



**Geotechnical Investigation and Geologic Hazard Assessment**

**Proposed Reed Road Residential Subdivision Site**

**Tax Lot No's. 100, 200, 400, 601, 1600 and 1700**

**Reed Road SE and Battle Creek Road SE**

**Salem (Marion County), Oregon**

**for**

**Multi/Tech Engineering Services, Inc.**

**Project No. 1001.058.G  
July 20, 2018**

July 20, 2018

Mr. Jeremy Grenz  
Multi/Tech Engineering Services, Inc.  
1155 13th Street SE  
Salem, Oregon 97302

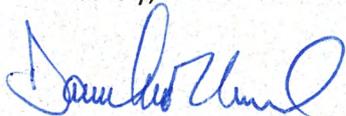
Dear Mr. Grenz:

**Re: Geotechnical Investigation and Geologic Hazard Assessment, Proposed Reed Road Residential Subdivision Site, Tax Lot No's. 100, 200, 400, 601, 1600 and 1700, Reed Road SE and Battle Creek Road SE, Salem (Marion County), Oregon**

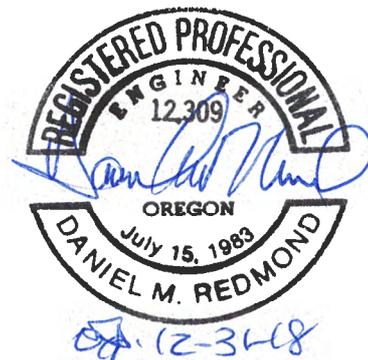
Submitted herewith is our report entitled "Geotechnical Investigation and Geologic Hazard Assessment, Proposed Reed Road Residential Subdivision Site, Tax Lot No's. 100, 200, 400, 601, 1600 and 1700, Reed Road SE and Battle Creek Road SE, Salem (Marion County), Oregon". The scope of our services was outlined in our formal proposal to Mr. Jeremy Grenz of Multi/Tech Engineering Services, Inc. dated February 12, 2018. Written authorization of our services was provided by Mr. Mark Grenz through a formal purchase order #6234 on April 30, 2018.

During the course of our investigation, we have kept you and/or others advised of our schedule and preliminary findings. We appreciate the opportunity to assist you with this phase of the project. Should you have any questions regarding this report, please do not hesitate to call.

Sincerely,



Daniel M. Redmond, P.E., G.E.  
President/Principal Engineer



# TABLE OF CONTENTS

|                                   | Page No. |
|-----------------------------------|----------|
| INTRODUCTION                      | 1        |
| PROJECT DESCRIPTION               | 1        |
| SCOPE OF WORK                     | 2        |
| SITE CONDITIONS                   | 3        |
| Site Geology                      | 3        |
| Surface Conditions                | 3        |
| Subsurface Soil Conditions        | 4        |
| Groundwater                       | 4        |
| INFILTRATION TESTING              | 5        |
| LABORATORY TESTING                | 5        |
| SEISMICITY AND EARTHQUAKE SOURCES | 5        |
| Liquefaction                      | 6        |
| Landslides                        | 7        |
| Surface Rupture                   | 7        |
| Tsunami and Seiche                | 7        |
| Flooding and Erosion              | 7        |
| CONCLUSIONS AND RECOMMENDATIONS   | 8        |
| General                           | 8        |
| Site Preparation                  | 8        |
| Foundation Support                | 10       |
| Shallow Foundations               | 10       |
| Floor Slab Support                | 11       |

## Table of Contents (continued)

|  |    |
|--|----|
| Retaining/Below Grade Walls                                  | 11 |
| Pavements  | 12 |
| Local Residential Streets                                    | 13 |
| Wet Weather Grading and Soft Spot Mitigation                 | 13 |
| Shrink-Swell and Frost Heave                                 | 14 |
| Excavations/Slopes   | 14 |
| Surface Drainage/Groundwater                                 | 15 |
| Design Infiltration Rates                                    | 15 |
| Seismic Design Considerations                                | 16 |
| CONSTRUCTION MONITORING AND TESTING                          | 16 |
| CLOSURE AND LIMITATIONS                                      | 17 |
| LEVEL OF CARE  | 17 |
| REFERENCES   | 18 |
| ATTACHMENTS  |    |
| Figure No. 1 - Site Vicinity Map                             |    |
| Figure No. 2 - Site Exploration Plan                         |    |
| Figure No. 3 - Typical Fill Slope Detail                     |    |
| Figure No. 4 - Perimeter Footing/Retaining Wall Drain Detail |    |
| APPENDIX A   |    |
| Test Pit Logs and Laboratory Data                            |    |
| APPENDIX B   |    |
| Geologic Hazard Study  |    |

**GEOTECHNICAL INVESTIGATION AND GEOLOGIC HAZARD ASSESSMENT  
PROPOSED REED ROAD RESIDENTIAL DEVELOPMENT SITE  
TAX LOT NO'S. 100, 200, 400, 601, 1600 AND 1700  
REED ROAD SE AND BATTLE CREEK ROAD SE  
SALEM (MARION COUNTY) OREGON**

**INTRODUCTION**

Redmond Geotechnical Services, LLC is please to submit to you the results of our Geotechnical Investigation and Geologic Hazard Assessment at the site of the proposed new residential development located to the east of the intersection of Reed Road SE and Battle Creek Road SE in Salem (Marion County), Oregon. The general location of the subject site is shown on the Site Vicinity Map, Figure No. 1. The purpose of our geotechnical investigation and geologic hazard study services at this time was to explore the existing subsurface soils and/or groundwater conditions across the subject site and to evaluate any potential concerns with regard to potential slope failure at the site as well as to develop and/or provide appropriate geotechnical design and construction recommendations for the proposed new residential development project.

**PROJECT DESCRIPTION**

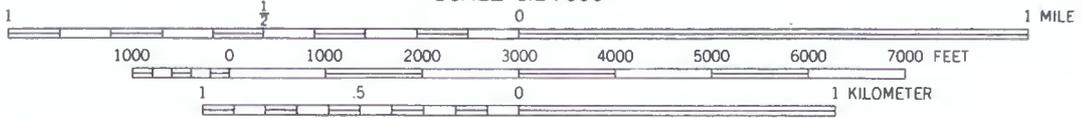
We understand that present plans are to develop the subject property into new single-family residential lots. Based on a review of a proposed site development plan prepared by Multi/Tech Engineering Services, Inc., we understand that the proposed new residential development will consist of the construction of approximately two hundred and twenty (220) new single-family residential lots ranging in size from about 5,000 to 10,000 square feet (see Site Exploration Plan, Figure No. 2). The new residential homes are anticipated to be of one- and/or three-story structures constructed with wood framing. Support of the new residential structures is anticipated to consist primarily of conventional shallow strip (continuous) footings although some individual (column) footings may also be required. Structural loading information, although unavailable at this time, is anticipated to be fairly typical and light for this type of wood-frame single-family residential structure and is expected to result in maximum dead plus live continuous (strip) and individual (column) footing loads on the order of about 1.5 to 3.0 kips per lineal foot (klf) and 10 to 30 kips, respectively.

Although a site grading plan is not available at this time, we understand that both cuts and fills are presently planned for the residential project. In general, both cuts and/or fills of between five (5) to ten (10) feet are generally anticipated across the proposed residential lots and will generally be located along the lot perimeters and/or site boundaries. In this regard, due to the existing and/or finish grade sloping site conditions, some of the proposed new single-family residential structures and/or lots may also include the construction of a partial below grade floor(s) and/or retaining walls.



SALEM WEST QUADRANGLE  
 OREGON  
 7.5 MINUTE SERIES (TOPOGRAPHIC)

SCALE 1:24 000



CONTOUR INTERVAL 10 FEET  
 DOTTED LINES CROSSING RIVER REPRESENT 5 FOOT CONTOURS  
 NATIONAL GEODETIC VERTICAL DATUM OF 1929

**SITE VICINITY MAP**

**REED ROAD SUBDIVISION**

Project No. 1011.058.G

Figure No. 1

Other associated site improvements for the project will include construction of new public and/or local residential streets. Additionally, the project will include the construction of new underground utility services as well as new concrete curbs and sidewalks. Further, we understand that storm water from hard and/or impervious surfaces (i.e., roofs and pavements) will be collected for on-site treatment and possible disposal.

### **SCOPE OF WORK**

The purpose of our geotechnical and/or geologic studies was to evaluate the overall subsurface soil and/or groundwater conditions underlying the subject site with regard to the proposed new residential development and construction at the site and any associated impacts or concerns with respect to potential slope failure at the site as well as provide appropriate geotechnical design and construction recommendations for the project. Specifically, our geotechnical investigation and landslide hazard study performed as a collaboration with Northwest Geological Services, Inc. (NWGS, Inc.) included the following scope of work items:

1. Review of available and relevant geologic and/or geotechnical investigation reports for the subject site and/or area.
2. A detailed field reconnaissance and subsurface exploration program of the soil and ground water conditions underlying the site by means of eleven (11) exploratory test pit excavations. The exploratory test pits were excavated to depths ranging from about four (4) to eight (8) feet beneath existing site grades at the approximate locations as shown on the Site Exploration Plan, Figure No. 2. Additionally, field infiltration testing was also performed within various test pits excavated across the subject site.
3. Laboratory testing to evaluate and identify pertinent physical and engineering properties of the subsurface soils encountered relative to the planned site development and construction at the site. The laboratory testing program included tests to help evaluate the natural (field) moisture content and dry density, maximum dry density and optimum moisture content, gradational characteristics, Atterberg Limits and (remolded) consolidation and direct shear strength tests as well as "R"-value tests.
4. A literature review and engineering evaluation and assessment of the regional seismicity to evaluate the potential ground motion hazard(s) at the subject site. The evaluation and assessment included a review of the regional earthquake history and sources such as potential seismic sources, maximum credible earthquakes, and reoccurrence intervals as well as a discussion of the possible ground response to the selected design earthquake(s), fault rupture, landsliding, liquefaction, and tsunami and seiche flooding.

5. Engineering analyses utilizing the field and laboratory data as a basis for furnishing recommendations for foundation support of the proposed new residential structures. Recommendations include maximum design allowable contact bearing pressure(s), depth of footing embedment, estimates of foundation settlement, lateral soil resistance, and foundation subgrade preparation. Additionally, construction and/or permanent subsurface water drainage considerations have also been prepared. Further, our report includes recommendations regarding site preparation, placement and compaction of structural fill materials, suitability of the on-site soils for use as structural fill, criteria for import fill materials, and preparation of foundation, pavement and/or floor slab subgrades.
  
6. Flexible pavement design and construction recommendations for the proposed new public street improvements.

## **SITE CONDITIONS**

### **Site Geology**

The subject site and/or area is underlain by highly weathered Basalt bedrock deposits and/or residual soils of the Columbia River Basalt formation. A more detailed description of the site geology across and/or beneath the site is presented in the Geologic Hazard Study in Appendix B.

### **Surface Conditions**

The subject proposed new residential development property consists of six (6) rectangular to irregular shaped tax lots (TL's 100, 200, 400, 601, 1600 and 1700) which encompass a total plan area of approximately 57 acres. The proposed residential development property is roughly located to the east of the intersection with Reed Road SE and Battle Creek Road SE, to the south by Kuebler Boulevard SE and to the northeast by Strong Road SE. The subject proposed residential development site is generally unimproved and consists of existing open farm land. Surface vegetation across the site generally consists of a light to moderate growth of grass, weeds and brush as well as some small to large sized trees along the northerly and westerly site boundaries. Additionally, the westerly portion of the subject property is generally low lying and contains an existing seasonal drainage basin.

Topographically, the site is characterized as gently to moderately sloping terrain (10 to 25 percent) descending downward towards the west and north with overall topographic relief estimated at about one hundred and sixty(160) feet and ranges from a low about Elevation 260 feet near Reed Road SE to a high of about Elevation 420 near the southeasterly portion of the site.

### **Subsurface Soil Conditions**

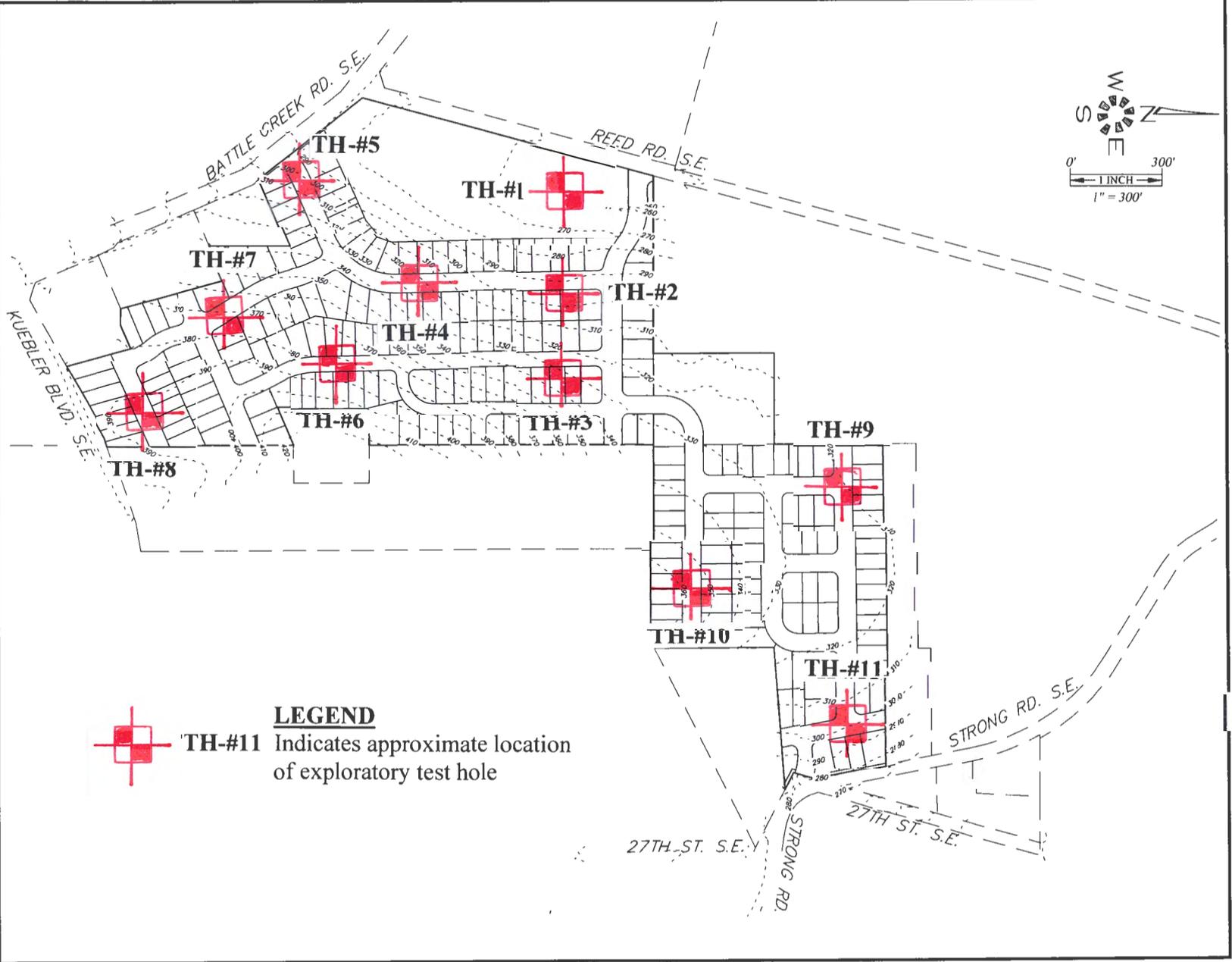
Our understanding of the subsurface soil conditions underlying the site was developed by means of eleven (11) exploratory test pits excavated to depths ranging from about four (4) to eight (8) feet beneath existing site grades on June 1, 2018 with a John Deere 200C track-mounted excavator. The location of the exploratory test pits were located in the field by marking off distances from existing and/or known site features and are shown in relation to the proposed new residential structures and/or site improvements on the Site Exploration Plan, Figure No. 2. Detailed logs of the test pit explorations, presenting conditions encountered at each location explored, are presented in the Appendix, Figure No's. A-5 through A-10.

The exploratory test pit excavations were observed by staff from Redmond Geotechnical Services, LLC who logged each of the test pit explorations and obtained representative samples of the subsurface soils encountered across the site. Additionally, the elevation of the exploratory test pit excavations were referenced from the proposed Site Development Plan prepared by Multi/Tech Engineering Services, Inc. and should be considered as approximate. All subsurface soils encountered at the site and/or within the exploratory test pit excavations were logged and classified in general conformance with the Unified Soil Classification System (USCS) which is outlined on Figure No. A-4.

The test pit explorations revealed that the subject site is underlain by native soil deposits comprised of highly weathered bedrock and/or residual soils composed of a surficial layer of dark brown, moist to very moist, soft, organic, sandy, clayey silt topsoil materials to depths of about 6 to 12 inches. These surficial topsoil materials were in turn underlain by medium to reddish-brown, moist to very moist, medium stiff, clayey, sandy silt to sandy, clayey silt to a depth of about two (2) to seven (7) feet beneath the existing site and/or surface grades. These upper clayey, sandy silt to sandy, clayey silt subgrade soils are best characterized by relatively low to moderate strength and moderate compressibility. These upper clayey, sandy silt to sandy, clayey silt subgrade soils were in turn underlain by gray-brown, damp, dense to very dense, slightly to highly weathered and fractured bedrock deposits the maximum depth explored of about eight (8) feet beneath the existing site and/or surface grades. These slightly to highly weathered and fractured bedrock deposits are best characterized by relatively moderate to high strength and low compressibility.

### **Groundwater**

Groundwater was generally not encountered within any of the exploratory test pit explorations (TH-#1 through TH-#11) at the time of excavation to depths of at least eight (8) feet beneath existing surface grades except. However, the westerly portion of the subject property is bounded by and/or contain an existing seasonal drainage basin and/or surface feature. In this regard, although groundwater elevations at the site may fluctuate seasonally in accordance with rainfall conditions and/or associated with runoff of the easterly and/or southerly drainage basins as well as changes in site utilization, we are generally of the opinion that the static water levels and/or surface water ponding not observed during our recent field exploration work generally reflect a high seasonal groundwater level(s) at and/or beneath the site.



## **INFILTRATION TESTING**

We performed four (4) field infiltration tests at the site on June 1, 2018. The infiltration tests were performed in test holes TH-#1 , TH-#5, TH-#9 and TH-#11 at depths of between two (2) to four (4) feet beneath the existing site and/or surface grades. The subgrade soils encountered in the infiltration test hole consisted of clayey, sandy silt and/or sandy, clayey silt. The infiltration testing was performed in general conformance with current EPA and/or the City of Salem Encased Falling Head test method which consisted of advancing a 6-inch diameter PVC pipe approximately 6 inches into the exposed soil horizon at each test location. Using a steady water flow, water was discharged into the pipe and allowed to penetrate and saturate the subgrade soils. The water level was adjusted over a two (2) hour period and allowed to achieve a saturated subgrade soil condition consistent with the bottom elevation of the surrounding test pit excavation. Following the required saturating period, water was again added into the PVC pipe and the time and/or rate at which the water level dropped was monitored and recorded. Each measurable drop in the water level was recorded until a consistent infiltration rate was observed and/or repeated.

Based on the results of the field infiltration testing at the site, we have found that the native sandy, clayey silt subgrade soil deposits possess an ultimate infiltration rate on the order of about 0.2 to 0.6 inches per hour (in/hr).

## **LABORATORY TESTING**

Representative samples of the on-site subsurface soils were collected at selected depths and intervals from various test pit excavations and returned to our laboratory for further examination and testing and/or to aid in the classification of the subsurface soils as well as to help evaluate and identify their engineering strength and compressibility characteristics. The laboratory testing consisted of visual and textural sample inspection, moisture content and dry density determinations, maximum dry density and optimum moisture content, gradation analyses and Atterberg Limits as well as remolded consolidation, direct shear strength and "R"-value tests. Results of the various laboratory tests are presented in the Appendix, Figure No's. A-11 through A-17.

## **SEISMICITY AND EARTHQUAKE SOURCES**

The seismicity of the southwest Washington and northwest Oregon area, and hence the potential for ground shaking, is controlled by three separate fault mechanisms. These include the Cascadia Subduction Zone (CSZ), the mid-depth intraplate zone, and the relatively shallow crustal zone. Descriptions of these potential earthquake sources are presented below.

The CSZ is located offshore and extends from northern California to British Columbia. Within this zone, the oceanic Juan de Fuca Plate is being subducted beneath the continental North American Plate to the east. The interface between these two plates is located at a depth of approximately 15 to 20 kilometers (km). The seismicity of the CSZ is subject to several uncertainties, including the maximum earthquake magnitude and the recurrence intervals associated with various magnitude earthquakes.

Anecdotal evidence of previous CSZ earthquakes has been observed within coastal marshes along the Washington and Oregon coastlines. Sequences of interlayered peat and sands have been interpreted to be the result of large Subduction zone earthquakes occurring at intervals on the order of 300 to 500 years, with the most recent event taking place approximately 300 years ago. A study by Geomatrix (1995) and/or USGS (2008) suggests that the maximum earthquake associated with the CSZ is moment magnitude ( $M_w$ ) 8 to 9. This is based on an empirical expression relating moment magnitude to the area of fault rupture derived from earthquakes that have occurred within Subduction zones in other parts of the world. An  $M_w$  9 earthquake would involve a rupture of the entire CSZ. As discussed by Geomatrix (1995) this has not occurred in other subduction zones that have exhibited much higher levels of historical seismicity than the CSZ. However, the 2008 USGS report has assigned a probability of 0.67 for a  $M_w$  9 earthquake and a probability of 0.33 for a  $M_w$  8.3 earthquake. For the purpose of this study an earthquake of  $M_w$  9.0 was assumed to occur within the CSZ.

The intraplate zone encompasses the portion of the subducting Juan de Fuca Plate located at a depth of approximately 30 to 50 km below western Washington and western Oregon. Very low levels of seismicity have been observed within the intraplate zone in western Oregon and western Washington. However, much higher levels of seismicity within this zone have been recorded in Washington and California. Several reasons for this seismic quiescence were suggested in the Geomatrix (1995) study and include changes in the direction of Subduction between Oregon, Washington, and British Columbia as well as the effects of volcanic activity along the Cascade Range. Historical activity associated with the intraplate zone includes the 1949 Olympia magnitude 7.1 and the 1965 Puget Sound magnitude 6.5 earthquakes. Based on the data presented within the Geomatrix (1995) report, an earthquake of magnitude 7.25 has been chosen to represent the seismic potential of the intraplate zone.

The third source of seismicity that can result in ground shaking within the Vancouver and southwest Washington area is near-surface crustal earthquakes occurring within the North American Plate. The historical seismicity of crustal earthquakes in this area is higher than the seismicity associated with the CSZ and the intraplate zone. The 1993 Scotts Mills (magnitude 5.6) and Klamath Falls (magnitude 6.0), Oregon earthquakes were crustal earthquakes.

### **Liquefaction**

Seismic induced soil liquefaction is a phenomenon in which loose, granular soils and some silty soils, located below the water table, develop high pore water pressures and lose strength due to ground vibrations induced by earthquakes. Soil liquefaction can result in lateral flow of material into river channels, ground settlements and increased lateral and uplift pressures on underground structures. Buildings supported on soils that have liquefied often settle and tilt and may displace laterally. Soils located above the ground water table cannot liquefy, but granular soils located above the water table may settle during the earthquake shaking.

Our review of the subsurface soil test pit logs from our exploratory field explorations (TH-#1 through TH-#11) and laboratory test results indicate that the site is generally underlain by medium stiff, sandy, clayey silt soils and/or dense to very dense, slightly to highly weathered bedrock deposits to depths of at least 8.0 feet beneath existing site grades. Additionally, groundwater was generally not encountered within any of the exploratory test pit excavations (TH-#1 through TH-#11) at the site during our field exploration work to depths of at least 8.0 feet. As such, due to the medium stiff and/or cohesive nature of the sandy, clayey silt subgrade soils as well as the dense to very dense nature of the underlying slightly to highly weathered bedrock deposits beneath the site, it is our opinion that the native sandy, clayey silt subgrade soil and/or slightly to highly weathered bedrock deposits located beneath the subject site have a very low potential for liquefaction during the design earthquake motions previously described.

### **Landslides**

No ancient and/or active landslides were observed or are known to be present on the subject site. Additionally, development of the subject site into the planned residential homes sites does not appear to present a potential geologic and/or landslide hazard provided that the site grading and development activities conform with the recommendations presented within this report. A more detailed assessment of the potential landslide hazard of the subject site is presented in the Geologic Hazard Study in Appendix B.

### **Surface Rupture**

Although the site is generally located within a region of the country known for seismic activity, no known faults exist on and/or immediately adjacent to the subject site. As such, the risk of surface rupture due to faulting is considered negligible.

### **Tsunami and Seiche**

A tsunami, or seismic sea wave, is produced when a major fault under the ocean floor moves vertically and shifts the water column above it. A seiche is a periodic oscillation of a body of water resulting in changing water levels, sometimes caused by an earthquake. Tsunami and seiche are not considered a potential hazard at this site because the site is not near to the coast and/or there are no adjacent significant bodies of water.

### **Flooding and Erosion**

Stream flooding is a potential hazard that should be considered in lowland areas of Marion County and Salem. The FEMA (Federal Emergency Management Agency) flood maps should be reviewed as part of the design for the proposed new residential structures and site improvements. Elevations of structures on the site should be designed based upon consultants reports, FEMA (Federal Emergency Management Agency), and Marion County requirements for the 100-year flood levels of any nearby creeks, streams and/or drainage basins.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **General**

Based on the results of our field explorations, laboratory testing, and engineering analyses, it is our opinion that the site is presently stable and suitable for the proposed new single-family residential development and its associated site improvements provided that the recommendations contained within this report are properly incorporated into the design and construction of the project.

The primary features of concern at the site are 1) the presence of highly moisture sensitive clayey and silty subgrade soils across the site, 2) the presence of gently to moderately sloping site conditions across the proposed new residential lots and/or home sites, and 3) the relatively low infiltration rates anticipated within the near surface clayey and silty subgrade soils.

With regard to the moisture sensitive clayey and silty subgrade soils, we are generally of the opinion that all site grading and earthwork activities be scheduled for the drier summer months which is typically June through September. In regards to the gently to moderately sloping site conditions across the proposed new residential home sites and/or lots, we are of the opinion that site grading and/or structural fill placement should be minimized where possible and should generally limit cuts and/or fills of less than ten (10) feet. Additionally, where existing site slopes and/or surface grades exceed about 20 percent (1V:5H) and in order to construct the proposed new residential lots and/or improvements to the new local residential streets, benching and keying of all fills into the natural site slopes may be required. With regard to the relatively low infiltration rates anticipated within the clayey and silty subgrade soils beneath the site, we generally do not recommend any storm water infiltration within structural and/or embankment fills. However, some limited storm water infiltration may be feasible within the residential lots and/or areas of the site where the existing and/or finish slope gradients are no steeper than about 20 percent (1V:5H). In this regard, we recommend that all proposed storm water detention and/or infiltration systems for the project be reviewed and approved by Redmond Geotechnical Services, LLC.

The following sections of this report provide specific recommendations regarding subgrade preparation and grading as well as foundation and floor slab design and construction for the new Reed Road residential development project.

### **Site Preparation**

As an initial step in site preparation, we recommend that the proposed new residential building sites and/or lots as well as their associated structural and/or site improvement area(s) be stripped and cleared of all existing improvements, any existing unsuitable fill materials, surface debris, existing vegetation, topsoil materials, and/or any other deleterious materials present at the time of construction. In general, we envision that the site stripping to remove existing vegetation and topsoil materials will generally be about 6 to 12 inches.

However, localized areas requiring deeper removals, such as any existing undocumented and/or unsuitable fill materials as well as old foundation remnants, may be encountered and should be evaluated at the time of construction by the Geotechnical Engineer. The stripped and cleared materials should be properly disposed of as they are generally considered unsuitable for use/reuse as fill materials.

Following the completion of the site stripping and clearing work and prior to the placement of any required structural fill materials and/or structural improvements, the exposed subgrade soils within the planned structural improvement area(s) should be inspected and approved by the Geotechnical Engineer and possibly proof-rolled with a half and/or fully loaded dump truck. Areas found to be soft or otherwise unsuitable should be over-excavated and removed or scarified and recompacted as structural fill. During wet and/or inclement weather conditions, proof rolling and/or scarification and recompaction as noted above may not be appropriate.

The on-site native sandy, clayey silt subgrade soil materials are generally considered suitable for use/reuse as structural fill materials provided that they are free of organic materials, debris, and rock fragments in excess of about 6 inches in dimension. However, if site grading is performed during wet or inclement weather conditions, the use of some of the on-site native soil materials which contain significant silt and clay sized particles will be difficult at best. In this regard, during wet or inclement weather conditions, we recommend that an import structural fill material be utilized which should consist of a free-draining (clean) granular fill (sand & gravel) containing no more than about 5 percent fines. Representative samples of the materials which are to be used as structural fill materials should be submitted to the Geotechnical Engineer and/or laboratory for approval and determination of the maximum dry density and optimum moisture content for compaction.

In general, all site earthwork and grading activities should be scheduled for the drier summer months (late June through September) if possible. However, if wet weather site preparation and grading is required, it is generally recommended that the stripping of topsoil materials be accomplished with a tracked excavator utilizing a large smooth-toothed bucket working from areas yet to be excavated. Additionally, the loading of strippings into trucks and/or protection of moisture sensitive subgrade soils will also be required during wet weather grading and construction. In this regard, we recommend that areas in which construction equipment will be traveling be protected by covering the exposed subgrade soils with a woven geotextile fabric such as Mirafi FW404 followed by at least 12 inches or more of crushed aggregate base rock. Further, the geotextile fabric should have a minimum Mullen burst strength of at least 250 pounds per square inch for puncture resistance and an apparent opening size (AOS) between the U.S. Standard No. 70 and No. 100 sieves.

All structural fill materials placed within the new building and/or pavement areas should be moistened or dried as necessary to near (within 3 percent) optimum moisture conditions and compacted by mechanical means to a minimum of 92 percent of the maximum dry density as determined by the ASTM D-1557 (AASHTO T-180) test procedures. Structural fill materials should be placed in lifts (layers) such that when compacted do not exceed about 8 inches.

Additionally, all fill materials placed within five (5) lineal feet of the perimeter (limits) of the proposed residential structures and/or pavements should be considered structural fill. Additionally, due to the sloping site conditions, we recommend that all structural fill materials planned in areas where existing surface and/or slope gradients exceed about 20 percent (1V:5H) be properly benched and/or keyed into the native (natural) slope subgrade soils. In general, a bench width of at least eight (8) feet and a keyway depth of at least one (1) foot is recommended. However, the actual bench width and keyway depth should be determined at the time of construction by the Geotechnical Engineer. Further, all fill slopes should be constructed with a finish slope surface gradient no steeper than about 2H:1V.

As such, settlement sensitive site and/or surface improvements (i.e., concrete curbs and sidewalks) should not be constructed until after primary consolidation and/or settlement has been completed. All aspects of the site grading, including a review of the proposed site grading plan(s), should be approved and/or monitored by a representative of Redmond Geotechnical Services, LLC.

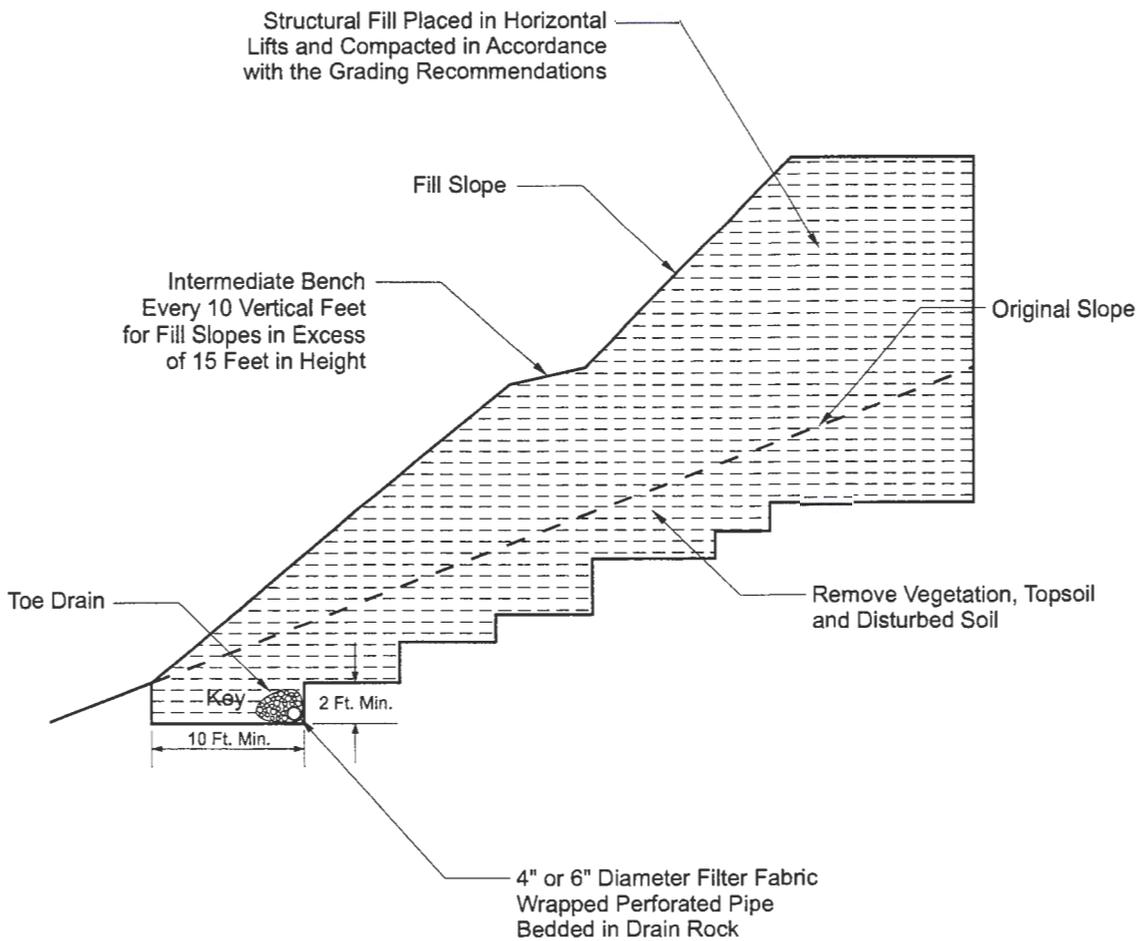
### **Foundation Support**

Based on the results of our investigation, it is our opinion that the site of the proposed new Reed Road residential development is suitable for support of the one- and/or two-story wood-frame structures provided that the following foundation design recommendations are followed. The following sections of this report present specific foundation design and construction recommendations for the planned new residential structures.

#### **Shallow Foundations**

In general, conventional shallow continuous (strip) footings and individual (spread) column footings may be supported by approved native (untreated) subgrade soil materials and/or silty sand structural fill soils based on an allowable contact bearing pressure of about 2,000 pounds per square foot (psf). This recommended allowable contact bearing pressure is intended for dead loads and sustained live loads and may be increased by one-third for the total of all loads including short-term wind or seismic loads. In general, continuous strip footings should have a minimum width of at least 16 inches and be embedded at least 18 inches below the lowest adjacent finish grade (includes frost protection). Individual column footings (where required) should be embedded at least 18 inches below grade and have a minimum width of at least 24 inches. Additionally, if foundation excavation and construction work is planned to be performed during wet and/or inclement weather conditions, we recommend that a 3 to 4 inch layer of compacted crushed rock be used to help protect the exposed foundation bearing surfaces until the placement of concrete.

Total and differential settlements of foundations constructed as recommended above and supported by approved native subgrade soils or by properly compacted structural fill materials are expected to be well within the tolerable limits for this type of lightly loaded wood-frame structure and should generally be less than about 1-inch and 1/2-inch, respectively.



**TYPICAL FILL SLOPE DETAIL**

Allowable lateral frictional resistance between the base of the footing element and the supporting subgrade bearing soil can be expressed as the applied vertical load multiplied by a coefficient of friction of 0.30 and 0.45 for native silty subgrade soils and/or import gravel fill materials, respectively. In addition, lateral loads may be resisted by passive earth pressures on footings poured "neat" against in-situ (native) subgrade soils or properly backfilled with structural fill materials based on an equivalent fluid density of 300 pounds per cubic foot (pcf). This recommended value includes a factor of safety of approximately 1.5 which is appropriate due to the amount of movement required to develop full passive resistance.

### **Floor Slab Support**

In order to provide uniform subgrade reaction beneath concrete slab-on-grade floors, we recommend that the floor slab area be underlain by a minimum of 6 inches of free-draining (less than 5 percent passing the No. 200 sieve), well-graded, crushed rock. The crushed rock should help provide a capillary break to prevent migration of moisture through the slab. However, additional moisture protection can be provided by using a 10-mil polyolefin geo-membrane sheet such as StegoWrap.

The base course materials should be compacted to at least 95 percent of the maximum dry density as determined by the ASTM D-1557 (AASHTO T-180) test procedures. Where floor slab subgrade materials are undisturbed, firm and stable and where the underslab aggregate base rock section has been prepared and compacted as recommended above, we recommend that a modulus of subgrade reaction of 150 pci be used for design.

### **Retaining/Below Grade Walls**

Retaining and/or below grade walls should be designed to resist lateral earth pressures imposed by native soils or granular backfill materials as well as any adjacent surcharge loads. For walls which are unrestrained at the top and free to rotate about their base, we recommend that active earth pressures be computed on the basis of the following equivalent fluid densities:

#### **Non-Restrained Retaining Wall Pressure Design Recommendations**

| <b>Slope Backfill<br/>(Horizontal/Vertical)</b> | <b>Equivalent Fluid Density/Silt<br/>(pcf)</b> | <b>Equivalent Fluid<br/>Density/Gravel (pcf)</b> |
|---|--|--|
| Level   | 35   | 30   |
| 3H:1V   | 60   | 50   |
| 2H:1V   | 90   | 80   |

For walls which are fully restrained at the top and prevented from rotation about their base, we recommend that at-rest earth pressures be computed on the basis of the following equivalent fluid densities:

**Restrained Retaining Wall Pressure Design Recommendations**

| <b>Slope Backfill<br/>(Horizontal/Vertical)</b> | <b>Equivalent Fluid Density/Silt<br/>(pcf)</b> | <b>Equivalent Fluid<br/>Density/Gravel (pcf)</b> |
|---|--|--|
| Level   | 45   | 35   |
| 3H:1V   | 65   | 60   |
| 2H:1V   | 95   | 90   |

The above recommended values assume that the walls will be adequately drained to prevent the buildup of hydrostatic pressures. Where wall drainage will not be present and/or if adjacent surcharge loading is present, the above recommended values will be significantly higher.

Backfill materials behind walls should be compacted to 90 percent of the maximum dry density as determined by the ASTM D-1557 (AASHTO T-180) test procedures. Special care should be taken to avoid over-compaction near the walls which could result in higher lateral earth pressures than those indicated herein. In areas within three (3) to five (5) feet behind walls, we recommend the use of hand-operated compaction equipment.

**Pavements**

Flexible pavement design for the proposed new street improvements for the residential development project was determined in accordance with the City of Salem Department of Public Works Administrative Rules Chapter 109-006 (Street Design Standards) Section 6 dated January 1, 2014.

Specifically, on June 1, 2018, samples of the subgrade soils from the proposed public streets were collected by means of test hole excavations. The subgrade soils encountered in the test holes located across the proposed residential subdivision site generally consisted of native and/or residual soils comprised of medium to reddish-brown, medium stiff, clayey, sandy silt to sandy, clayey SILT (ML).

The subgrade soil samples collected at the site were tested in the laboratory in accordance with the ASTM Vol. 4.08 Part D-2844-69 (AASHTO T-190-93) test method for the determination of the subgrade soil "R"-value and expansion pressure. The results of the "R"-value testing was then converted to an equivalent Resilient Modulus ( $M_{RSG}$ ) in accordance with current AASHTO methodology. The results of the laboratory "R"-value tests revealed that the subgrade soils have an apparent "R"-value of between 24 and 28 with an average "R"-value of 26 (see Figure No's. A-16 and A-17). Using the current AASHTO methodology for converting "R"-value to Resilient Modulus ( $M_{RSG}$ ), the subgrade soils have a Resilient Modulus ( $M_{RSG}$ ) of about 5,291 psi which is classified a "Fair" ( $M_{RSG} = 5,000$  psi to 10,000 psi).

In addition to the above, Dynamic Cone Penetration (DCP) tests were performed along the proposed new interior public street alignment at approximate 200-foot intervals. The results of the DCP tests found that the underlying native sandy, clayey silt subgrade soils have a DCP value of between 2 to 3 blows per 2-inches which correlates to a California Bearing Ratio (CBR) of between 5 and 12. Using current AASHTO methodology for converting CBR to Resilient Modulus (M<sub>RSG</sub>), the subgrade soils have a Resilient Modulus (M<sub>RSG</sub>) of between 5,842 and 10,637 psi with an average M<sub>RSG</sub> of 7,150 psi which is classified as "Fair" (M<sub>RSG</sub> = 5,000 psi to 10,000 psi).

### **Local Residential Streets**

The following documents and/or design input parameters were used to help determine the flexible pavement section design for new local residential streets:

- . **Street Classification:** Local Residential Street
- . **Design Life:** 25 years
- . **Serviceability:** 4.2 initial, 2.5 terminal
- . **Traffic Loading Data:** 100,000 18-kip EAL's
- . **Reliability Level:** 90%
- . **Drainage Coefficient:** 1.0 (asphalt), 0.8 (aggregate)
- . **Asphalt Structural Coefficient:** 0.41
- . **Aggregate Structural Coefficient:** 0.10

Based on the above design input parameters and using the design procedures contained within the AASHTO 1993 Design of Pavement Structures Manual, a Structural Number (SN) of 2.6 was determined.

In this regard, we recommend the following flexible pavement section for the construction of new Local Residential Streets:

| <b><u>Material Type</u></b> | <b><u>Pavement Section (inches)</u></b> |
|-----------------------------|---|
| Asphaltic Concrete          | 4.0                                     |
| Aggregate Base Rock         | 10.0                                    |

### **Wet Weather Grading and Soft Spot Mitigation**

Construction of the proposed new public street improvements is generally recommended during dry weather. However, during wet weather grading and construction, excavation to subgrade can proceed during periods of light to moderate rainfall provided that the subgrade remains covered with aggregate. A total aggregate thickness of 8-inches may be necessary to protect the subgrade soils from heavy construction traffic.

Construction traffic should not be allowed directly on the exposed subgrade but only atop a sufficient compacted base rock thickness to help mitigate subgrade pumping. If the subgrade becomes wet and pumps, no construction traffic shall be allowed on the road alignment. Positive site drainage away from the street shall be maintained if site paving will not occur before the on-set of the wet season.

Depending on the timing for the project, any soft subgrade found during proof-rolling or by visual observations can either be removed and replaced with properly dried and compacted fill soils or removed and replaced with compacted crushed aggregate. However, and where approved by the Geotechnical Engineer, the soft area may be covered with a bi-axial geogrid and covered with compacted crushed aggregate.

#### **Soil Shrink-Swell and Frost Heave**

The results of the laboratory "R"-value tests indicate that the native subgrade soils possess a low to moderate expansion potential. As such, the exposed subgrade soils should not be allowed to completely dry and should be moistened to near optimum moisture content (plus or minus 3 percent) at the time of the placement of the crushed aggregate base rock materials. Additionally, exposure of the subgrade soils to freezing weather may result in frost heave and softening of the subgrade. As such, all subgrade soils exposed to freezing weather should be evaluated and approved by the Geotechnical Engineer prior to the placement of the crushed aggregate base rock materials.

#### **Excavation/Slopes**

Temporary excavations of up to about four (4) feet in depth may be constructed with near vertical inclinations. Temporary excavations greater than about four (4) feet but less than eight (8) feet should be excavated with inclinations of at least 1 to 1 (horizontal to vertical) or properly braced/shored. Where excavations are planned to exceed about eight (8) feet, this office should be consulted. All shoring systems and/or temporary excavation bracing for the project should be the responsibility of the excavation contractor. Permanent slopes should be constructed no steeper than about 2H to 1V unless approved by the Geotechnical Engineer.

Depending on the time of year in which trench excavations occur, trench dewatering may be required in order to maintain dry working conditions if the invert elevations of the proposed utilities are located at and/or below the groundwater level. If groundwater is encountered during utility excavation work, we recommend placing trench stabilization materials along the base of the excavation.

Trench stabilization materials should consist of 1-foot of well-graded gravel, crushed gravel, or crushed rock with a maximum particle size of 4 inches and less than 5 percent fines passing the No. 200 sieve. The material should be free of organic matter and other deleterious material and placed in a single lift and compacted until well keyed.

### **Surface Drainage/Groundwater**

We recommend that positive measures be taken to properly finish grade the site so that drainage waters from the residential structures and landscaping areas as well as adjacent properties or buildings are directed away from the new residential structures foundations and/or floor slabs. All roof drainage should be directed into conduits that carry runoff water away from the residential structures to a suitable outfall. Roof downspouts should not be connected to foundation drains. A minimum ground slope of about 2 percent is generally recommended in unpaved areas around the proposed new residential structures.

Groundwater was not encountered at the site in any of the exploratory test pits (TH-#1 through TH-#11) at the time of excavation to depths of at least 7 feet beneath existing site grades. However, the northwesterly and/or westerly portion(s) of the site contains an existing seasonal drainage basin feature. Additionally, groundwater elevations in the area and/or across the subject property may fluctuate seasonally and may temporarily pond/perch near the ground surface during periods of prolonged rainfall.

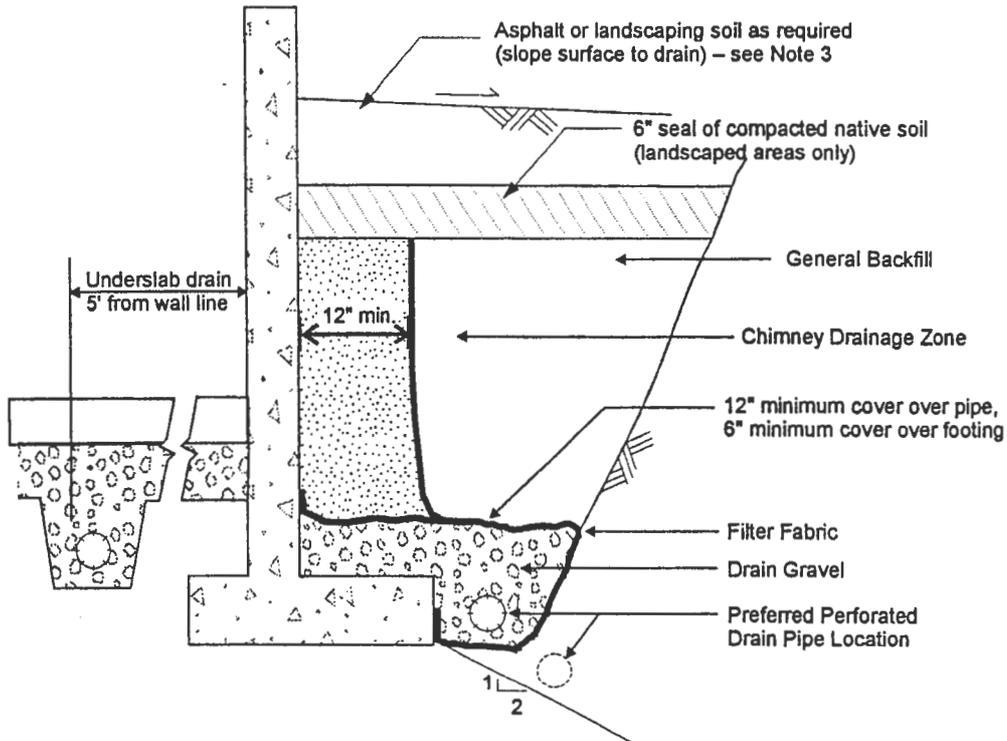
As such, based on our current understand of the possible site grading required to bring the subject site and/or residential lots to finish design grade(s), we are of the opinion that an underslab drainage system is not required for the proposed single-family residential structures. However, a perimeter foundation drain is recommended for any perimeter footings and/or below grade retaining walls. A typical recommended perimeter footing/retaining wall drain detail is shown on Figure No. 4. Further, due to our understanding that various surface infiltration ditches and/or swales may be utilized for the project as well as the relatively low infiltration rates of the near surface clayey, sandy silt and/or silty sand subgrade soils anticipated within and/or near to the foundation bearing level of the proposed residential structures, we are generally of the opinion that storm water detention and/or disposal systems should not be utilized within the residential lots and/or around the proposed residential structures unless approved by the Geotechnical Engineer.

### **Design Infiltration Rates**

Based on the results of our field infiltration testing, we recommend using the following infiltration rate(s) to design any on-site near surface storm water infiltration systems for the project:

| <b>Subgrade Soil Type</b> | <b>Recommended Infiltration Rate</b> |
|---------------------------|--------------------------------------|
| sandy, clayey SILT (ML)   | 0.1 to 0.3 inches per hour (in/hr)   |

Note: A safety factor of two (2) was used to calculate the above recommended design infiltration rate. Additionally, given the gradational variability of the on-site sandy, clayey sit subgrade soils beneath the site as well as the anticipation of some site grading for the project, it is generally recommended that field testing be performed during and/or following construction of any on-site storm water infiltration system(s) in order to confirm that the above recommended design infiltration rates are appropriate.



**SCHEMATIC - NOT TO SCALE**

**NOTES:**

1. Filter Fabric to be non-woven geotextile (Amoco 4545, Mirafi 140N, or equivalent)
2. Lay perforated drain pipe on minimum 0.5% gradient, widening excavation as required. Maintain pipe above 2:1 slope, as shown.
3. All-granular backfill is recommended for support of slabs, pavements, etc. (see text for structural fill).
4. Drain gravel to be clean, washed ¾" to 1½" gravel.
5. General backfill to be on-site gravels, or ¾"-0 or 1½"-0 crushed rock compacted to 92% Modified Proctor (AASHTO T-180).
6. Chimney drainage zone to be 12" wide (minimum) zone of clean washed, medium to coarse sand or drain gravel if protected with filter fabric. Alternatively, prefabricated drainage structures (Miradrain 6000 or similar) may be used.

**PERIMETER FOOTING/RETAINING WALL DRAIN DETAIL**

### **Seismic Design Considerations**

Structures at the site should be designed to resist earthquake loading in accordance with the methodology described in the 2014 and/or latest edition of the State of Oregon Structural Specialty Code (OSSC) and/or Amendments to the 2015 International Building Code (IBC). The maximum considered earthquake ground motion for short period and 1.0 period spectral response may be determined from the Oregon Structural Specialty Code and/or from the National Earthquake Hazard Reduction Program (NEHRP) "Recommended Provisions for Seismic Regulations for New Buildings and Other Structures" published by the Building Seismic Safety Council. We recommend Site Class "C" be used for design. Using this information, the structural engineer can select the appropriate site coefficient values ( $F_a$  and  $F_v$ ) from the 2012 IBC to determine the maximum considered earthquake spectral response acceleration for the project. However, we have assumed the following response spectrum for the project:

**Table 1. Recommended Seismic Design Parameters**

| Site Class | $S_s$ | $S_1$ | $F_a$ | $F_v$ | $S_{M_s}$ | $S_{M_1}$ | $S_{D_s}$ | $S_{D_1}$ |
|------------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|
| C          | 0.911 | 0.430 | 1.036 | 1.370 | 0.944     | 0.589     | 0.629     | 0.393     |

Notes: 1.  $S_s$  and  $S_1$  were established based on the USGS 2015 mapped maximum considered earthquake spectral acceleration maps for 2% probability of exceedence in 50 years.

2.  $F_a$  and  $F_v$  were established based on IBC 2015 tables using the selected  $S_s$  and  $S_1$  values.

### **CONSTRUCTION MONITORING AND TESTING**

We recommend that **Redmond Geotechnical Services, LLC** be retained to provide construction monitoring and testing services during all earthwork operations for the proposed new residential development. The purpose of our monitoring services would be to confirm that the site conditions reported herein are as anticipated, provide field recommendations as required based on the actual conditions encountered, document the activities of the grading contractor and assess his/her compliance with the project specifications and recommendations. It is important that our representative meet with the contractor prior to any site grading to help establish a plan that will minimize costly over-excavation and site preparation work. Of primary importance will be observations made during site preparation and stripping, structural fill placement, footing excavations and construction as well as retaining wall backfill.

## **CLOSURE AND LIMITATIONS**

This report is intended for the exclusive use of the addressee and/or their representative(s) to use to design and construct the proposed new single-family residential structures and their associated site improvements described herein as well as to prepare any related construction documents. The conclusions and recommendations contained in this report are based on site conditions as they presently exist and assume that the explorations are representative of the subsurface conditions between the explorations and/or at other locations across the study area. The data, analyses, and recommendations herein may not be appropriate for other structures and/or purposes. We recommend that parties contemplating other structures and/or purposes contact our office. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. Additionally, the above recommendations are contingent on Redmond Geotechnical Services, LLC being retained to provide all site inspections and construction monitoring services for this project. Redmond Geotechnical Services, LLC will not assume any responsibility and/or liability for any engineering judgment, inspection and/or testing services performed by others.

It is the owners/developers responsibility for insuring that the project designers and/or contractors involved with this project implement our recommendations into the final design plans, specifications and/or construction activities for the project. Further, in order to avoid delays during construction, we recommend that the final design plans and specifications for the project be reviewed by our office to evaluate as to whether our recommendations have been properly interpreted and incorporated into the project.

If during any future site grading and construction, subsurface conditions different from those encountered in the explorations are observed or appear to be present beneath excavations, we should be advised immediately so that we may review these conditions and evaluate whether modifications of the design criteria are required. We also should be advised if significant modifications of the proposed site development are anticipated so that we may review our conclusions and recommendations.

## **LEVEL OF CARE**

The services performed by the Geotechnical Engineer for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in the area under similar budget and time restraints. No warranty or other conditions, either expressed or implied, is made.

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# **Appendix "A"**

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**Test Pit Logs and Laboratory Test Data**

## **APPENDIX**

### **FIELD EXPLORATIONS AND LABORATORY TESTING**

#### **FIELD EXPLORATION**

Subsurface conditions at the site were explored by excavating eleven (11) exploratory test pits (TH-#1 through TH-#11) on June 1, 2018. The approximate location of the test pit explorations are shown in relation to the proposed new residential lots and the associated site improvements on the Site Exploration Plan, Figure No. 2.

The test pits were excavated using track-mounted excavating equipment in general conformance with ASTM Methods in Vol. 4.08, D-1586-94 and D-1587-83. The test pits were excavated to depths ranging from about 4.0 to 8.0 feet beneath existing site grades. Detailed logs of the test pits are presented on the Log of Test Pits, Figure No's. A-5 through A-10. The soils were classified in accordance with the Unified Soil Classification System (USCS), which is outlined on Figure No. A-4.

The exploration program was coordinated by a field engineer who monitored the excavating and exploration activity, obtained representative samples of the subsurface soils encountered, classified the soils by visual and textural examination, and maintained continuous logs of the subsurface conditions. Disturbed and/or undisturbed samples of the subsurface soils were obtained at appropriate depths and/or intervals and placed in plastic bags and/or with a thin walled ring sample.

Groundwater was not encountered in any of the exploratory test pits (TH-#1 through TH-#11) at the time of excavating to depths of at least 8.0 feet beneath existing surface grades.

#### **LABORATORY TESTING**

Pertinent physical and engineering characteristics of the soils encountered during our subsurface investigation were evaluated by a laboratory testing program to be used as a basis for selection of soil design parameters and for correlation purposes. Selected tests were conducted on representative soil samples. The program consisted of tests to evaluate the existing (in-situ) moisture-density, maximum dry density and optimum moisture content, gradational characteristics, and Atterberg Limits as well as consolidation, direct shear strength and "R"-value tests.

##### **Dry Density and Moisture Content Determinations**

Density and moisture content determinations were performed on both disturbed and relatively undisturbed samples from the test pit explorations in general conformance with ASTM Vol. 4.08 Part D-216. The results of these tests were used to calculate existing overburden pressures and to correlate strength and compressibility characteristics of the soils. Test results are shown on the test pit logs at the appropriate sample depths.

### **Maximum Dry Density**

Two (2) Maximum Dry Density and Optimum Moisture Content tests were performed on representative samples of the on-site clayey, sandy silt and sandy, clayey silt subgrade soils in accordance with ASTM Vol. 4.08 Part D-1557. This test was conducted to help establish various engineering properties for use as structural fill. The test results are presented on Figure No. A-11.

### **Atterberg Limits**

Two (2) Liquid Limit (LL) and Plastic Limit (PL) tests were performed on representative samples of the clayey, sandy silt and sandy, clayey silt subgrade soils in accordance with ASTM Vol. 4.08 Part D-4318-85. These tests were conducted to facilitate classification of the soils and for correlation purposes. The test results appear on Figure No. A-12.

### **Gradation Analysis**

Two (2) Gradation analyses were performed on representative samples of the clayey, sandy silt and sandy, clayey silt subsurface soils in accordance with ASTM Vol. 4.08 Part D-422. The test results were used to classify the soil in accordance with the Unified Soil Classification System (USCS). The test results are shown graphically on Figure No. A-13.

### **Consolidation Test**

One (1) Consolidation test was performed on a remolded sample of the sandy, clayey silt subgrade soil to assess the compressibility characteristics of the underlying subgrade soils in accordance with ASTM Vol. 4.08 Part D-2435-80.

Conventional loading increments of 100, 200, 400, ... 12,800 psf were applied after the 100 percent time of primary consolidation was identified for each loading increment. The samples were unloaded and allowed to rebound after the completion of the loading sequence. Deflection versus time readings were recorded for all load increments from 100 through 12,800 psf. The deflection corresponding to 100 percent primary consolidation was plotted on the consolidation strain versus consolidation pressure curve, which is presented on Figure No. A-14.

### **Direct Shear Strength Test**

One (1) Direct Shear Strength test was performed on a undisturbed and/or remolded sample of the sandy, clayey silt subgrade soil at a continuous rate of shearing deflection (0.02 inches per minute) in accordance with ASTM Vol. 4.08 Part D-3080-79. The test results were used to determine engineering strength properties and are shown graphically on Figure No. A-15.

**"R"-Value Tests**

Three (3) "R"-value tests were performed on a remolded subgrade soil sample in accordance with ASTM Vol. 4.08 Part D-2844. The test results were used to help evaluate the subgrade soils supporting and performance capabilities when subjected to traffic loading. The test results are shown on Figure No's. A-16 and A-17.

The following figures are attached and complete the Appendix:

|                                |                                    |
|--------------------------------|------------------------------------|
| Figure No. A-4                 | Key To Exploratory Test Pit Logs   |
| Figure No's. A-5 through A-10  | Log of Test Pits/Dynamic Cone      |
| Figure No. A-11                | Maximum Dry Density                |
| Figure No. A-12                | Atterberg Limits Test Results      |
| Figure No. A-13                | Gradation Test Results             |
| Figure No. A-14                | Consolidation Test Results         |
| Figure No. A-15                | Direct Shear Strength Test Results |
| Figure No's. A-16 and A-17     | Results of "R"-Value Tests         |
| Figure No's. A-18 through A-21 | Field Infiltration Test Results    |

| PRIMARY DIVISIONS  |   |                                       | GROUP SYMBOL  | SECONDARY DIVISIONS  |
|--|---|---------------------------------------|---|--|
| COARSE GRAINED SOILS<br>MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVELS<br>MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE | CLEAN GRAVELS<br>(LESS THAN 5% FINES) | GW  | Well graded gravels, gravel-sand mixtures, little or no fines.     |
|  |   |                                       | GP  | Poorly graded gravels or gravel-sand mixtures, little or no fines. |
|  |   | GRAVEL WITH FINES                     | GM  | Silty gravels, gravel-sand-silt mixtures, non-plastic fines.       |
|  |   |                                       | GC  | Clayey gravels, gravel-sand-clay mixtures, plastic fines.          |
|  | SANDS<br>MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE  | CLEAN SANDS<br>(LESS THAN 5% FINES)   | SW  | Well graded sands, gravelly sands, little or no fines.             |
|  |   |                                       | SP  | Poorly graded sands or gravelly sands, little or no fines.         |
|  |   | SANDS WITH FINES                      | SM  | Silty sands, sand-silt mixtures, non-plastic fines.                |
|  |   |                                       | SC  | Clayey sands, sand-clay mixtures, plastic fines.                   |
| FINE GRAINED SOILS<br>MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE  | SILTS AND CLAYS<br><br>LIQUID LIMIT IS LESS THAN 50%                    | ML                                    | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |  |
|  |   | CL                                    | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.                  |  |
|  |   | OL                                    | Organic silts and organic silty clays of low plasticity.  |  |
|  | SILTS AND CLAYS<br><br>LIQUID LIMIT IS GREATER THAN 50%                 | MH                                    | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.                                |  |
|  |   | CH                                    | Inorganic clays of high plasticity, fat clays.  |  |
|  |   | OH                                    | Organic clays of medium to high plasticity, organic silts.  |  |
| HIGHLY ORGANIC SOILS   |   |                                       | Pt  | Peat and other highly organic soils.                               |

**DEFINITION OF TERMS**

| SILTS AND CLAYS | U.S. STANDARD SERIES SIEVE |        |        | CLEAR SQUARE SIEVE OPENINGS |        |    | COBBLES | BOULDERS |
|-----------------|----------------------------|--------|--------|-----------------------------|--------|----|---------|----------|
|                 | 200                        | 40     | 10     | 4                           | 3/4"   | 3" |         |          |
|                 | SAND                       |        |        | GRAVEL                      |        |    |         |          |
|                 | FINE                       | MEDIUM | COARSE | FINE                        | COARSE |    |         |          |

**GRAIN SIZES**

| SANDS, GRAVELS AND NON-PLASTIC SILTS | BLOWS/FOOT <sup>†</sup> |
|--------------------------------------|-------------------------|
| VERY LOOSE                           | 0 - 4                   |
| LOOSE                                | 4 - 10                  |
| MEDIUM DENSE                         | 10 - 30                 |
| DENSE                                | 30 - 50                 |
| VERY DENSE                           | OVER 50                 |

| CLAYS AND PLASTIC SILTS | STRENGTH <sup>‡</sup> | BLOWS/FOOT <sup>†</sup> |
|-------------------------|-----------------------|-------------------------|
| VERY SOFT               | 0 - 1/4               | 0 - 2                   |
| SOFT                    | 1/4 - 1/2             | 2 - 4                   |
| FIRM                    | 1/2 - 1               | 4 - 8                   |
| STIFF                   | 1 - 2                 | 8 - 16                  |
| VERY STIFF              | 2 - 4                 | 16 - 32                 |
| HARD                    | OVER 4                | OVER 32                 |

**RELATIVE DENSITY**

<sup>†</sup> Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1-3/8 inch I.D.) split spoon (ASTM D-1586).

<sup>‡</sup> Unconfined compressive strength in tons/sq. ft. as determined by laboratory testing or approximated by the standard penetration test (ASTM D-1586), pocket penetrometer, torvane, or visual observation.

**CONSISTENCY**

**KEY TO EXPLORATORY TEST PIT LOGS  
Unified Soil Classification System (ASTM D-2487)**

REED ROAD SUBDIVISION

Salem, Oregon

PROJECT NO.

DATE

1001.058.G

7/20/18

Figure A-4



PO Box 20547 • PORTLAND, OREGON 97294

BACKHOE COMPANY: Gene S. McMurrin

BUCKET SIZE: 24 inches

DATE: 6/01/18

| DEPTH (FEET) | BAG SAMPLE | DENSITY TEST | DRY DENSITY (pcf) | MOISTURE CONTENT (%) | SOIL CLASS. (U.S.C.S.) | SOIL DESCRIPTION |   |
|--------------|------------|--------------|-------------------|----------------------|------------------------|------------------|---|
|              |            |              |                   |                      |                        | TEST PIT NO.     | ELEVATION   |
| 0            |            |              |                   |                      |                        | TH-#1            | 265'±   |
|              | X          |              |                   | 20.6                 | ML                     |                  | Dark brown, very moist, soft, organic, clayey, sandy SILT (Topsoil)         |
|              |            |              |                   |                      | ML                     |                  | Medium brown, very moist, medium stiff, clayey, sandy SILT                  |
| 5            | X          |              |                   | 28.9                 |                        |                  | Becomes wet at 6 feet   |
|              |            |              |                   |                      |                        |                  | Total Depth = 7.0 feet<br>No groundwater encountered at time of exploration |

|   |   |  |  |      |    | TEST PIT NO. | ELEVATION   |
|---|---|--|--|------|----|--------------|---|
|   |   |  |  |      |    | TH-#2        | 295'±   |
| 0 | X |  |  | 17.7 | ML |              | Dark brown, moist, soft, organic, clayey, sandy SILT (Topsoil)                                |
|   |   |  |  |      | ML |              | Medium brown, moist to very moist, medium stiff, clayey, sandy SILT                           |
| 5 |   |  |  |      | RK |              | Gray-brown, damp, dense to very dense, slightly to moderately weathered and fractured BEDROCK |
|   |   |  |  |      |    |              | Total Depth = 4.0 feet<br>No groundwater encountered at time of exploration                   |

**LOG OF TEST PITS**

PROJECT NO. 1001.058.G

REED ROAD SUBDIVISION

FIGURE NO. A-5

| DEPTH (FEET) | BAG SAMPLE | DENSITY TEST | DRY DENSITY (pcf) | MOISTURE CONTENT (%) | SOIL CLASS. (U.S.C.S.) | SOIL DESCRIPTION   |
|--------------|------------|--------------|-------------------|----------------------|------------------------|--|
|              |            |              |                   |                      |                        | TEST PIT NO. TH-#3      ELEVATION 335'±                                      |
| 0            |            |              |                   |                      | ML                     | Dark brown, moist to very moist, soft, organic, sandy, clayey SILT (Topsoil) |
| X            |            |              |                   | 28.6                 | ML/MH                  | Medium to reddish-brown, very moist, medium stiff, sandy, clayey SILT        |
| 5            | X          |              |                   | 32.2                 | ML/RK                  | Gray-brown, moist, dense, highly weathered and fractured BEDROCK             |
| 10           |            |              |                   |                      |                        | Total Depth = 8.0 feet<br>No groundwater encountered at time of exploration  |

| TEST PIT NO. TH-#4      ELEVATION 330'± |  |  |  |  |    |   |
|---|--|--|--|--|----|---|
| 0                                       |  |  |  |  | ML | Dark brown, moist, soft, organic, clayey, sandy SILT (Topsoil)                                |
|   |  |  |  |  | ML | Medium brown, moist to very moist, medium stiff, clayey, sandy SILT                           |
| 5                                       |  |  |  |  | RK | Gray-brown, damp, dense to very dense, slightly to moderately weathered and fractured BEDROCK |
| 10                                      |  |  |  |  |    | Total Depth = 5.0 feet<br>No groundwater encountered at time of exploration                   |

**LOG OF TEST PITS**

PROJECT NO. 1001.058.G

REED ROAD SUBDIVISION

FIGURE NO. A-6

BACKHOE COMPANY: Gene S. McMurrin

BUCKET SIZE: 24 inches

DATE: 6/01/18

| DEPTH (FEET) | BAG SAMPLE | DENSITY TEST | DRY DENSITY (pcf) | MOISTURE CONTENT (%) | SOIL CLASS. (U.S.C.S.) | SOIL DESCRIPTION  |           |
|--------------|------------|--------------|-------------------|----------------------|------------------------|---|-----------|
|              |            |              |                   |                      |                        | TEST PIT NO.  | ELEVATION |
|              |            |              |                   |                      |                        | TH-#5   | 300'±     |
| 0            |            |              |                   |                      | ML                     | Dark brown, moist to very moist, soft, organic, clayey, sandy SILT (Topsoil)                  |           |
|              | X          |              |                   | 29.1                 | ML                     | Medium brown, moist to very moist, medium stiff, clayey, sandy SILT                           |           |
| 5            |            |              |                   |                      | RK                     | Gray-brown, damp, dense to very dense, slightly to moderately weathered and fractured BEDROCK |           |
|              |            |              |                   |                      |                        | Total Depth = 6.0 feet<br>No groundwater encountered at time of exploration                   |           |

|   |   |  |  |      |          | TEST PIT NO.   | ELEVATION |
|---|---|--|--|------|----------|--|-----------|
|   |   |  |  |      |          | TH-#6  | 380'±     |
| 0 |   |  |  |      | ML       | Dark brown, moist to very moist, soft, organic, sandy, clayey SILT (Topsoil) |           |
|   | X |  |  | 27.7 | ML<br>MH | Medium to reddish-brown, very moist, medium stiff, sandy, clayey SILT        |           |
| 5 |   |  |  | 29.5 |          |  |           |
|   | X |  |  |      | ML<br>RK | Gray-brown, moist, dense, highly weathered and fractured BEDROCK             |           |
|   |   |  |  |      |          | Total Depth = 8.0 feet<br>No groundwater encountered at time of exploration  |           |

**LOG OF TEST PITS**

PROJECT NO. 1001.058.G

REED ROAD SUBDIVISION

FIGURE NO. A-7

BACKHOE COMPANY: Gene S. McMurrin

BUCKET SIZE: 24 inches

DATE: 6/01/18

| DEPTH (FEET) | BAG SAMPLE | DENSITY TEST | DRY DENSITY (pcf) | MOISTURE CONTENT (%) | SOIL CLASS. (U.S.C.S.) | SOIL DESCRIPTION   |           |
|--------------|------------|--------------|-------------------|----------------------|------------------------|--|-----------|
|              |            |              |                   |                      |                        | TEST PIT NO.   | ELEVATION |
| 0            |            |              |                   |                      |                        | TH-#7  | 370'±     |
| 0 - 1.5      |            |              |                   |                      | ML                     | Dark brown, moist to very moist, soft, organic, clayey, sandy SILT (Topsoil) |           |
| 1.5 - 6.0    |            |              |                   |                      | ML / MH                | Medium to reddish-brown, moist to very, medium stiff, sandy, clayey SILT     |           |
| 6.0 - 7.0    |            |              |                   |                      | ML / RK                | Gray-brown, moist, dense, highly weathered and fractured BEDROCK             |           |
|              |            |              |                   |                      |                        | Total Depth = 7.0 feet<br>No groundwater encountered at time of exploration  |           |

|           |   |  |  |      |         | TEST PIT NO.   | ELEVATION |
|-----------|---|--|--|------|---------|--|-----------|
|           |   |  |  |      |         | TH-#8  | 395'±     |
| 0         |   |  |  |      |         |  |           |
| 0 - 1.5   |   |  |  |      | ML      | Dark brown, moist to very moist, soft, organic, sandy, clayey SILT (Topsoil)   |           |
| 1.5 - 6.0 | X |  |  | 28.2 | ML / MH | Medium to reddish-brown, moist to very moist, medium stiff, sandy, clayey SILT |           |
| 6.0 - 7.0 |   |  |  |      |         | Total Depth = 7.0 feet<br>No groundwater encountered at time of exploration    |           |

**LOG OF TEST PITS**

PROJECT NO. 1001.058.G

REED ROAD SUBDIVISION

FIGURE NO. A-8

BACKHOE COMPANY: Gene S. McMurrin

BUCKET SIZE: 24 inches

DATE: 6/01/18

| DEPTH (FEET) | BAG SAMPLE | DENSITY TEST | DRY DENSITY (pcf) | MOISTURE CONTENT (%) | SOIL CLASS. (U.S.C.S.) | SOIL DESCRIPTION  |
|--------------|------------|--------------|-------------------|----------------------|------------------------|---|
|              |            |              |                   |                      |                        | TEST PIT NO. TH-#9      ELEVATION 320'±   |
| 0            | X          |              |                   | 23.3                 | ML                     | Dark brown, moist to very moist, soft, organic, clayey, sandy SILT (Topsoil)    |
|              |            |              |                   |                      | ML                     | Medium brown, moist to very moist, medium stiff, clayey, sandy SILT             |
| 5            |            |              |                   |                      | RK                     | Gray-brown, damp, dense to very dense, slightly weathered and fractured BEDROCK |
|              |            |              |                   |                      |                        | Total Depth = 6.0 feet<br>No groundwater encountered at time of exploration     |
| 10           |            |              |                   |                      |                        |   |
| 15           |            |              |                   |                      |                        |   |

|    |  |  |  |  |       | TEST PIT NO. TH-#10      ELEVATION 355'±                                      |
|----|--|--|--|--|-------|---|
| 0  |  |  |  |  | ML    | Dark brown, moist to very moist, soft, organic, clayey, sandy SILT (Topsoil)  |
|    |  |  |  |  | ML/MH | Medium to reddish-brown, moist to very moist medium stiff, sandy, clayey SILT |
| 5  |  |  |  |  | ML/RK | Gray-brown, moist, dense, highly weathered and fractured BEDROCK              |
|    |  |  |  |  |       | Total Depth = 7.0 feet<br>No groundwater encountered at time of exploration   |
| 10 |  |  |  |  |       |   |
| 15 |  |  |  |  |       |   |

**LOG OF TEST PITS**

PROJECT NO. 1001.058.G

REED ROAD SUBDIVISION

FIGURE NO. A-9

BACKHOE COMPANY: Gene S. McMurrin

BUCKET SIZE: 24 inches

DATE: 6/01/18

| DEPTH (FEET) | BAG SAMPLE | DENSITY TEST | DRY DENSITY (pcf) | MOISTURE CONTENT (%) | SOIL CLASS. (U.S.C.S.) | SOIL DESCRIPTION  |
|--------------|------------|--------------|-------------------|----------------------|------------------------|---|
|              |            |              |                   |                      |                        | TEST PIT NO. TH-#11      ELEVATION 300'±  |
| 0            | X          |              |                   | 26.1                 | ML                     | Dark brown, moist to very moist, soft, organic, sandy, clayey SILT (Topsoil)                  |
|              |            |              |                   |                      | ML                     | Medium brown, moist to very moist, medium stiff, clayey, sandy SILT                           |
| 5            |            |              |                   |                      | RK                     | Gray-brown, damp, dense to very dense, slightly to moderately weathered and fractured BEDROCK |
|              |            |              |                   |                      |                        | Total Depth = 6.0 feet<br>No groundwater encountered at time of exploration                   |

| TEST PIT NO. |  |  |  |  |  | ELEVATION |  |  |  |  |  |
|--------------|--|--|--|--|--|-----------|--|--|--|--|--|
| 0            |  |  |  |  |  |           |  |  |  |  |  |
| 5            |  |  |  |  |  |           |  |  |  |  |  |
| 10           |  |  |  |  |  |           |  |  |  |  |  |
| 15           |  |  |  |  |  |           |  |  |  |  |  |

**LOG OF TEST PITS**

|                        |                       |                 |
|------------------------|-----------------------|-----------------|
| PROJECT NO. 1001.058.G | REED ROAD SUBDIVISION | FIGURE NO. A-10 |
|------------------------|-----------------------|-----------------|

**MAXIMUM DENSITY TEST RESULTS**

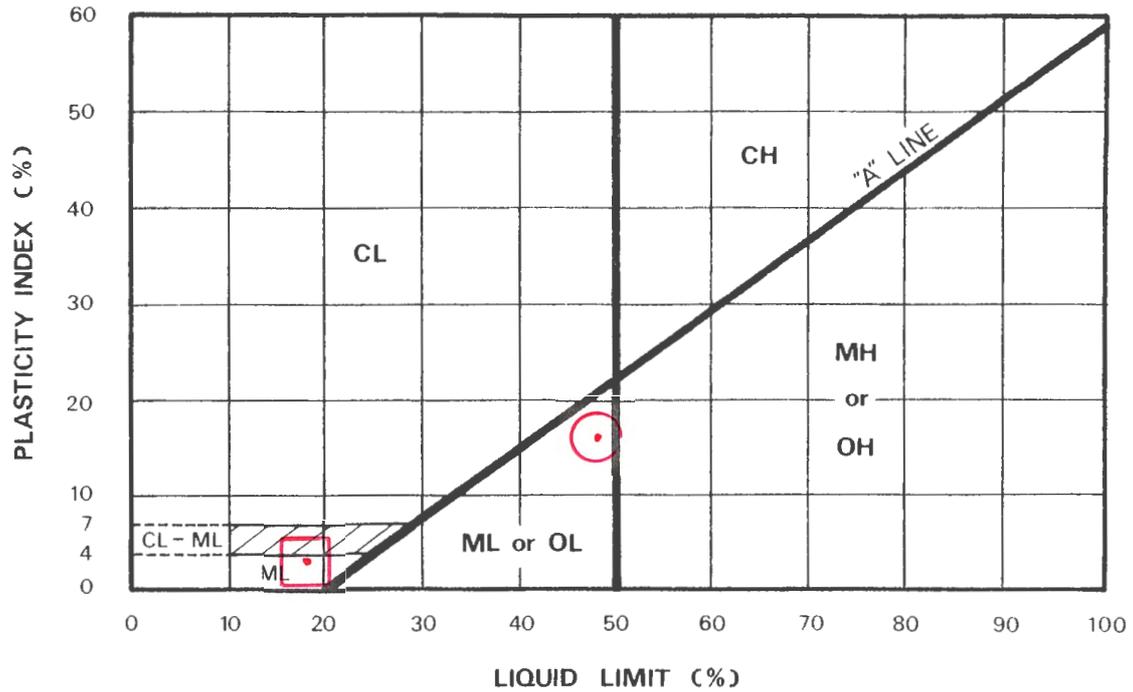
| SAMPLE LOCATION    | SOIL DESCRIPTION                                    | MAXIMUM DRY DENSITY (pcf) | OPTIMUM MOISTURE CONTENT (%) |
|--------------------|---|---------------------------|------------------------------|
| TH-#1<br>@<br>2.0' | Medium brown, clayey, sandy SILT (ML)               | 110.0                     | 17.0                         |
| TH-#3<br>@<br>2.0' | Medium to reddish-brown, sandy, clayey SILT (ML/MH) | 104.0                     | 24.0                         |

**EXPANSION INDEX TEST RESULTS**

| SAMPLE LOCATION | INITIAL MOISTURE (%) | COMPACTED DRY DENSITY (pcf) | FINAL MOISTURE (%) | VOLUMETRIC SWELL (%) | EXPANSION INDEX | EXPANSIVE CLASS. |
|-----------------|----------------------|-----------------------------|--------------------|----------------------|-----------------|------------------|
|                 |                      |                             |                    |                      |                 |                  |

**MAXIMUM DENSITY & EXPANSION INDEX TEST RESULTS**

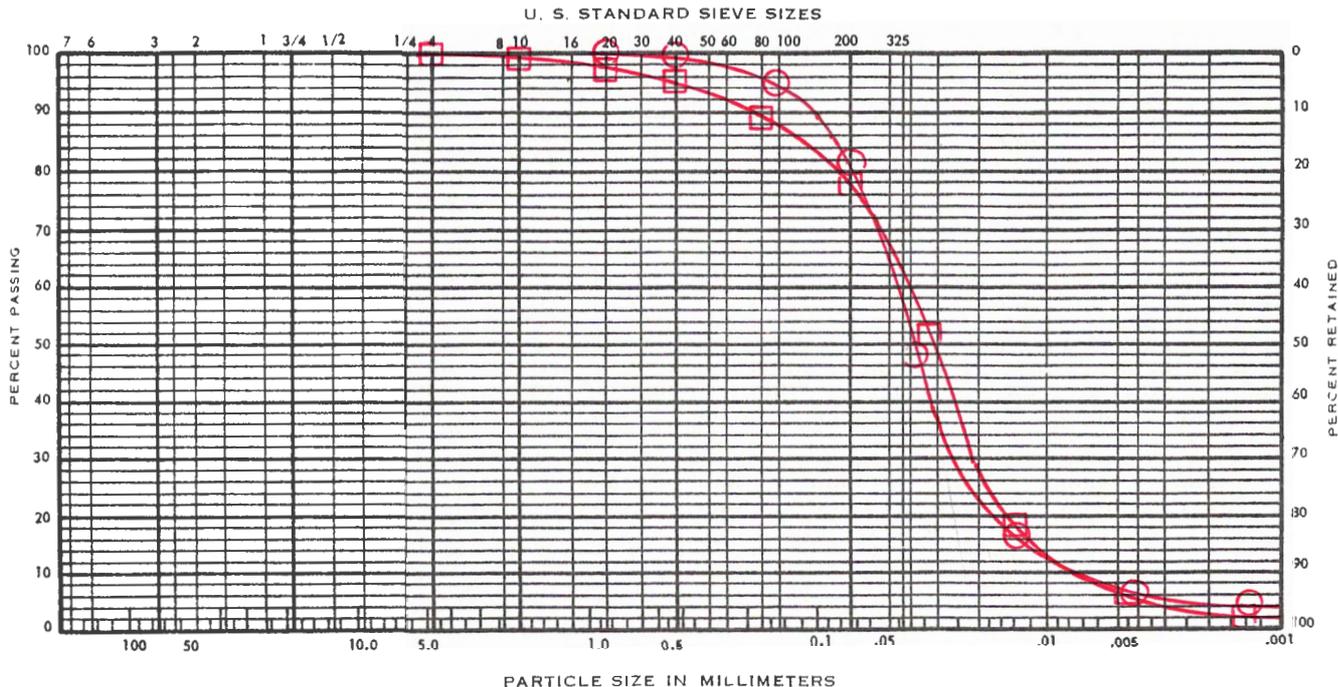
|                         |                       |                  |
|-------------------------|-----------------------|------------------|
| PROJECT NO.: 1001.058.G | REED ROAD SUBDIVISION | FIGURE NO.: A-11 |
|-------------------------|-----------------------|------------------|



| KEY SYMBOL | BORING NO. | SAMPLE DEPTH (feet) | NATURAL WATER CONTENT % | LIQUID LIMIT % | PLASTICITY INDEX % | PASSING NO. 200 SIEVE % | LIQUIDITY INDEX | UNIFIED SOIL CLASSIFICATION SYMBOL |
|------------|------------|---------------------|-------------------------|----------------|--------------------|-------------------------|-----------------|------------------------------------|
| □          | TH-#1      | 2.0                 | 20.6                    | 18.8           | 3.8                | 78.1                    |                 | ML                                 |
| ○          | TH-#3      | 2.0                 | 28.6                    | 48.3           | 16.4               | 81.7                    |                 | ML                                 |

# UNIFIED SOIL CLASSIFICATION SYSTEM

(ASTM D 422-72)



|         |        |      |        |        |      |               |
|---------|--------|------|--------|--------|------|---------------|
| COBBLES | GRAVEL |      | SAND   |        |      | SILT AND CLAY |
|         | COARSE | FINE | COARSE | MEDIUM | FINE |               |

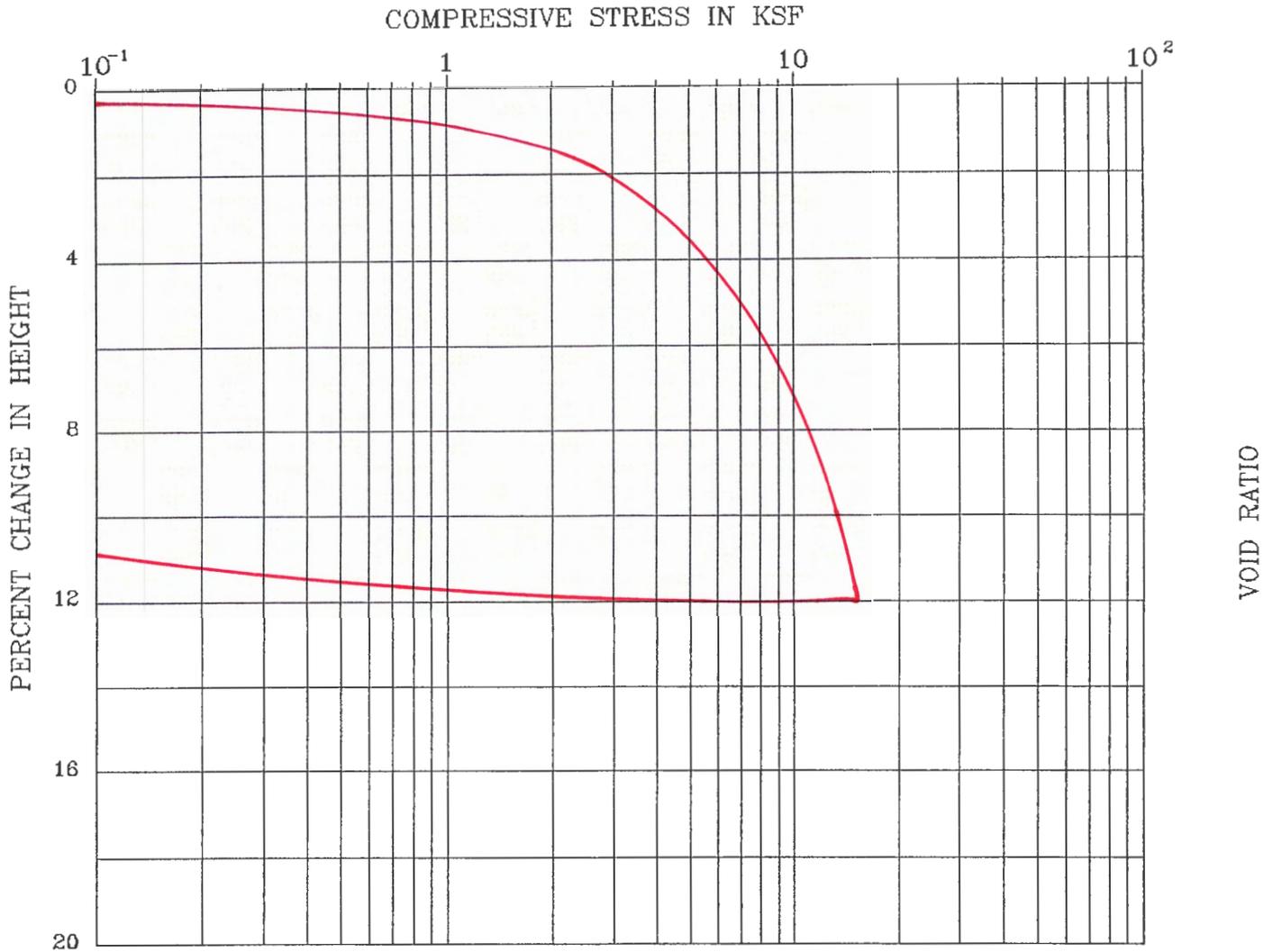
| KEY SYMBOL | BORING NO. | SAMPLE DEPTH (feet) | ELEV. (feet) | UNIFIED SOIL CLASSIFICATION SYMBOL | SAMPLE DESCRIPTION                          |
|------------|------------|---------------------|--------------|------------------------------------|---|
| □          | TH-#1      | 2.0                 |              | ML                                 | Medium brown, clayey, sandy SILT            |
| ○          | TH-#3      | 2.0                 |              | ML                                 | Medium to reddish-brown, sandy, clayey SILT |



### GRADATION TEST DATA

REED ROAD SUBDIVISION  
Salem, Oregon

|             |         |             |
|-------------|---------|-------------|
| PROJECT NO. | DATE    | FIGURE A-13 |
| 1001.058.G  | 7/20/18 |             |

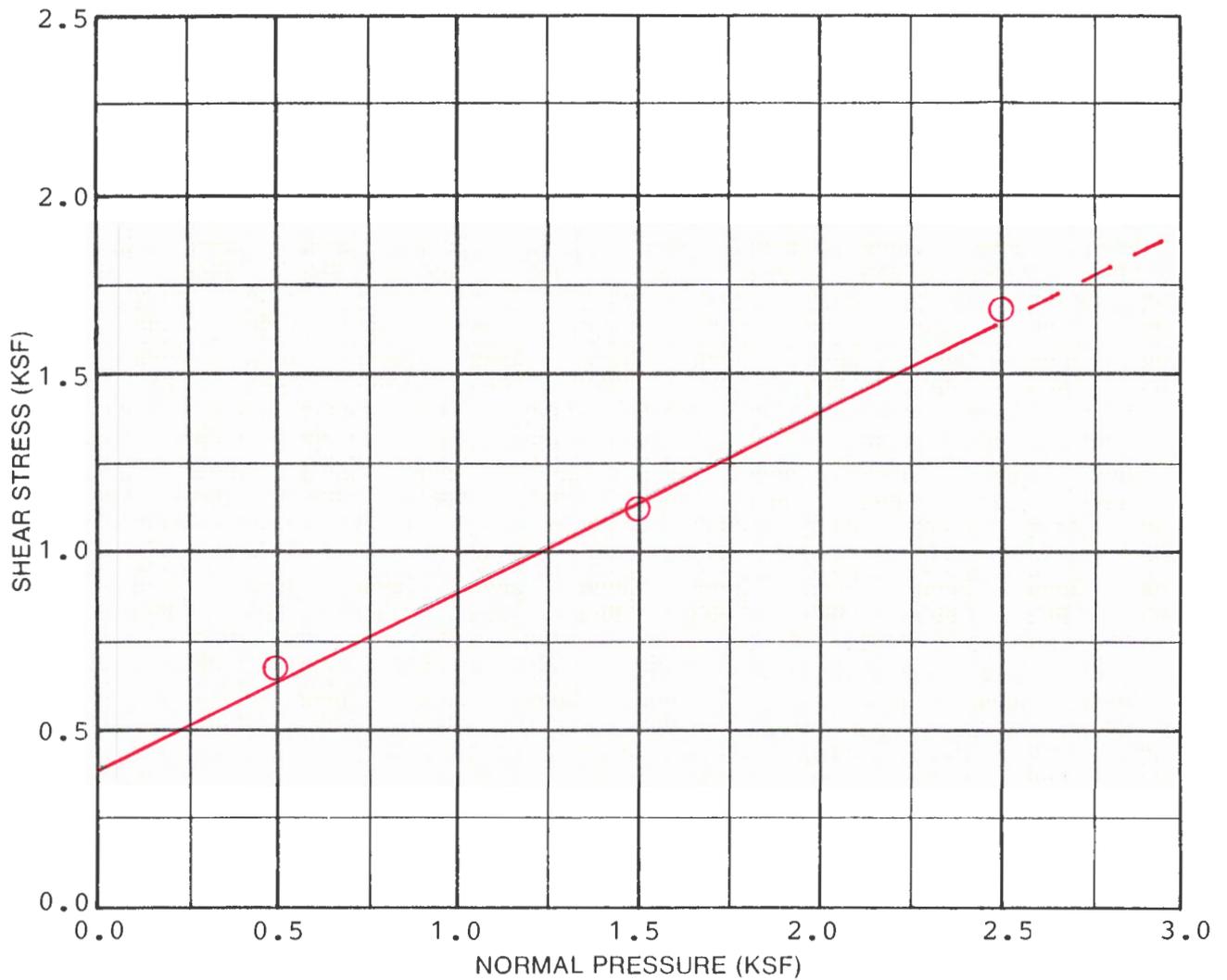


BORING : TH-#3                      DESCRIPTION : sandy, clayey SILT (M)  
 DEPTH (ft) : 2.0                      LIQUID LIMIT : 48.3  
 SPEC. GRAVITY : 2.5 (assumed)      PLASTIC LIMIT : 31.9

|         | MOISTURE<br>CONTENT (%) | DRY DENSITY<br>(pcf) | PERCENT<br>SATURATION | VOID<br>RATIO |
|---------|-------------------------|----------------------|-----------------------|---------------|
| INITIAL | 24.0                    | 94.0                 | 86.5                  |               |
| FINAL   | 14.2                    | 103.3                | 95.6                  |               |



| CONSOLIDATION TEST DATA                |         |             |
|--|---------|-------------|
| REED ROAD SUBDIVISION<br>Salem, Oregon |         |             |
| PROJECT NO.                            | DATE    | Figure A-14 |
| 1001.058.G                             | 7/20/18 |             |



| SAMPLE DATA   |                 |
|---|-----------------|
| DESCRIPTION: Medium to reddish-brown, sandy, clayey SILT (ML) |                 |
| BORING NO.: TH-#3   |                 |
| DEPTH (ft): 2.0   | ELEVATION (ft): |
| TEST RESULTS  |                 |
| APPARENT COHESION (C): 400 psf                                |                 |
| APPARENT ANGLE OF INTERNAL FRICTION ( $\phi$ ): 26°           |                 |

| TEST DATA                            |      |      |       |   |
|--------------------------------------|------|------|-------|---|
| TEST NUMBER                          | 1    | 2    | 3     | 4 |
| NORMAL PRESSURE (KSF)                | 0.5  | 1.5  | 2.5   |   |
| SHEAR STRENGTH (KSF)                 | 0.7  | 1.1  | 1.7   |   |
| INITIAL H <sub>2</sub> O CONTENT (%) | 24.0 | 24.0 | 24.0  |   |
| FINAL H <sub>2</sub> O CONTENT (%)   | 24.7 | 20.1 | 15.6  |   |
| INITIAL DRY DENSITY (PCF)            | 94.0 | 94.0 | 94.0  |   |
| FINAL DRY DENSITY (PCF)              | 04.8 | 98.1 | 103.3 |   |
| STRAIN RATE: 0.02 inches per minute  |      |      |       |   |



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| DIRECT SHEAR TEST DATA                |         |             |
|---------------------------------------|---------|-------------|
| REED ROAD SUBDIVISION<br>Slem, Oregon |         |             |
| PROJECT NO.                           | DATE    | Figure A-15 |
| 1001.058.G                            | 7/20/18 |             |

## RESULTS OF R (RESISTANCE) VALUE TESTS

**SAMPLE LOCATION: TH-#1**

**SAMPLE DEPTH: 2.0 feet bgs**

| Specimen                                     | A    | B     | C     |
|--|------|-------|-------|
| Exudation Pressure (psi)                     | 219  | 329   | 431   |
| Expansion Dial (0.0001")                     | 0    | 0     | 1     |
| Expansion Pressure (psf)                     | 0    | 0     | 3     |
| Moisture Content (%)                         | 18.6 | 15.4  | 12.1  |
| Dry Density (pcf)                            | 99.4 | 104.2 | 109.6 |
| Resistance Value, "R"                        | 17   | 29    | 41    |
| "R"-Value at 300 psi Exudation Pressure = 28 |      |       |       |

**SAMPLE LOCATION: TH-#7**

**SAMPLE DEPTH: 2.0 feet bgs**

| Specimen                                     | A    | B    | C     |
|--|------|------|-------|
| Exudation Pressure (psi)                     | 208  | 326  | 439   |
| Expansion Dial (0.0001")                     | 0    | 1    | 2     |
| Expansion Pressure (psf)                     | 0    | 3    | 8     |
| Moisture Content (%)                         | 27.3 | 22.1 | 16.7  |
| Dry Density (pcf)                            | 94.9 | 99.1 | 105.7 |
| Resistance Value "R"                         | 13   | 25   | 36    |
| "R"-Value at 300 psi Exudation Pressure = 24 |      |      |       |

## RESULTS OF R (RESISTANCE) VALUE TESTS

**SAMPLE LOCATION: TH-#9**

**SAMPLE DEPTH: 2.0 feet bgs**

| Specimen                                     | A    | B     | C     |
|--|------|-------|-------|
| Exudation Pressure (psi)                     | 210  | 322   | 426   |
| Expansion Dial (0.0001")                     | 0    | 1     | 2     |
| Expansion Pressure (psf)                     | 0    | 3     | 8     |
| Moisture Content (%)                         | 26.1 | 21.8  | 16.2  |
| Dry Density (pcf)                            | 95.4 | 100.7 | 106.1 |
| Resistance Value, "R"                        | 15   | 27    | 38    |
| "R"-Value at 300 psi Exudation Pressure = 26 |      |       |       |

**SAMPLE LOCATION:**

**SAMPLE DEPTH:**

| Specimen                                  | A | B | C |
|---|---|---|---|
| Exudation Pressure (psi)                  |   |   |   |
| Expansion Dial (0.0001")                  |   |   |   |
| Expansion Pressure (psf)                  |   |   |   |
| Moisture Content (%)                      |   |   |   |
| Dry Density (pcf)                         |   |   |   |
| Resistance Value "R"                      |   |   |   |
| "R"-Value at 300 psi Exudation Pressure = |   |   |   |

## Division 004 Appendix C - Infiltration Testing

|   |                                       |  |
|---|---------------------------------------|--|
| <b>Location:</b> Reed Road Subdivision                      | <b>Date:</b> June 1, 2018             | <b>Test Hole:</b> TH-#1                      |
| <b>Depth to Bottom of Hole:</b> 4.0 feet                    | <b>Hole Diameter:</b> 6 inches        | <b>Test Method:</b> Encased Falling Head     |
| <b>Tester's Name:</b> Daniel M. Redmond, P.E., G.E.         |                                       |  |
| <b>Tester's Company:</b> Redmond Geotechnical Services, LLC |                                       | <b>Tester's Contact Number:</b> 503-285-0598 |
| <b>Depth (feet)</b>   | <b>Soil Characteristics</b>           |  |
| 0-1.0   | Dark brown Topsoil                    |  |
| 1.0-4.0   | Medium brown, clayey, sandy SILT (ML) |  |
|   |                                       |  |
|   |                                       |  |

| Time  | Time Interval (Minutes) | Measurement (inches) | Drop in Water (inches) | Infiltration Rate (inches/hour) | Remarks            |
|-------|-------------------------|----------------------|------------------------|---------------------------------|--------------------|
| 9:00  | 0                       | 36.00                | ----                   |                                 | Filled w/12" water |
| 9:20  | 20                      | 36.50                | 0.50                   | 1.50                            |                    |
| 9:40  | 20                      | 36.90                | 0.40                   | 1.20                            |                    |
| 10:00 | 20                      | 37.23                | 0.33                   | 0.99                            |                    |
| 10:20 | 20                      | 37.49                | 0.26                   | 0.78                            |                    |
| 10:40 | 20                      | 37.72                | 0.23                   | 0.69                            |                    |
| 11:00 | 20                      | 37.93                | 0.21                   | 0.63                            |                    |
| 11:20 | 20                      | 38.13                | 0.20                   | 0.60                            |                    |
| 11:40 | 20                      | 38.33                | 0.20                   | 0.60                            |                    |
|       |                         |                      |                        |                                 |                    |

Infiltration Test Data Table

## Division 004 Appendix C - Infiltration Testing

|   |                                       |  |
|---|---------------------------------------|--|
| <b>Location:</b> Reed Road Subdivision                      | <b>Date:</b> June 1, 2018             | <b>Test Hole:</b> TH-#5                      |
| <b>Depth to Bottom of Hole:</b> 3.0 feet                    | <b>Hole Diameter:</b> 6 inches        | <b>Test Method:</b> Encased Falling Head     |
| <b>Tester's Name:</b> Daniel M. Redmond, P.E., G.E.         |                                       |  |
| <b>Tester's Company:</b> Redmond Geotechnical Services, LLC |                                       | <b>Tester's Contact Number:</b> 503-285-0598 |
| <b>Depth (feet)</b>   | <b>Soil Characteristics</b>           |  |
| 0-0.5   | Dark brown Topsoil                    |  |
| 0.5-3.0   | Medium brown, clayey, sandy SILT (ML) |  |
|   |                                       |  |
|   |                                       |  |

| Time  | Time Interval (Minutes) | Measurement (inches) | Drop in Water (inches) | Infiltration Rate (inches/hour) | Remarks            |
|-------|-------------------------|----------------------|------------------------|---------------------------------|--------------------|
| 9:30  | 0                       | 24.00                | ----                   |                                 | Filled w/12" water |
| 9:50  | 20                      | 24.45                | 0.45                   | 1.35                            |                    |
| 10:10 | 20                      | 24.79                | 0.34                   | 1.02                            |                    |
| 10:30 | 20                      | 25.05                | 0.26                   | 0.78                            |                    |
| 10:50 | 20                      | 25.25                | 0.20                   | 0.60                            |                    |
| 11:10 | 20                      | 25.41                | 0.16                   | 0.48                            |                    |
| 11:30 | 20                      | 25.55                | 0.14                   | 0.42                            |                    |
| 11:50 | 20                      | 25.68                | 0.13                   | 0.39                            |                    |
| 12:10 | 20                      | 25.81                | 0.13                   | 0.39                            |                    |
|       |                         |                      |                        |                                 |                    |

Infiltration Test Data Table

## Division 004 Appendix C - Infiltration Testing

|   |                                       |  |
|---|---------------------------------------|--|
| <b>Location:</b> Reed Road Subdivision                      | <b>Date:</b> June 1, 2018             | <b>Test Hole:</b> TH-#9                      |
| <b>Depth to Bottom of Hole:</b> 3.0 feet                    | <b>Hole Diameter:</b> 6 inches        | <b>Test Method:</b> Encased Falling Head     |
| <b>Tester's Name:</b> Daniel M. Redmond, P.E., G.E.         |                                       |  |
| <b>Tester's Company:</b> Redmond Geotechnical Services, LLC |                                       | <b>Tester's Contact Number:</b> 503-285-0598 |
| <b>Depth (feet)</b>   | <b>Soil Characteristics</b>           |  |
| 0-0.5   | Dark brown Topsoil                    |  |
| 0.5-3.0   | Medium brown, clayey, sandy SILT (ML) |  |
|   |                                       |  |
|   |                                       |  |

| Time  | Time Interval (Minutes) | Measurement (inches) | Drop in Water (inches) | Infiltration Rate (inches/hour) | Remarks            |
|-------|-------------------------|----------------------|------------------------|---------------------------------|--------------------|
| 9:50  | 0                       | 24.00                | ----                   |                                 | Filled w/12" water |
| 10:10 | 20                      | 24.40                | 0.40                   | 1.20                            |                    |
| 10:30 | 20                      | 24.72                | 0.32                   | 0.96                            |                    |
| 10:50 | 20                      | 24.96                | 0.24                   | 0.72                            |                    |
| 11:10 | 20                      | 25.15                | 0.19                   | 0.57                            |                    |
| 11:30 | 20                      | 25.29                | 0.14                   | 0.42                            |                    |
| 11:50 | 20                      | 25.41                | 0.12                   | 0.36                            |                    |
| 12:10 | 20                      | 25.52                | 0.11                   | 0.33                            |                    |
| 12:30 | 20                      | 25.62                | 0.10                   | 0.30                            |                    |
|       |                         |                      |                        |                                 |                    |

Infiltration Test Data Table

**Division 004 Appendix C - Infiltration Testing**

|   |                                       |  |
|---|---------------------------------------|--|
| <b>Location:</b> Reed Road Subdivision                      | <b>Date:</b> June 1, 2018             | <b>Test Hole:</b> TH-#11                     |
| <b>Depth to Bottom of Hole:</b> 2.0 feet                    | <b>Hole Diameter:</b> 6 inches        | <b>Test Method:</b> Encased Falling Head     |
| <b>Tester's Name:</b> Daniel M. Redmond, P.E., G.E.         |                                       |  |
| <b>Tester's Company:</b> Redmond Geotechnical Services, LLC |                                       | <b>Tester's Contact Number:</b> 503-285-0598 |
| <b>Depth (feet)</b>   | <b>Soil Characteristics</b>           |  |
| 0-0.5   | Dark brown Topsoil                    |  |
| 0.5-2.0   | Medium brown, clayey, sandy SILT (ML) |  |
|   |                                       |  |
|   |                                       |  |

| Time  | Time Interval (Minutes) | Measurement (inches) | Drop in Water (inches) | Infiltration Rate (inches/hour) | Remarks            |
|-------|-------------------------|----------------------|------------------------|---------------------------------|--------------------|
| 10:10 | 0                       | 12.00                | ----                   |                                 | Filled w/12" water |
| 10:30 | 20                      | 12.30                | 0.30                   | 0.90                            |                    |
| 10:50 | 20                      | 12.53                | 0.23                   | 0.69                            |                    |
| 11:10 | 20                      | 12.70                | 0.17                   | 0.51                            |                    |
| 11:30 | 20                      | 12.83                | 0.13                   | 0.39                            |                    |
| 11:50 | 20                      | 12.93                | 0.10                   | 0.30                            |                    |
| 12:10 | 20                      | 13.01                | 0.08                   | 0.24                            |                    |
| 12:30 | 20                      | 13.08                | 0.07                   | 0.21                            |                    |
| 12:50 | 20                      | 13.15                | 0.07                   | 0.21                            |                    |
|       |                         |                      |                        |                                 |                    |

Infiltration Test Data Table

# **Appendix "B"**

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**Geologic Hazard Assessment**

# NORTHWEST GEOLOGICAL SERVICES, INC.

*Consulting Geologists and Hydrogeologists*  
2505 N.E. 42<sup>nd</sup> Avenue, Portland, Oregon 97213-1201  
503-249-1093 nwgeological@gmail.com

**Redmond Geotechnical Services**  
**P. O. Box 20547**  
**Portland, Or 97294**

**20 June 2018**

Attention: Dan Redmond

**Geologic Hazard Assessment**  
**Reed Rd SE Site**  
**8S/3W– 11D TLs 100, 101, 200, 400 & 601**  
**8S/3W - 12B TL 1600**  
**Salem, Oregon**

Dear Dan:

The purpose of this letter is to present Northwest Geological Services, Inc. (NGS) Geologic Hazard Assessment for the above referenced properties as per your verbal authorization of 2 February 2018. We understand that our services are in support of your client's effort to subdivide and develop the site.

## **1. Purpose and Scope of Study**

The City slope hazard database indicates that the site has a hazard score of from 2 to 3 points. City of Salem Planning rules indicate that site requires a geologic hazard assessment. The purpose of this letter is to meet that requirement.

For the study we conducted the following tasks:

- Reviewed DOGAMI hazard studies and maps of the area;
- Obtained GIS survey and Hazard maps from City of Salem Public Works;
- Reviewed geologic and topographic maps for the site area;
- Reviewed aerial imagery (1944-2017);
- Observed samples from three test pits and conducted a brief site reconnaissance; and
- Prepared this letter.

## **2. Site Setting and Slopes**

The subject property consists of six Tax lots totaling 46.28 acres located north of Kuebler Blvd and east of Battle Creek and Reed Roads SE in Salem, Oregon (Figures 1 and 2).

The highest elevations are on the NNE-SSW ridge extending across the site. Elevations range from about 426 at the east edge of TL 101 down to 260 along the creek at the north end of TL 200 and 270 at the NE corner of TL 1600 (Figure 2). The steepest natural slopes are ~12 acres of 17% – 20% in the center of TL 100 with two small (1/3 acre) patches of slope up to 24%. The steepest slopes are man-made and up to 50% for Kuebler Blvd SE and Battle Creek Rd SE. The gentlest slopes are on the alluvial terrace above the creek in TL 200 and in TL 1600 and in the summit area in TL 101.

Figure 3 shows 1967 and 2017 aerial photos of the site and adjacent area. Our review of aerial photos<sup>1</sup> and reconnaissance indicates that the cuts for Battle Creek Rd were made before 1944 and

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<sup>1</sup> We reviewed photos and images from 1944 through 2014, see Section 7, References.

widened in the 1980s. The aerial photo shows the large cut for Kuebler immediately south of the site was built between 1984 and 1994. All natural and man-made cuts appear stable.

The aerial photos also indicate that the site has been fallow scrubland, pasture and/or used to grow grasses or grains since the mid 1940s. Presently the site is covered by grasses and scrub with scattered wooded areas.

### 3. Site Engineering Geology

According to published mapping (Foxworthy, 1970; Bella, 1981; Beeson & Tolan, 2001) and our geologic mapping for Marion County (NGS, 1997), most of the site is underlain by the Sentinel Bluffs flows of the Columbia River Basalt (Figure 4). The summit area, above about 350 ft, is underlain by the Silver Falls flow. The lowest area along Reed Rd SE is underlain by the Winter Water flows. Slopes below 400 ft were scoured by the Missoula Floods 13,000 to ~ 50,000 years ago (Waitt, 1985). Flood scour removed much of the soil below about 400 leaving generally thinner soils and/or weathered basalt.

The basalt flows are mantled by a few feet of red-brown clayey SILT and weathered to severely weathered. The severely weathered to decomposed basalt is weathered to a hard to very hard clayey silt (laterite). The Silver Falls flows are more open-textured than the older flows and thus more susceptible to weathering. Consequently, the residual soils from weathering of those flow are deeper than those at lower elevations.

Three test pits were excavated at the site to confirm the depth to basalt and the nature of the overlying soils for the geologic hazards study. Figure 5 shows the locations of the test pits. Hard decomposed basalt was found at shallow depths in test pits TP-2 and -3 (Table 1, below). Additionally, alluvial silt fills the low area along the stream paralleling Reed Rd SE<sup>2</sup>.

Table 1 - Test Pit Data

| Geologic Unit            | TP-1       | TP-2       | TP-3       |
|--------------------------|------------|------------|------------|
| Topsoil                  | 0 - 0.7 ft | 0 - 0.7 ft | 0 - 0.7 ft |
| Brown clayey, sandy SILT | 0.7 - 8 ft |            |            |
| Red brown clayey SILT    |            | 0.7 - 2 ft | 0.7 - 6 ft |
| Weathered Basalt         |            | 2 - 6 ft   | 6 ft       |
| Total Depth              |            | 6 ft       | 6 ft       |

The residual soils in TP-2 was stiff and bedrock was present below 2 ft. The silt in TP-3 was medium stiff and graded down to highly weathered basalt by 6 ft. TP-2 was dug near the bottom of the Sentinel Bluffs basalt where the basalt is generally comprised of large blocks or columns and is generally only slightly weathered. TP-3 was located within the flow top zone where the basalt is usually vesicular and moderately to severely weathered. However, even the undisturbed weathered - or even decomposed - basalt is very competent.

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<sup>2</sup> Additional test pits were excavated for the geotechnical investigation.

## 4. Geologic Hazards

The available geologic mapping indicates a lack of potential geologic hazards at the site or to the proposed subdivision development (Figure 4). Our mapping and the test pits show the site is underlain by a few feet of stiff to hard soils with weathered basalt at shallow depths. However, several years ago DOGAMI estimated a “low to intermediate” relative earthquake risk for the site area (Wang & Leonard, 1996).<sup>3</sup> Additionally DOGAMI recently added potential landslide susceptibility ranking to its SLIDO web site. That ranking shows the site with a moderate to high susceptibility to landslides. Finally, the City of Salem shows some slopes steep enough to present a level 2 to 3 risk (on a scale of 0 to 6).

### 4.1 GMS-105 Estimated Earthquake Hazards

GMS-105 (Wang & Leonard, 1996) show the following relative earthquake hazard risks:

- Liquefaction susceptibility: 0 on a scale of 0 (none) to 5 (high) based on an estimated lack of potentially liquefiable soil in the subsurface.
- Amplification susceptibility: 1 to 5 depending on location across the site on a scale of 0 (low) to 5 (high). This ranking is supposedly based on an estimated presence of unconsolidated or soft soils in the subsurface.
- Landslide susceptibility: 1 to 2 on scale of 0 (low) to 5 (high) based on slopes of less than 6% up to 15%.
- Overall Relative Earthquake Hazard: Zone C (low to intermediate) for the development area on scale of D (low) to A (highest) based on combination of the above hazards. However the thicker and softer alluvial soil along the creek in TL 200 is Zone B (intermediate to high).

Our reconnaissance of the site indicates that areas shown "moderate" or "high" hazard by GMS-105 are, in fact, the man made slopes and very localized features of a few feet in amplitude. Additionally, the test pits and nearby cut slopes demonstrate a lack of soil or rock susceptible to slope failure on slopes as low as those at the site. Thus on-the-ground geologic reconnaissance indicates that there are no geologic or topographic features that create seismic induced slope failure risk beyond that of adjacent areas shown as "no risk" areas by GMS-105.

### 4.2 DOGAMI Landslide Susceptibility

The landslide susceptibility maps are derived from generalized digital geologic maps, evaluation of LIDAR imagery and comparison with information for existing nearby landslides (Burns and others, 2012). They are not maps of landslides. Rather, they denote areas that should be evaluated by a qualified professional Engineering Geologist. They are similar to – but more advanced – than the City of Salem risk maps that are based mainly on slope and the presence of nearby landslides.

### 4.3 Actual Potential for Earthquake or Water Induced Geologic Hazards

The site has gentle to moderate slopes. There are no natural slopes at the site steep enough to fail during an earthquake. Site soils below 3 to 3.5 ft depth are stiff to hard, thus limiting the potential for lateral spreading. Possibly, GMS-105 overestimated this risk because the GIS indicated a “steep slope” somewhere in an estimation cell that included the site. The City GIS map we obtained shows no steep slopes present other than the small areas associated with the man made cuts and the 2 small patches of slope >20%. However, the lack of elevated risk for seismic induced slope failure does not imply a lack of seismic risk. The site is subject to the same strong ground motions from local or

---

<sup>3</sup> The newer DOGAMI earthquake risk map (IMS-17 by Hofmeister & others, 2000) does not extend to the site.

distant earthquakes as are similar shallow bedrock sites throughout the area. The existing natural slopes appear stable with respect to saturation. However, steep cuts into them or fills place on them may be less stable than the natural slope.

## 5. Conclusions and Recommendations

The site is gently to moderately sloped and has a very low susceptibility to landsliding under any natural geologic circumstance, in our opinion. In our experience, the weathered basalt is not susceptible to slope spreading or liquefaction during strong ground motions from earthquakes. The basalt bedrock is at shallow depth and is not susceptible to failure during earthquakes beneath the existing site slopes. Thus, the site does not appear to be at significant risk from the forms of slope instability evaluated by GMS-105 or the DOGAMI landslide susceptibility maps. In our opinion, development of this site should not create new or exacerbate existing geologic hazards. However, we caution that any fills at the site may be subject to failure or settlement during strong ground motions. As noted above, cuts into the natural slopes may be less stable than the existing slope. Consequently, we recommend that foundations, cuts and fills should be designed by a qualified professional using recommendations from your geotechnical investigation.

In our experience, the decomposed and weathered basalt have relatively low permeability. Consequently, the thin soil overlying the basalt may become fully saturated during intense precipitation or after prolonged intervals of moderate precipitation. We recommend provision be made for on site storm water retention and off site disposal. The system should be designed by a qualified professional.

## 6. LIMITATIONS AND LIABILITY

We call your attention to the paragraphs on Warranty and Liability in the General Conditions (dated 1/2018) that you previously approved. Interpretations and recommendations presented herein are based on limited data and observations. Actual subsurface conditions may vary from those inferred from the limited information available to us. If site excavations for development find conditions to differ significantly from those inferred herein, you should contact us and provide an opportunity for us to review our recommendations for the site.

We thank you for the opportunity to assist you with your project. Please contact me if you have questions about the report.

Yours very truly,  
Northwest Geological Services, Inc.  
Clive F. (Rick) Kienle, Jr.  
Principal Engineering Geologist  
and Vice President

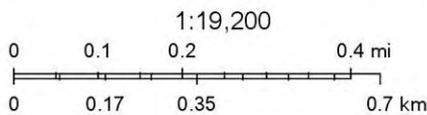
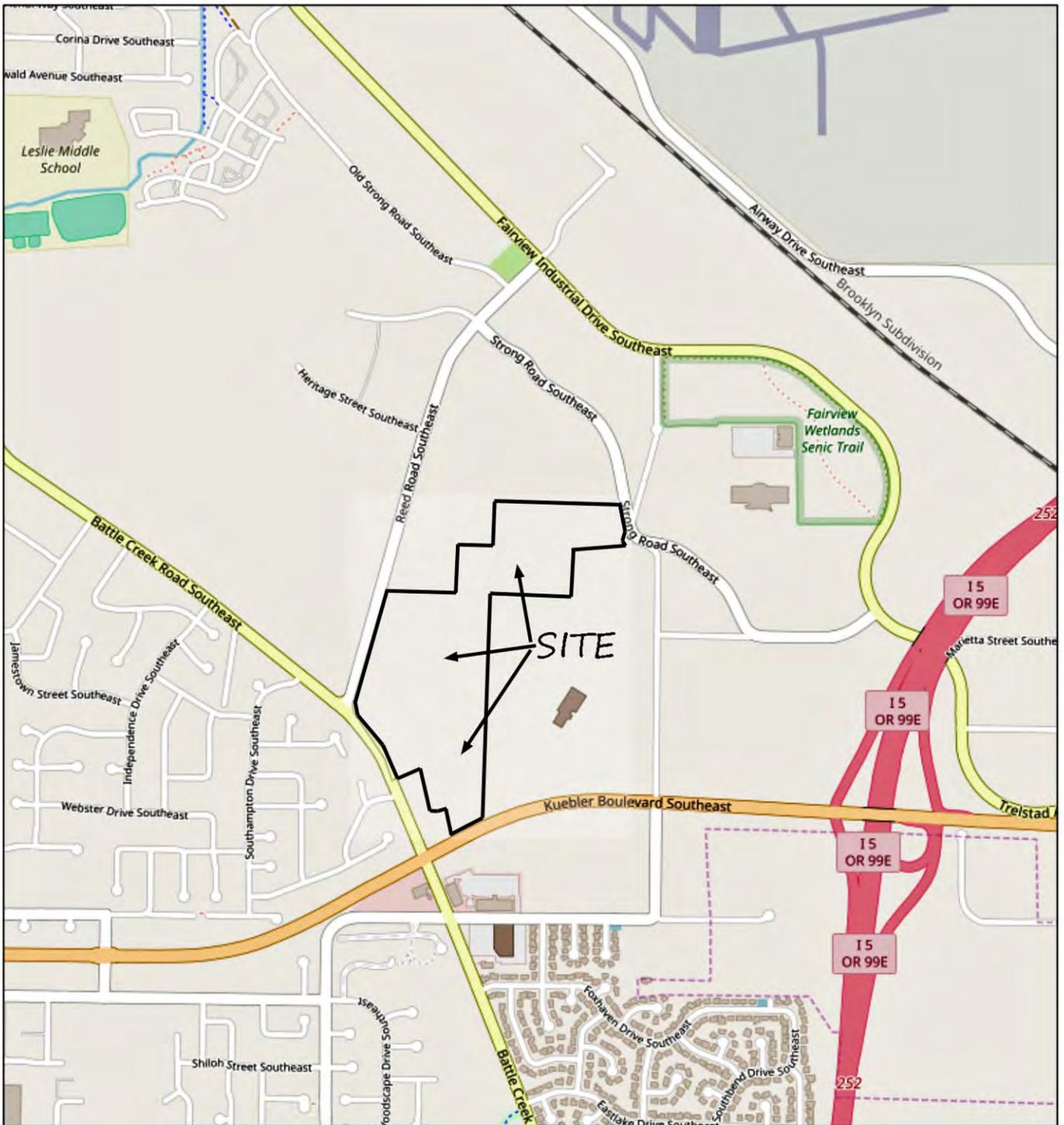


NGS Reference 235.104-1

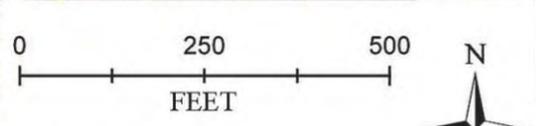


## 7. References

- Aerial Photographs & Imagery: US Geological Survey – 1944, 10 August 1954, 16 October 1967, 3 July 1973, 18 June 1994, 23 July 2000, 29 February 2008; USDA Farm Service Agency – 17 August 2003; WAC Corp – 28 March 1990; State of Oregon – 28 June 2005, 8 July 2010; Google, Inc. – 6 October 2017.
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|   |           |                 |
|---|-----------|-----------------|
| <b>Reed Rd SE Site</b>                                  |           |                 |
| <b>8S/3W-11D-100, 101, 200, 400 &amp; 601; 12B-1600</b> |           |                 |
| <b>Geologic Assessment</b>                              |           |                 |
| <b>Site Location Map</b>                                |           |                 |
| NGS, Inc.   | June 2018 | <b>Figure 1</b> |



Map provided by City of Salem Public Works Dept.

24% ← Areas with natural slope > 20%

**Legend**

|   |                    |                 |
|---|--------------------|-----------------|
| + | Spot elevation     | <b>Contours</b> |
| □ | Taxlot boundary    | — 2 ft          |
| — | Creek              | — 10 ft         |
| ■ | Building footprint |                 |

|  |           |                 |
|--|-----------|-----------------|
| <b>Reed Rd SE Site</b>                       |           |                 |
| 8S/3W-11D-100, 101, 200, 400 & 601; 12B-1600 |           |                 |
| <b>Geologic Assessment</b>                   |           |                 |
| <b>Site LIDAR Topography Map</b>             |           |                 |
| NGS, Inc.                                    | June 2018 | <b>Figure 2</b> |



|  |           |                 |
|--|-----------|-----------------|
| <b>Reed Rd SE Site</b>                       |           |                 |
| 8S/3W-11D-100, 101, 200, 400 & 601; 12B-1600 |           |                 |
| <b>Geologic Assessment</b>                   |           |                 |
| <b>1967 &amp; 2017 Aerial Photos</b>         |           |                 |
| NGS, Inc.                                    | June 2018 | <b>Figure 3</b> |

1967 photo from US Geological Survey  
 2017 from Digital Globe

Geologic Units

Sedimentary units

Qal - Stream alluvium

Qoal - older alluvium

Volcanic Rocks (Miocene age)

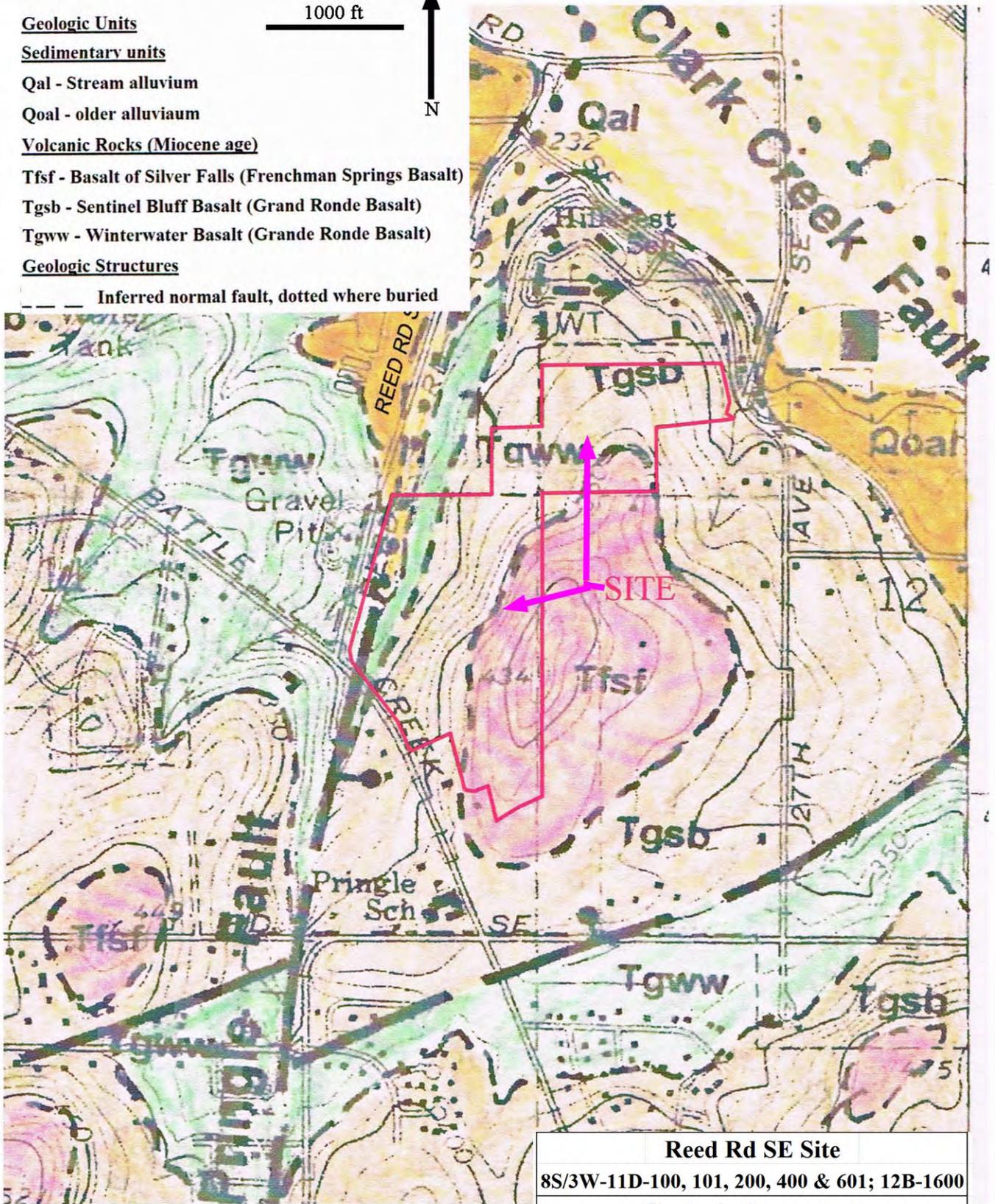
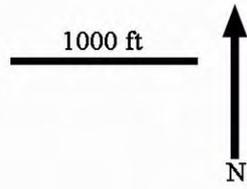
Tfsf - Basalt of Silver Falls (Frenchman Springs Basalt)

Tgsb - Sentinel Bluff Basalt (Grand Ronde Basalt)

Tgww - Winterwater Basalt (Grande Ronde Basalt)

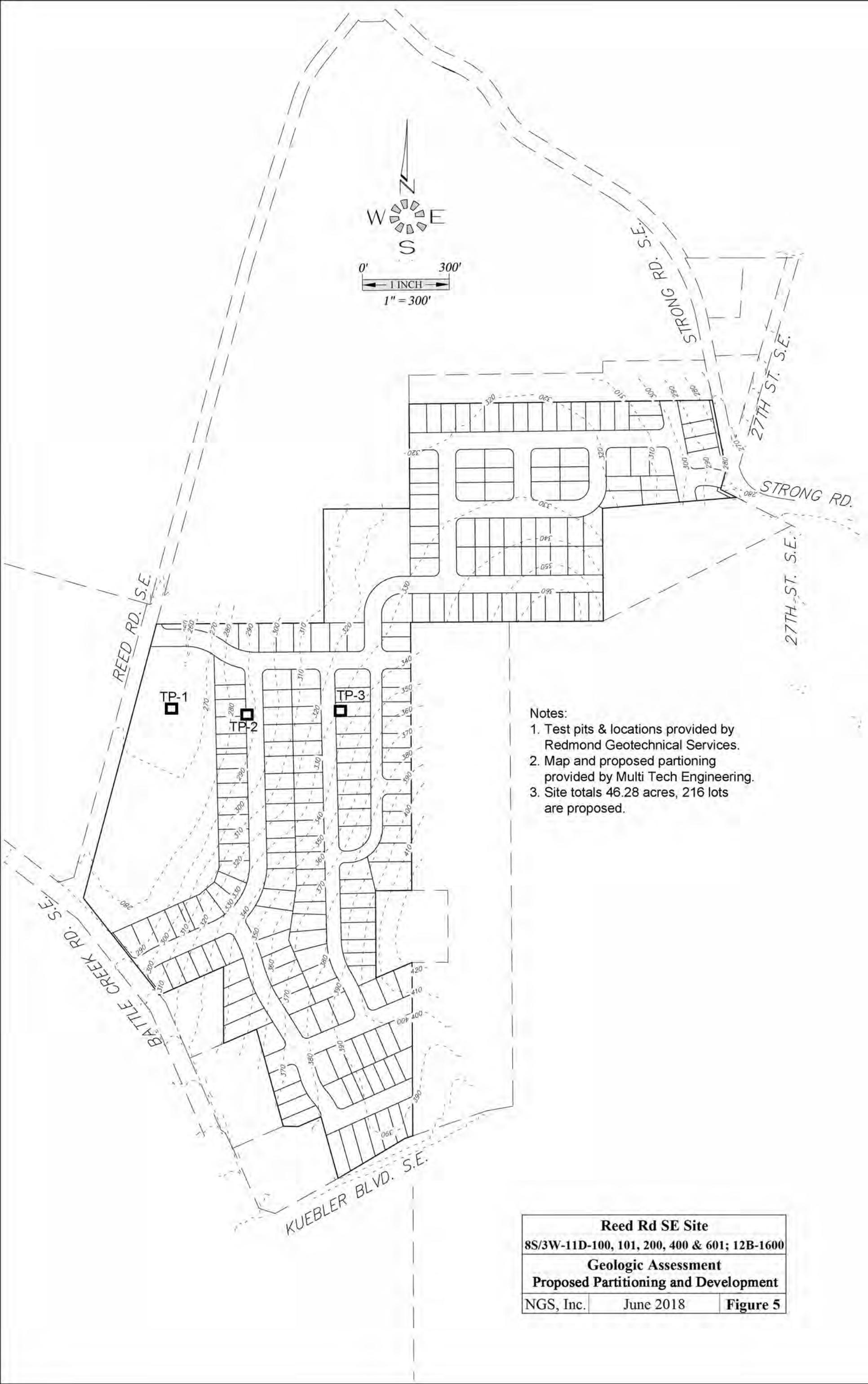
Geologic Structures

--- Inferred normal fault, dotted where buried



Geology from Beeson & Tolan (2001)

|  |           |          |
|--|-----------|----------|
| Reed Rd SE Site                              |           |          |
| 8S/3W-11D-100, 101, 200, 400 & 601; 12B-1600 |           |          |
| Geologic Assessment                          |           |          |
| Site Area Geology                            |           |          |
| NGS, Inc.                                    | June 2018 | Figure 4 |



- Notes:
1. Test pits & locations provided by Redmond Geotechnical Services.
  2. Map and proposed partitioning provided by Multi Tech Engineering.
  3. Site totals 46.28 acres, 216 lots are proposed.

|  |           |                 |
|--|-----------|-----------------|
| <b>Reed Rd SE Site</b>                       |           |                 |
| 8S/3W-11D-100, 101, 200, 400 & 601; 12B-1600 |           |                 |
| <b>Geologic Assessment</b>                   |           |                 |
| <b>Proposed Partitioning and Development</b> |           |                 |
| NGS, Inc.                                    | June 2018 | <b>Figure 5</b> |