 push piers along the areas of concern. The piers will be installed from the interior of the crawl space with placement of the piers being two-feet off corners and spaced every six-feet.

## Site Geology and Soils

As part of this project, we reviewed available geologic data and prepared a site-specific geologic map, attached as Figure 2, WA DNR Geologic map. This figure indicates the project vicinity consists of Holocene artificial fill and modified land, Pleistocene continental glacial till, and Pleistocene glacial and nonglacial deposits. The project site is directly underlain by Pleistocene continental glacial drift. Glacial drift deposits can exhibit poor drainage characteristics, making appropriate drainage a priority on the parcel. Conditions observed at the site are generally consistent with the mapped geology at the site.

In addition to the geologic map, a site-specific soils map was created using data made available by the United States Department of Agriculture (USDA). The prepared figure is attached to this report as Figure 3, USDA Soil Map. This figure indicates that the site is directly underlain by *Alderwood gravelly sandy loam, 15 to 30 percent slopes*. The Alderwood soil series is characterized as glacial drift and/or outwash deposits overlying dense glaciomarine deposits. The estimated depth to water table is 18 to 37 inches below ground surface, likely in the form of perched aquifers and water-bearing layers. It should be noted that the slope percentages mapped by the USDA are estimates and are subject to verification.

## Subsurface Exploration

As part of the geotechnical investigation, two shallow hand augured borings were performed at the approximate locations shown on Figure 4. The borings were completed using a Humboldt Manufacturing model H-4414QC hand auger with a 4-inch diameter bucket tube sampler. In situ testing was performed at selected depths using a Humboldt Manufacturing model H-4202A dynamic cone penetrometer to estimate the density ofthe soil. The dynamic cone penetrometer uses a 15-lb steel mass falling a height of 20-inchesonto an anvil to penetrate a 1.5-inch diameter 45-degree cone tip seated into the bottom of the hole.

The number of blows is recorded to achieve a total of ¾ inches of penetration into the soil. This recorded blow count is correlated to the Standard Penetration Test (SPT) field N-value blow count

determined in accordance with ASTM D1586, which is the standard in situ test method for determining relative density of cohesionless soils and the consistency of cohesive soils. Hand auger samples were removed from the bottom of the holes after the dynamic cone penetration testing was performed in order to observe the soil material at the approximate depth the test was performed.

The soil samples were classified visually in the field in general accordance with ASTM D2488, The Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Once transported back to the office, the samples were re-examined, and the field classifications were modified accordingly. Summary logs of the borings are included in Appendix A. Note the soil descriptions and interfaces shown on the log are interpretive, and actual changes may be gradual. Upon completion, the holes were backfilled to the original ground surface using excavated material from the spoil piles.

**Subsurface Soil Conditions**

Based on the soils encountered in BH-1-20, the front yard of the home consists of an upper 6-inches of topsoil underlain by *medium dense, moist, grayish-brown, well-graded gravel with silt and sand (GW-GM)* to a depth of 29-inches. From 29 to 39-inches, a layer of *moist, gray-blue silt with heavy mottling (ML)* was noted, indicating interaction with groundwater. Immediately underlying this unit was a layer of *dense, wet, tan, well-graded gravel with silt and sand (GW-GM)* to the final depth of boring at 48-inches. A large cobble obstruction impeded further digging. Groundwater seepage was noted at a depth of 39-inches at the contact between the fine-grained ML unit and coarser GW-GM layer.

BH-2-20 was performed off the southwestern corner of the home, where less foundation settlement has occurred. The findings in this boring reveal that the subsurface consists of an upper 4-inches of topsoil underlain by *loose, moist, tan, well-graded sand with silt and gravel (SW-SM)* to a depth of 42-inches and *very dense, moist, brown, concreted sandy silt (ML)* to the final depth of boring at 48-inches.

Given the elevation of the borings in relation to one another, the borings are considered to show a nearly continuous stratigraphy of the site. In terms of foundation settlement, it is our interpretation that the southeastern portion of the home is undergoing settlement resulting from the presence of soft upper soils and perched water-bearing units. This is supported by the fact that the crawl space and foundation footings along the west side of the home are at elevations very near the hardpan sandy silt layer. Hardpan soils were noted to be occupying the subgrade of the crawl space and are believed to be the reason why the differential settlement is mostly focused on the upslope side of the home. Our interpretation of the site is that the foundation footings are not supported by these very dense glacial soils along the eastern side of the home but are stepped down onto them along the western side.

**Surface Water and Groundwater Conditions**

No major surface water bodies or wetland areas were noted upslope of the project site. However, a local stream exists downslope to the west and north of the home. As such, any stormwater sourced from the upland portion of the regional drainage basin likely flows through the site in the

form of surface runoff or perched aquifers. Any water on-site is likely to continue northwestward to the stream channel which terminates in the Dyes Inlet of the Puget Sound.

Groundwater was seen to seep from the sidewall in boring BH-1-20 at a depth of 39-inches below ground surface, though no water was seen in BH-2-20. As such, this groundwater is interpreted to be a perched aquifer that flows through the coarse GW-GM unit. The groundwater was not observed in BH-2-20, likely due to the finer-grained and hardpan soils observed in the backyard area. If this is the case, it may explain the presence of water seeping into the crawl space along the southeastern and eastern portions of the foundation as well as the settlement seen in the paved walkway along the eastern side of the home.

As a part of this project, nearby well logs made available from the Washington State Department of Ecology were reviewed in an effort to estimate the depth to the water table. Using this data, it is estimated that static groundwater levels in the region can vary from depths of 40 feet to 180 feet below ground surface. The water bearing layers are often seen to be coarse sand and gravel deposits capped by hardpan or clayey soils. The shallow water bearing units (<80 feet) are typically underlain by less porous soils and seen as seepage rather than static groundwater.

**Landslide Hazard Assessment**

Along with the site geology, the landslide hazard mapping inventory available from the Washington State Department of Natural Resources was reviewed to assess potential landslide hazards at the site and surrounding vicinity. The Landslide Map revealed no mapped landslides or hazard risks on-site with the nearest landslide mapped at the 1:24,000 scale positioned over 0.5 miles to the east of the project area. This figure is attached to the report as Figure 5, WA DNR Landslide Map.

The geomorphology (shape of the land) was analyzed during the site evaluation and compared to the Light Detection and Ranging images (LiDAR) from the Washington State LiDAR portal. LiDAR is a remote sensing method were light is pulsed down to the surface of the Earth and back to a sensor. This methodology enables bare earth images of the surface to be analyzed for the presence of geologic landforms. The most recent available LiDAR imagery of this site is from 2018 and is included as Figure 6 attached to this report. The data reveals no landforms indicating historic landslides on the parcel. The area surrounding the site has been modified by construction related to residential development. The topography of the region illustrates this development with the only geologic feature to note being the stream channel located to the north and west of the subject site.

Using the LiDAR data from the WA-DNR, a map showing the site's topography and slope percentages was created using Quantum Geographic Information System software (QGIS). This figure was created using the imagery dated from 2018 and is included to the report as Figure 7. The slope map indicates that the front and rear yards of the home, eastern and western margins of the parcel, contain slopes on the order of 5 to 15 percent with the slopes near the center of the parcel recorded as 15 to 30 percent. A limited portion of the parcel near the southern, central area contains slopes of 40 to 55 percent though this is location where the 4-foot landscape block retaining wall is located. It should be noted that given the topography to the east and southeast of the home, stormwater and subsurface water is anticipated to flow perpendicular to the topographic contours downward toward the subject site.

## Geotechnical Recommendations

We understand that push piers are the preferred foundation alternative to stabilize the existing foundations and reduce the potential for further settlement to occur. All push piers should meet the design and installation specifications in the Push Pier Technical Manual, Third Edition, dated June 20, 2018 including all supporting documentation included with the manual.

BH-1-20 and BH-2-20 were used to interpret the subsurface conditions. Based on the conditions observed in the borings, we recommend installing the push piers to a minimum depth of 7 feet below the current ground surface, or to a pressure of 2,400 psi, whichever is deeper. Load testing should be performed to 2.0 times the design load on a minimum of 1 push pier in accordance with ASTM Standard D1143-81.

The new foundations and other work performed as part of the project may require new backfill be placed to get the final ground surface back up to the current grade. We recommend all backfill be placed in horizontal layers no more than 6 inches thick with each layer compacted to 95 percent of the maximum dry density. The backfill material should be comprised of Common Borrow as defined in Section 9-03.143) of the WSDOT Standard Specifications. Based on the subsurface conditions observed in the explorations, the material likely to be excavated to perform the work meets the requirements for Common Borrow and may be reused as backfill of foundations.

If the perimeter footing drain is disturbed as part of the construction, then it should be reconnected to preserve the continuity of the drainage. We recommend that the perimeter footing drain consist of a 4-inch diameter, perforated or slotted, rigid plastic pipe placed at the base of the structure excavations wherever existing footings are exposed as part of the work. The perimeter drain should be connected at both ends to the existing drain, if one is present. The drain should be embedded in a clean, free-draining sand and gravel meeting the requirements of Section 9-03.12(4) of the WSDOT Standard Specifications for Gravel Backfill for Drains.

## Recommended Additional Services

Before construction begins, we recommend a copy of the draft plans and specifications prepared for the project are made available for review so that we can ensure that the geotechnical recommendations in this report are included in the Contract. Mud Bay Geotechnical Services, LLC is also available to provide geotechnical engineering and construction monitoring services throughout the remainder of the design and construction of the project. The integrity of the geotechnical elements of a project depend on proper site preparation and construction procedures. In addition, engineering decisions may need to be made in the field if conditions are encountered that differ from those described in this report. During the construction phase of the project, we recommend that Mud Bay Geotechnical Services, LLC be retained to review construction proposals and submittals, observe installation and load testing of push piers, and provide recommendations for any other geotechnical considerations that may arise during construction.

**Intended Use and Limitations**

This report has been prepared to assist the client and their consultants in the engineering design and construction of the subject project. It should not be used, in part or in whole for other purposes without contacting Mud Bay Geotechnical Services, LLC for a review of the applicability of such reuse. This report should be made available to prospective contractors for their information only and not as a warranty of ground conditions.

The conclusions and recommendations contained in this report are based on Mud Bay Geotechnical Services, LLC understanding of the project at the time that the report was written and on-site conditions that existed at time of the field exploration. If significant changes to the nature, configuration, or scope of the project occur during the design process, we should be consulted to determine the impact of such changes on the recommendations and conclusions presented in this report.

Site exploration and testing describes subsurface conditions only at the sites of subsurface exploration and at the intervals where samples are collected. These data are interpreted by Mud Bay Geotechnical Services, LLC rendering an opinion regarding the general subsurface conditions. Actual subsurface conditions can be discovered only during earthwork and construction operations. The distribution, continuity, thickness, and characteristics of identified (and unidentified) subsurface materials may vary considerably from that indicated by the subsurface data. While nothing can be done to prevent such variability, Mud Bay Geotechnical Services, LLC is prepared to work with the project team to reduce the impacts of variability on project design, construction, and performance.

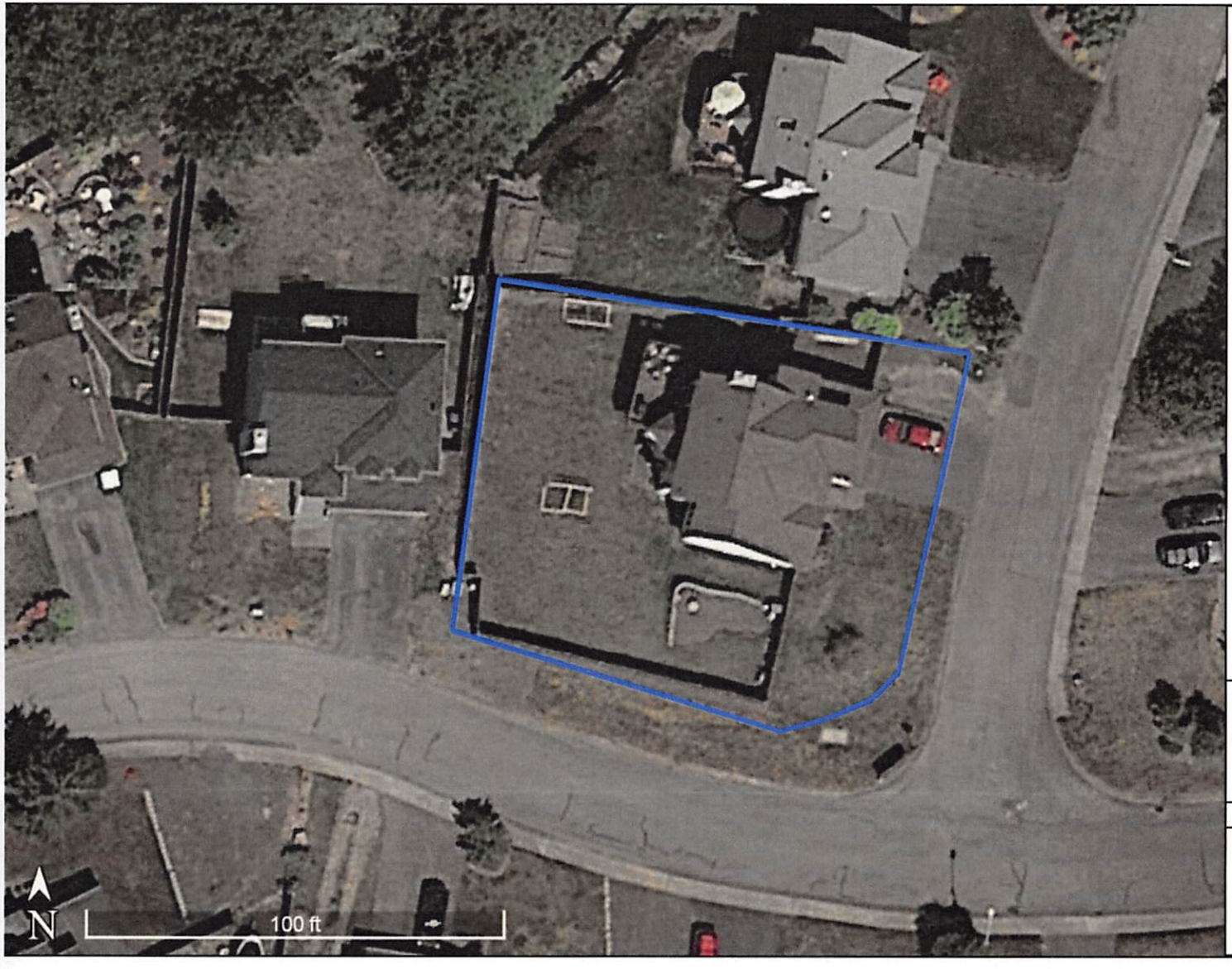
We appreciate the opportunity to serve your geotechnical needs on this project and look forward to working with you in the future. Please contact us at your earliest convenience if you have any questions or would like to discuss any of the contents of this report.

Sincerely,

Chris Heathman, P.E.
Mud Bay Geotechnical Services, LLC


Digitally signed by Chris Heathman
Date: 2020.10.12 22:48:04 -07'00'

**Permit Number: 20-02834**





**Legend**

- Site Location
- Parcel Boundary

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| JOB #:1328-KIT | Date: Sept., 2020 |
|---|---|

**Figure 1: Site Map**
9781 Enchantment Ave NW,
Silverdale, WA 98383
Foundation Repair Geotechnical Report


WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND EARTH RESOURCES

## Legend

Parcel Boundary

Geologic Units 24k

- Holocene artificial fill and modified land
- Pleistocene continental glacial drift
- Pleistocene continental glacial till
- Pleistocene glacial and nonglacial deposits

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| JOB #:1328-KIT | Date: Sept., 2020 |
|---|---|

**Figure 2: WA DNR Geologic Map**
9781 Enchantment Ave NW,
Silverdale, WA 98383
Foundation Repair Geotechnical Report

**Permit Number: 20-02834**

Soil Map—Kitsap County Area, Washington


Map Scale: 1:2,440 if printed on A landscape (11" x 8.5") sheet.
Meters: 0, 35, 70, 140, 210
Feet: 0, 100, 200, 400, 800
Map projection: Web Mercator Corner coordinates: WGS84

USDA **Natural Resources Conservation Service**

## Legend

Parcel Boundary

| Map Unit Symbol | Map Unit Name |
|---|---|
| 2 | Alderwood gravelly sandy loam, 8 to 15 percent slopes |
| 3 | Alderwood gravelly sandy loam, 15 to 30 percent slopes |

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JOB #:1328-KIT | Date: Sept., 2020

**Figure 3: USDA Soil Map**
9781 Enchantment Ave NW,
Silverdale, WA 98383
Foundation Repair Geotechnical Report

**Permit Number: 20-02834**


## Legend

Parcel Boundary

Boring Location

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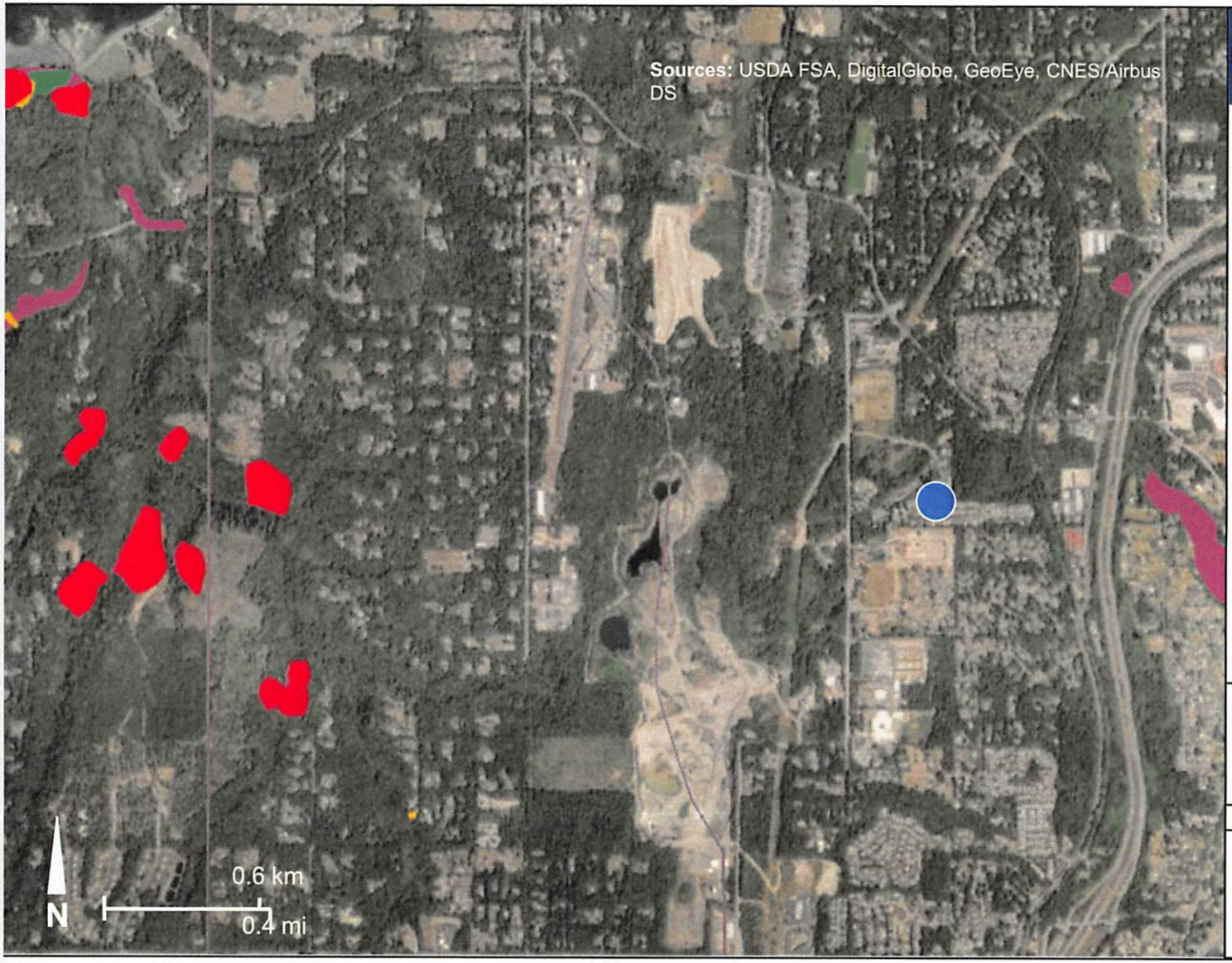
| JOB #:1328-KIT | Date: Sept., 2020 |
|---|---|

**Figure 4: Site Exploration Map**
9781 Enchantment Ave NW,
Silverdale, WA 98383
Foundation Repair Geotechnical Report




WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES
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## Legend

- Site Location
- 1:24,000-scale and Watershed Analysis Study Extents
- Salish Sea Landforms
- Watershed Analysis Landslides
- 1:100,000-scale Landslides from Geologic Mapping
- 1:24,000-scale Landslides from Geologic Mapping

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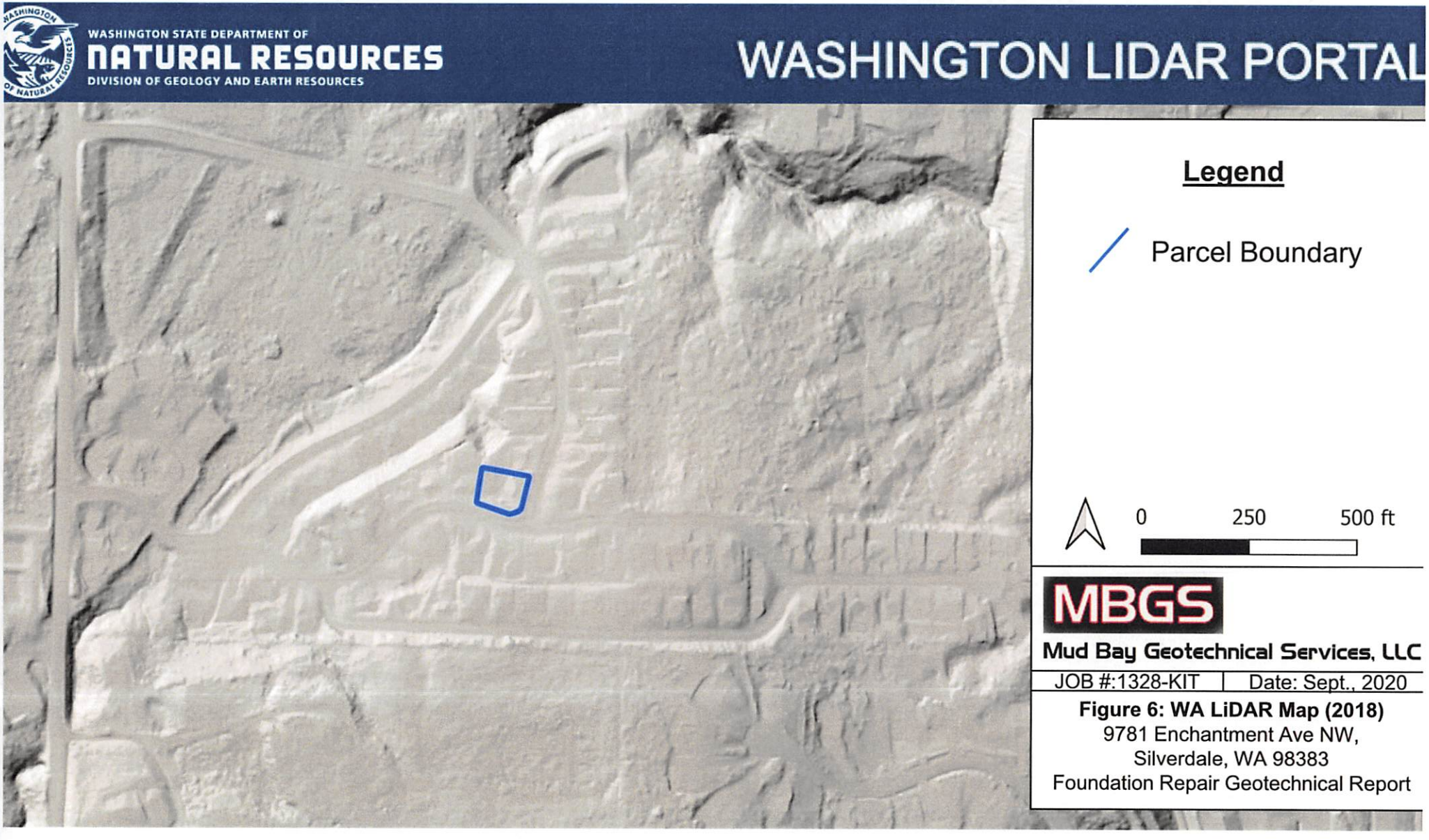
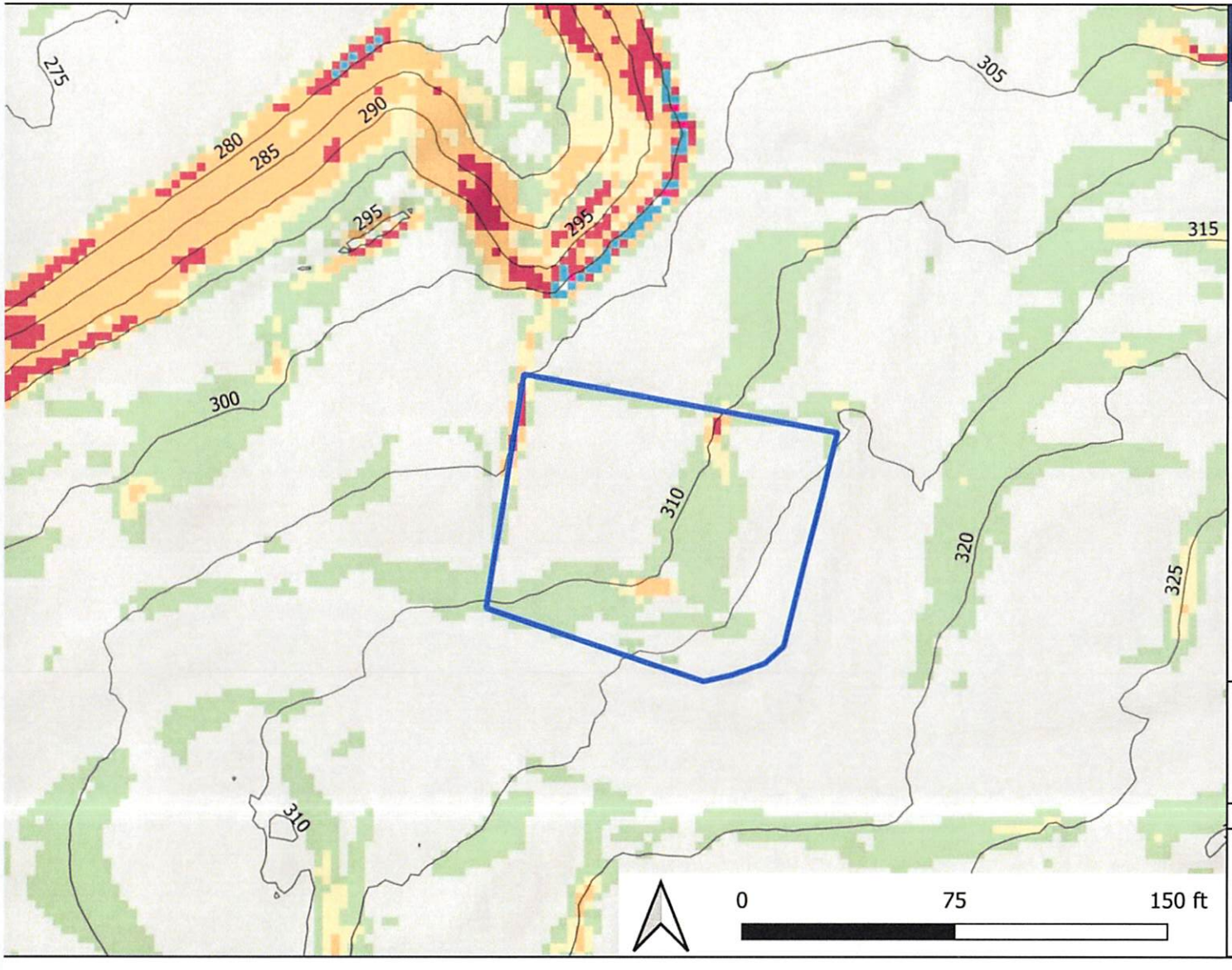
**Mud Bay Geotechnical Services, LLC**

| JOB #:1328-KIT | Date: Sept., 2020 |
|---|---|

**Figure 5: WA DNR Landslide Map**
9781 Enchantment Ave NW,
Silverdale, WA 98383
Foundation Repair Geotechnical Report



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## Legend

Parcel Boundary

5' Contour Lines

Slope

- 5-15%
- 15-30%
- 30-40%
- 40-55%
- 55-70%
- 70-85%
- 85-100%
- >100%

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| JOB #:1328-KIT | Date: Sept., 2020 |
|---|---|

**Figure 7: QGIS Slope Map (2018)**
9781 Enchantment Ave NW,
Silverdale, WA 98383
Foundation Repair Geotechnical Report

**Permit Number: 20-02834**

# APPENDIX A – FINAL BORING LOGS

| MBGS Mud Bay Geotechnical Services, LLC | Project: Foundation Repair | Client: Toby Weston | Bore No. 1 of 2: BH-1-20 |
|---|---|---|---|
| | Project Number: 1328-KIT | Contractor: TerraFirma Foundation Systems | Equipment: Humboldt H-4414QC Auger |
| Address: 9781 Enchantment Ave NW, Silverdale WA, 98383 | Date Started: 9/24/2020 | Bit Type: Bucket Tube Auger | Diameter: 4 inches |
| | Date Completed: 9/24/2020 | Hammer Type: Humboldt H-4202A | Fluid: n/a |
| Logged By: Alex Yannello | Date Backfilled: 9/24/2020 | Hammer Weight: 15 lbs | Hammer Drop: 20 inches |
| Helper: Hannah Anderson | Groundwater Depth: 39 inches | Elevation: Existing Surface | Total Depth of Boring: 46 inches |
| GPS Method: n/a | GPS Coordinates: n/a | | GPS Elevation: n/a |

| Depth (in.) | Sample Type | Sample Number | Blow Counts (blows/3/4") | Graphic Log | Lithology<br>**Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors<br>**Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions. | Dry Density (pcf) | Moisture Content (%) | Additional Test |
|---|---|---|---|---|---|---|---|---|
| | | | | | Topsoil. | | | |
| 24" | ☒ | S-1 | 14 | | Medium dense, moist, grayish-brown, well-graded gravel with silt and sand (GW-GM). | | | |
| | ▽ | | | | Moist, gray-blue silt (ML) with heavy mottling. Gravel clasts decreasing in size. | | | |
| 48" | ☒ | S-2 | 34 | | Dense, wet, tan, well-graded gravel with silt and sand (GW-GM). DCP bouncing and deflecting for final 3/4" increment - likely on cobble obstruction. | | | |

## Test Pit and Boring Log Symbols

- Standard Penetration Slit Spoon Sampler (SPT)
- California Sampler
- Shelby Tube
- CPP Sampler
- Stabllized Ground water
- Groundwater At time of Drilling
- Bulk/ Bag Sample

## Soil Density Modifiers

| Gravel, Sand, Non-Plastic Silt | | Elastic Silts and Clays | |
|---|---|---|---|
| Blows/3/4" | Density | Blows/3/4" | Consistency |
| 0-4 | Very Loose | 0-1 | Very Soft |
| 5-10 | Loose | 2-4 | Soft |
| 11-24 | Medium Dense | 5-8 | Medium Stiff |
| 25-50 | Dense | 9-15 | Stiff |
| REF | Very Dense | 16-30 | Very Stiff |
| | | 31-60 | Hard |
| | | >60 | Very Hard |

**Permit Number: 20-02834**

| MBGS Mud Bay Geotechnical Services, LLC | Project: Foundation Repair | Client: Toby Weston | Bore No. 2 of 2: BH-2-20 |
|---|---|---|---|
| | Project Number: 1328-KIT | Contractor: TerraFirma Foundation Systems | Equipment: Humboldt H-4414QC Auger |
| Address: 9781 Enchantment Ave NW, Silverdale WA, 98383 | Date — Started: 9/24/2020 | Bit Type: Bucket Tube Auger | Diameter: 4 inches |
| | Date — Completed: 9/24/2020 | Hammer Type: Humboldt H-4202A | Fluid: n/a |
| Logged By: Alex Yannello | Date — Backfilled: 9/24/2020 | Hammer Weight: 15 lbs | Hammer Drop: 20 inches |
| Helper: Hannah Anderson | Groundwater Depth: Not Encountered | Elevation: Existing Surface | Total Depth of Boring: 48 inches |
| GPS Method: n/a | GPS Coordinates: n/a | | GPS Elevation: n/a |

| Depth (in.) | Sample Type | Sample Number | Blow Counts (blows/3/4") | Graphic Log | Lithology<br>**Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors<br>**Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions. | Dry Density (pcf) | Moisture Content (%) | Additional Test |
|---|---|---|---|---|---|---|---|---|
| | | | | | Topsoil. | | | |
| 24" | ☒ | S-1 | 9 | | Loose, moist, tan, well-graded sand with silt and gravel (SW-SM). | | | |
| 48" | ☒ | S-2 | REF | | Very dense, moist, brown, concreted sandy silt (ML). Refusal criteria met with 1/2" embedment of DCP. | | | |

## Test Pit and Boring Log Symbols

- Standard Penetration Slit Spoon Sampler (SPT)
- California Sampler
- Shelby Tube
- CPP Sampler
- Stabllized Ground water
- Groundwater At time of Drilling
- Bulk/ Bag Sample

## Soil Density Modifiers

| Gravel, Sand, Non-Plastic Silt | | Elastic Silts and Clays | |
|---|---|---|---|
| Blows/3/4" | Density | Blows/3/4" | Consistency |
| 0-4 | Very Loose | 0-1 | Very Soft |
| 5-10 | Loose | 2-4 | Soft |
| 11-24 | Medium Dense | 5-8 | Medium Stiff |
| 25-50 | Dense | 9-15 | Stiff |
| REF | Very Dense | 16-30 | Very Stiff |
| | | 31-60 | Hard |
| | | >60 | Very Hard |

**Permit Number: 20-02834**