Attachment 18

GEOTECHNICAL REPORT

Hawks Glen
17656 NE 116th Street
Redmond, Washington

Project No. T-7103

Terra Associates, Inc.

Prepared for:

Quadrant Homes
Bellevue, Washington

August 29, 2014
Revised February 10, 2016
Revised February 25, 2016
Revised April 11, 2016
Revised June 14, 2016

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TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

August 29, 2014
Revised February 10, 2016
Revised February 25, 2016
Revised April 11, 2016
Revised June 14, 2016
Project No. T-7103

Mr. Matt Perkins
Quadrant Homes
14725 SE 36th Street, Suite 200
Bellevue, Washington 98006

Subject: Geotechnical Report
Hawks Glen
17656 NE 116th Street
Redmond, Washington

Dear Mr. Perkins:

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

Our study indicates the site soils generally consist of about six to ten inches of topsoil overlying glacial deposits comprised predominantly of silty fine sand to fine sandy silt with varying amounts of gravel and cobbles, and occasional boulders. We observed light seepage of perched groundwater in one test pit between depths of about five to seven feet.

In our opinion, there are no geotechnical conditions that would preclude the planned residential development. Residences can be supported on conventional spread footings bearing on competent native soils underlying the organic surface soils or on structural fill placed on competent native soils. Floor slabs and pavements can be similarly supported.

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Detailed recommendations addressing these issues and other geotechnical design considerations are presented in the attached report. We trust the information presented is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

John C. Sadler

John C. Sadler, L.E.G., L.H.G.
Project Manager

Carolyn S. Decker 6/14/16

47016

Carolyn S. Decker, P.E.
Project Engineer

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1.0 PROJECT DESCRIPTION

The proposed project is a residential development. A grading plan by The Blueline Group (Blueline) dated February 25, 2016 indicates that the property will be developed with 27 single-family residential lots located in the central and southern portions of the site. Proposed site grading consists predominantly of fills with maximum thicknesses ranging between about 2 feet and 6.5 feet.

Site stormwater will be detained in a buried vault in the northeastern portion of the planned development area. Preliminary dimensions shown on the plan indicate the vault will be 85 feet long and 65 feet wide. Based on our conversations with Blueline, we understand that the bottom of the vault will be approximately 18 feet below existing ground surface.

Building plans are not available; however, we expect that the residences would be two-story, wood-frame structures, with their main floors constructed at grade. Foundation loads should be relatively light, in the range of 2 to 3 kips per foot for bearing walls and 25 to 50 kips for isolated columns.

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

2.0 SCOPE OF WORK

We explored subsurface conditions at the site by observing conditions in 8 test pits excavated to maximum depths of about 7 to 8.5 feet below existing surface grades using a track-mounted excavator. Using the results of our field study and laboratory testing, analyses were undertaken to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions
- Geologic hazards per the Redmond Zoning Code
- Seismic design parameters per the current International Building Code (IBC)
- Site preparation and grading
- Excavations
- Foundations

- Slab-on-grade floors
- Infiltration feasibility
- Stormwater detention
- Drainage
- Utilities
- Pavements

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

3.0 SITE CONDITIONS

3.1 Surface

The site is a 9.76-acre parcel located northwest of and adjacent to the intersection of NE 116th Street and 178th Place NE in Redmond, Washington. The approximate location of the site is shown on Figure 1.

Existing site improvements include a vacant single-family residence and several outbuildings. Existing surface grades are relatively flat with a gentle gradient down to the south-southeast. Available topographic information on a conceptual grading and utility plan by Goldsmith Land Development Services (Goldsmith) dated August 6, 2014 indicates that maximum surface gradients in the planned development area are about 6 to 7 percent. Vegetation in the planned development area consists primarily of mowed pasture grasses and lawn.

The portion of the property located north of the planned development area consists primarily of mature conifer forest. A natural drainage ravine runs south through the wooded area before exiting at the east site margin approximately 400 feet south of the northeast property corner. The available topographic information indicates that the ravine sideslopes are about 12 to 18 feet high with inclinations ranging between about 27 and 43 percent.

Gravity block retaining walls support roadway fills for NE 116th Street adjacent to the southern site margin and for 178th Place NE adjacent to the southern approximately 180 feet of the eastern site margin. The wall heights range between about 2 and 6 feet along 178th Place NE and about 7 to 8 feet along NE 116th Street.

Supplemental Site Visit

In January 2016, we visited the subject site to view existing shallow perforated pipes installed previously by the property owner. Based on our observations, it appears that all of the existing on-site perforated pipes were intended to intercept and convey surface water and shallow perched interflow to the downgradient eastern side of the property. Passive dewatering devices that we observed include several shallow ditches dug along the western site margin; several rows of sand bags placed on the ground surface along the western site margin; and a network of shallow perforated pipes in the pasture areas located in the southern approximately 620 feet of the site.

We did not observe any pipes installed to drain water from ditches along the western site margin. However, we observed a 2-foot long vertical section of 2-foot diameter plastic pipe in the ditch located west of the detached garage/shop building that likely served as a sump for periodic pumping. We did not observe any indications of permanent pipes or pump installations in this area.

The ditches we observed on the western site margin contained standing water to the adjacent ground surface or just below the ground surface. We observed an accumulation of surface water on the upgradient western side of the detached garage/shop building and in a localized topographic depression in the pasture, near the eastern site margin. We also observed localized areas of surface water in the undeveloped property immediately west of the subject site.

We observed a light flow of water draining into a corrugated metal culvert at the eastern property margin, east-southeast of the residence. We anticipate that the water was discharging from one or more of the shallow perforated pipes installed in the southeastern portion of the pasture; however, we were unable to confirm this. We were unable to locate the discharge location(s) of the shallow perforated pipes in the northeastern portion of the pasture to verify that they were functioning.

3.2 Soils

The soils observed in the test pits consist of about six to ten inches of sod and overlying glacial deposits comprised predominantly of silty fine sand to fine sandy silt with varying amounts of gravel and cobbles, and occasional boulders. The soils observed in the upper approximately five to seven feet of the test pits were typically medium dense, moist, and mottled. With the exceptions of Test Pits TP-1 and TP-2, the upper medium dense soils were generally slightly clayey.

We observed medium dense to dense, weakly cemented, till-like silty sand with gravel below depths of about five to seven feet in six of the eight test pits. Approximately 2.5 feet of outwash sand overlies the till-like soils in Test Pit TP-2.

The *Geologic map of the Redmond quadrangle, King County Washington*, by J.P. Minard and Derek B. Booth (1988) shows site geology mapped as Vashon till (Qvt). The medium dense to dense, weakly cemented silty sand with gravel that we observed below depths of about five to seven feet in six of the test pits is generally consistent with the relative density and texture of till. The trace to slightly clayey, silty fine sand/fine sandy silt with scattered gravel and trace to scattered cobbles and 1.5-foot diameter boulders observed overlying the till-like deposits are interpreted to be an ice contact deposit.

Detailed descriptions of the subsurface conditions we observed in the test pits are presented on the Test Pit Logs in Appendix A. The approximate locations of the test pits are shown on Figure 2.

3.3 Groundwater

We observed light groundwater seepage between depths of about five and seven feet in Test Pit TP-2. The groundwater at this location occurs within an outwash sand layer that is perched above medium dense to dense till-like soils. The near-surface silt and silty fine sand soils observed in the test pits are typically mottled indicating that a shallow perched groundwater table has developed at times. Based on our study, the perched groundwater observed between five and seven feet is localized to a laterally-discontinuous outwash layer in the area of Test Pit TP-2, and is not representative of the shallow perched groundwater condition indicated by the presence of mottling in soils just below the topsoil.

The occurrence of shallow perched groundwater is typical for sites underlain by till and other relatively impermeable soils. We expect that perched groundwater levels and flow rates will fluctuate seasonally and will typically reach their highest levels during and shortly following the wet winter months (October through May). We expect that the groundwater conditions observed during our August 2014 field work are representative of seasonal low levels.

The development of a fluctuating seasonal perched groundwater table at the site has been documented by shallow monitoring performed by Wetland Resources, Inc. during the winter and spring of 2014. The Wetland Resources, Inc. report dated June 10, 2014 also documents the presence of saturated surface soils and localized standing water, which are both consistent with a shallow perched groundwater table.

In January 2016, we hand excavated several shallow test holes upgradient from the localized accumulation of surface water in the eastern portion of the pasture. The observed soils consist of about seven to eight inches of sod and moist to wet topsoil overlying medium dense to dense silt. Groundwater seepage observed in the test holes is perched above the silt within the topsoil layer. This is consistent with the findings of our previous studies and the Wetland Resources, Inc. monitoring. Based on our observations, it is our opinion that direct precipitation and shallow interflow from upgradient areas are the predominant sources of the surface water observed at the site.

3.4 Geologic Hazards

We evaluated site conditions for the presence of geologic hazards. Section 21.64.060 (Geologically Hazardous Areas) of the City of Redmond Zoning Code (RZC) defines geologically hazardous areas as erosion hazard areas, landslide hazard areas, and seismic hazard areas.

3.4.1 Erosion Hazard Areas

Section 21.64.060A.1.a of the RZC defines erosion hazard areas as "...lands or areas underlain by soils identified by the U.S. Department of Agriculture Soil Conservation Service (SCS) as having "severe" or "very severe" rill and inter-rill erosion hazards. This includes, but is not limited to, the following group of soils when they occur on slopes of 15 percent or greater: Alderwood-Kitsap (AkF), Alderwood gravelly sandy loam (AgD), Kitsap silt loam (KpD), Everett (EvD), and Indianola (InD)."

The Soil Conservation Service (SCS) has classified the soils underlying the west and east portions of the site as Alderwood gravelly sandy loam, 6 to 15 percent slopes (AgC). Alderwood soils are described as formed over till, which is generally consistent with the soils observed in the test pits. The SCS describes the erosion hazard of AgC soils as moderate, which does not meet the criteria for an erosion hazard area.

However, the site soils will be susceptible to erosion when exposed during construction. In our opinion, proper implementation and maintenance of Best Management Practices (BMPs) for erosion prevention and sedimentation control will adequately mitigate the erosion potential in the planned development area. Erosion protection measures as required by the City of Redmond will need to be in place prior to and during grading activity on the site.

3.4.2 Landslide Hazard Areas

Section 21.64.060A.1.b of the RZC defines landslide hazard areas as "…areas potentially subject to significant or severe risk of landslides based on a combination of geologic, topographic, and hydrogeologic factors.

They include areas susceptible because of any combination of bedrock, soil, slope, slope aspect, structure, hydrology, or other factors. They are areas of the landscape that are at a high risk of failure or that presently exhibit downslope movement of soil and/or rocks and that are separated from the underlying stationary part of the slope by a definite plane of separation. The plane of separation may be thick or thin and may be composed of multiple failure zones depending on local conditions, including soil type, slope gradient, and groundwater regime." Landslide hazard areas include the following:

i. Areas of historic failures, such as:
    a. Areas designated as quaternary slumps or landslides on maps published by the United States Geologic Survey (USGS).
    b. Those areas designated by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) as having a "severe" limitation for building site development.

ii. Areas containing a combination of slopes steeper than 15 percent, springs or groundwater seepage, and hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock.

iii. Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of that epoch.

iv. Slopes that are parallel or subparallel to planes of weakness in subsurface materials.

v. Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking.

vi. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action.

vii. Any area with a slope 40 percent or steeper with a vertical relief of 10 feet or more.

Localized areas of the ravine sideslopes in the northern portion of the site are steeper than 40 percent with slope heights ranging between about 12 feet and 18 feet. This geometry meets the criteria for a landslide hazard area given in above Item vii. These slope areas will not be impacted by the proposed site development. They are located more than 150 feet away from the planned development area, and located within, and are protected by the 150-foot stream buffer.

3.4.3 Seismic Hazard Areas

Section 21.64.060A.1.c of the RZC defines seismic hazard areas as "...lands subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, soil liquefaction, or surface faulting."

Based on the soil and groundwater conditions we observed at the site, it is our opinion that the risk for damage resulting from earthquake induced slope failure, ground settlement, surface faulting, or soil liquefaction is negligible. Therefore, in our opinion, unusual seismic hazard areas do not exist at the site, and design in accordance with local building codes for determining seismic forces would adequately mitigate impacts associated with ground shaking.

3.5 Seismic Design Parameters

Based on the site soil conditions and our knowledge of the area geology, per the 2012 International Building Code (IBC), site class "C" should be used in structural design. Based on this site class, in accordance with the 2012 IBC, the following parameters should be used in computing seismic forces:

Seismic Design Parameters (IBC 2012)

Spectral response acceleration (Short Period), S_{Ms}	1.254 g
Spectral response acceleration (1 – Second Period), S_{M1}	0.635 g
Five percent damped .2 second period, S_{Ds}	0.836 g
Five percent damped 1.0 second period, S_{D1}	0.424 g

Values determined using the United States Geological Survey (USGS) Ground Motion Parameter Calculator accessed on August 28, 2014 at the web site http://earthquake.usgs.gov/designmaps/us/application.php.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

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

The site soils contain a sufficient amount of fines (silt- and clay-sized particles) such that they will be difficult to compact as structural fill when too wet or too dry. If grading activities will take place during the winter season, the owner should be prepared to import free-draining granular material for use as structural fill and backfill.

Based on our study, it is our opinion that removal of the on-site perforated pipes would not have a significant impact on the existing shallow groundwater conditions at the site. Assuming that the shallow perforated pipes are functioning properly, it is likely that their removal would result in some increase of the duration of the seasonal perched groundwater condition at the site; however, we do not anticipate that this potential increase in duration would result in seasonal surface ponding that differs significantly from current conditions. This is supported by surface conditions shown on historical aerial photographs that show no indication of persistent surface water at the site in photographs dating to 1936.

In our opinion, the potential for interception and drainage of shallow interflow by buried utilities can be mitigated by constructing trench barriers or dams at regular intervals along the sanitary and storm sewer utilities using less permeable material. The construction interval of the trench barriers would typically be about 200 feet, but will depend on field conditions observed at the time of construction. A typical trench barrier detail is attached as Figure 3.

We anticipate that shallow interflow will be incepted in the proposed cut areas in the northwestern portion of the planned development area. Shallow interflow that is intercepted by drainage associated with rockery/retaining wall, buried structures, or footing drains will be conveyed to the on-site detention vault. The vault will release controlled flow to a closed system that conveys the water under 178th Avenue NE and discharges into the Monticello Creek drainage, which is the natural downgradient receptor of interflow from the subject site. Because all interflow collected by site drainage systems will be routed to the project stormwater system, it is our opinion that potential adverse impacts to interflow recharge to the Monticello Creek drainage will be negligible.

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

4.2 Site Preparation and Grading

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

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

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

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

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

*Based on the 3/4-inch fraction.

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

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-698 (Standard Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas, the degree of compaction can be reduced to 90 percent.

4.3 Excavations

All excavations at the site associated with confined spaces, such as lower building level retaining walls, must be completed in accordance with local, state, and federal requirements. Based on the Washington State Safety and Health Administration (WSHA) regulations, the medium dense to dense native soils would typically be classified as Type C soils. Unweathered, dense to very dense till and till-like soils would typically be classified as Type A soils.

Accordingly, for temporary excavations of more than 4 feet and less than 20 feet in depth, the side slopes in Type C soils should be laid back at a slope inclination of 1.5:1 (Horizontal:Vertical) or flatter. Temporary excavations in Type A soils can be laid back at inclinations of 0.75:1 or flatter. For temporary excavation slopes less than 8 feet in height in Type A soils, the lower 3.5 feet can be cut to a vertical condition with a 0.75:1 slope graded above. For temporary excavation slopes greater than 8 feet in height up to a maximum height of 12 feet, the slope above the 3.5-foot high vertical portion should be laid back to an inclination of 1:1 or flatter. No vertical cut with a backslope immediately above is allowed for excavation depths that exceed 12 feet. In this case, a 4-foot high vertical cut with an equivalent horizontal bench to the cut slope toe is required. If there is insufficient room to complete the excavations in the manners discussed above, or if excavations greater than 20 feet deep are planned, you may need to use temporary shoring to support the excavations.

Seepage of perched groundwater should be anticipated within excavations extending to the dense to very dense till and till-like soils, particularly in the vicinity of Test Pit TP-2. In our opinion, the volume of water and rate of flow into the excavation should be relatively minor and would not be expected to impact the stability of the excavations when completed as described above. Conventional sump pumping procedures along with a system of collection trenches, if necessary, should be capable of maintaining a relatively dry excavation for construction purposes in these soils.

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

4.4 Foundations

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

Perimeter foundations exposed to the weather should bear at a minimum depth of 1.5 feet below final exterior grades for frost protection. Interior foundations can be constructed at any convenient depth below the floor slab. We recommend designing foundations for a net allowable bearing capacity of 2,500 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used in design. With the anticipated loads and this bearing stress applied, building settlements should be less than one-half inch total and one-fourth inch differential.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressure acting on the sides of the footings may also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pounds per cubic foot (pcf). We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundations will be constructed neat against competent native soil or the excavations are backfilled with structural fill, as described in Section 4.2 of this report. The recommended passive and friction values include a safety factor of 1.5.

4.5 Slab-on-Grade Floors

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

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

4.6 Infiltration Feasibility

Based on the conditions observed in our test pits, it is our opinion that on-site infiltration is not a viable option for management of site stormwater. Based on the presence of mottling in the vast majority of soils observed at the site, it is also our opinion that the site conditions would generally not be suitable for applying other natural drainage practices (NDPs).

4.7 Stormwater Detention

As discussed, on-site detention of stormwater runoff will be provided by a buried vault located in the northeastern portion of the planned development area. We did not have the conceptual vault location or dimensions at the time of our subsurface exploration, and therefore, did not investigate subsurface conditions to the proposed bottom of vault elevation. We anticipate that dense to very dense glacial deposits exist at the planned bottom of vault elevation; however, this should be verified prior to construction.

Vault foundations supported by dense to very dense native soils at a depth greater than 8 feet may be designed for an allowable bearing capacity of 5,000 psf. For short-term loads, such as seismic, a one-third increase in this allowable capacity can be used. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressure acting on the sides of the vault footings may also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pounds per cubic foot (pcf).

The magnitude of earth pressures developing on the vault walls will depend in part on the quality and compaction of the wall backfill. We recommend placing and compacting wall backfill as structural fill as recommended in Section 4.2.

To prevent development of hydrostatic pressure and uplift on the vault, wall drainage must be installed. A typical recommended wall drainage detail is shown on Figure 4. If it is not possible to discharge collected water at the footing invert elevation, we recommend setting the invert elevation of the wall drainpipe equivalent to the outfall invert and connecting the drain to the outfall pipe for discharge.

With the recommended wall backfill and drainage, we recommend designing the vault walls for an earth pressure imposed by an equivalent fluid weighing 50 pcf. For any portion of the wall that falls below the invert elevation of the wall drain, an earth pressure equivalent to a fluid weighing 85 pcf should be used. For evaluating walls under seismic loading, an additional uniform earth pressure equivalent to 8H psf, where H is the height of the below-grade wall in feet, can be used. These values assume a horizontal backfill condition. If necessary, a uniform horizontal traffic surcharge value of 75 psf should be included in design of vault walls.

The vault will be subject to uplift pressures if drainage is not provided the full depth of the structure. The weight of the structure and the weight of the backfill soil above its foundation will provide resistance to uplift. A soil unit weight of 125 pcf can be used for the vault backfill provided the backfill is placed and compacted as structural fill as recommended in Section 4.2.

4.8 Drainage

Surface

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

Subsurface

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

4.9 Utilities

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

4.10 Pavements

Pavement subgrade should be prepared as described in the Section 4.2 of this report. Regardless of the degree of relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. The subgrade should be proofrolled with heavy rubber-tire construction equipment such as a loaded 10-yard dump truck to verify this condition.

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. For residential access, with traffic consisting mainly of light passenger vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of hot mix asphalt (HMA) over six inches of crushed rock base (CRB)
- Five inches full depth HMA over prepared subgrade

The paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for ½-inch class HMA and CRB.

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

5.0 ADDITIONAL SERVICES

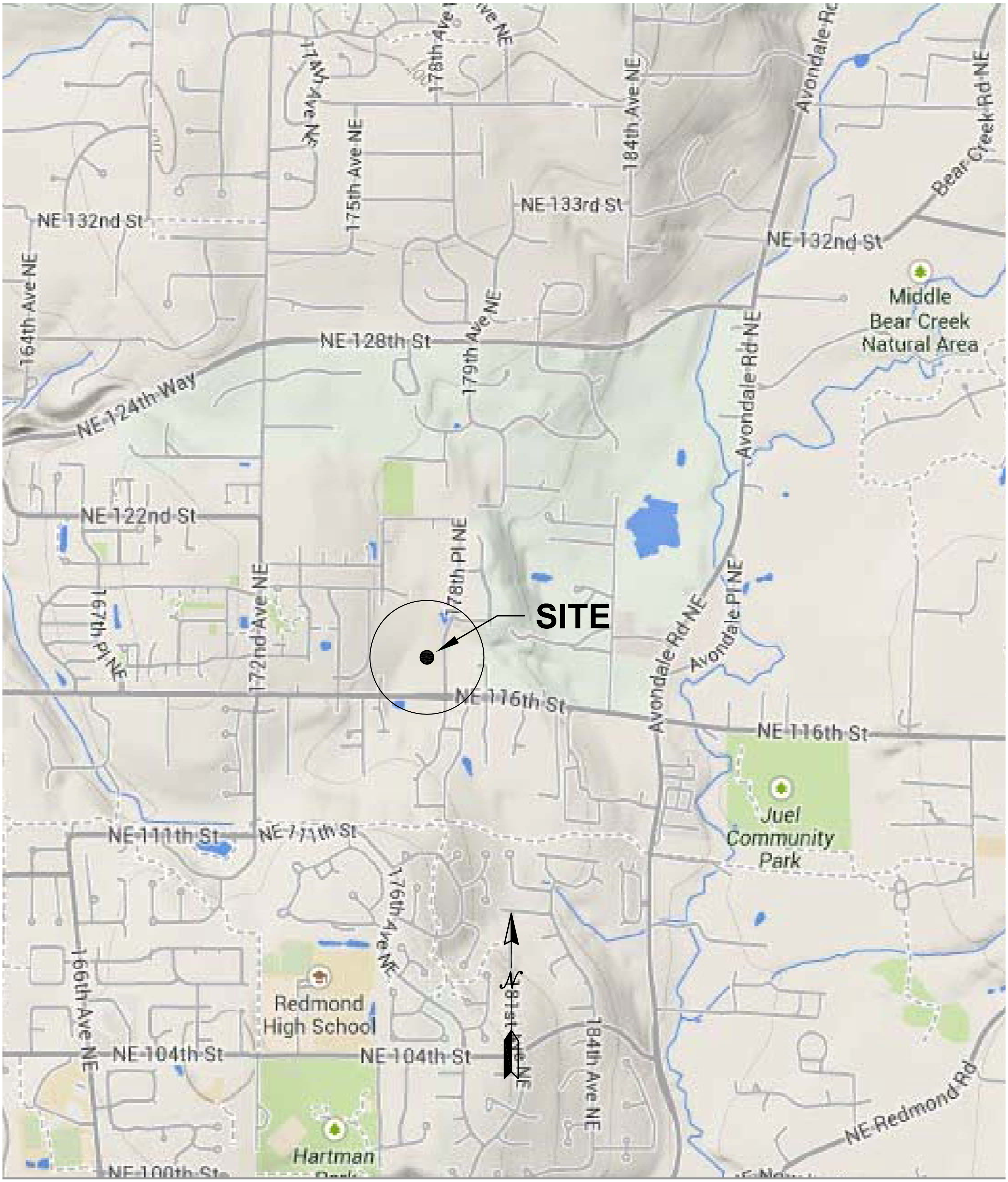
Terra Associates, Inc. should review the final designs and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical services during construction in order to observe compliance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

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Hawks Glen project. This report is for the exclusive use of Quadrant Homes and their authorized representatives. No other warranty, expressed or implied, is made.

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

Attachment 18

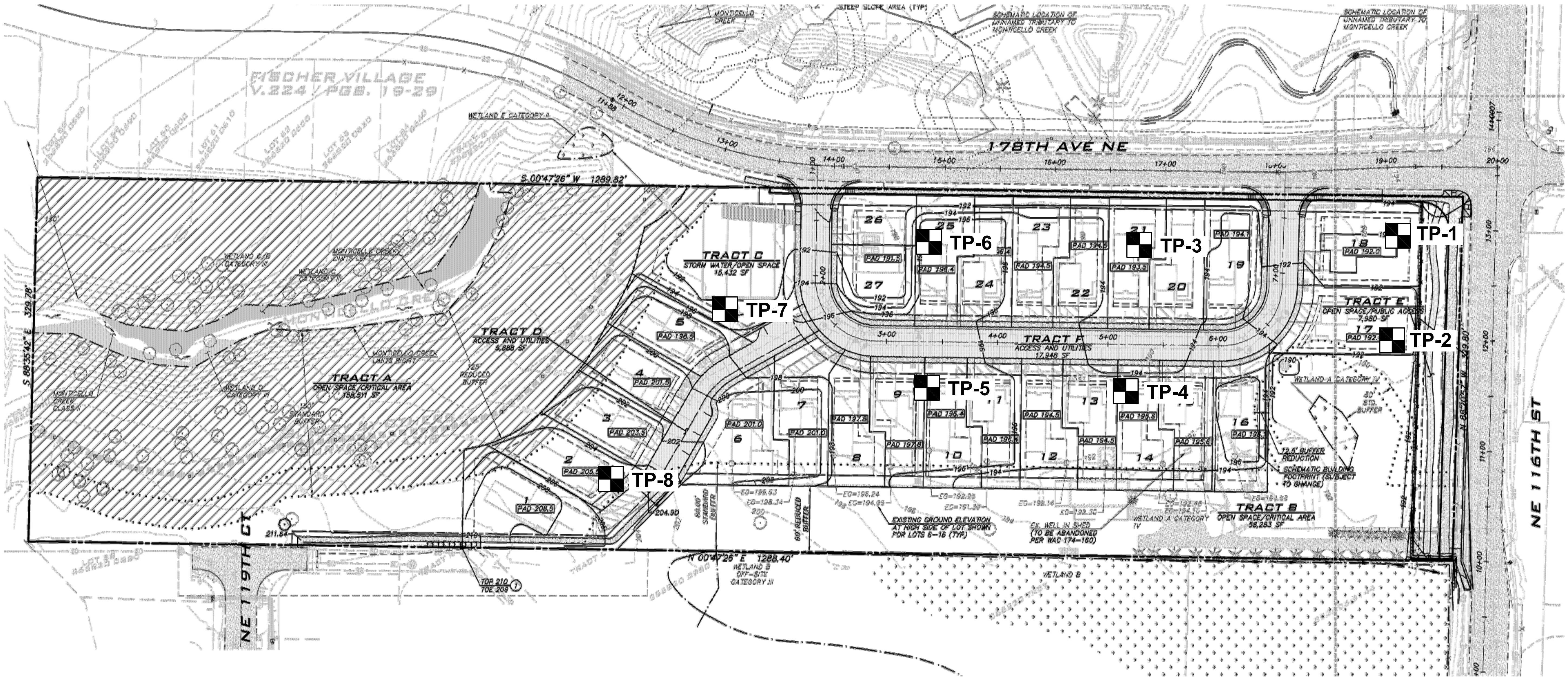


Terra Associates, Inc.

Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

VICINITY MAP
HAWKS GLEN
REDMOND, WASHINGTON

Proj. No.T-7103	Date JUN 2016	Figure 1



NOTE:

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

REFERENCE:

SITE PLAN BY THE BLUELINE GROUP (2-25-16)

LEGEND:

▚ APPROXIMATE TEST PIT LOCATION (AUGUST 2014)

0 100 200

APPROXIMATE SCALE IN FEET

Terra Associates, Inc.
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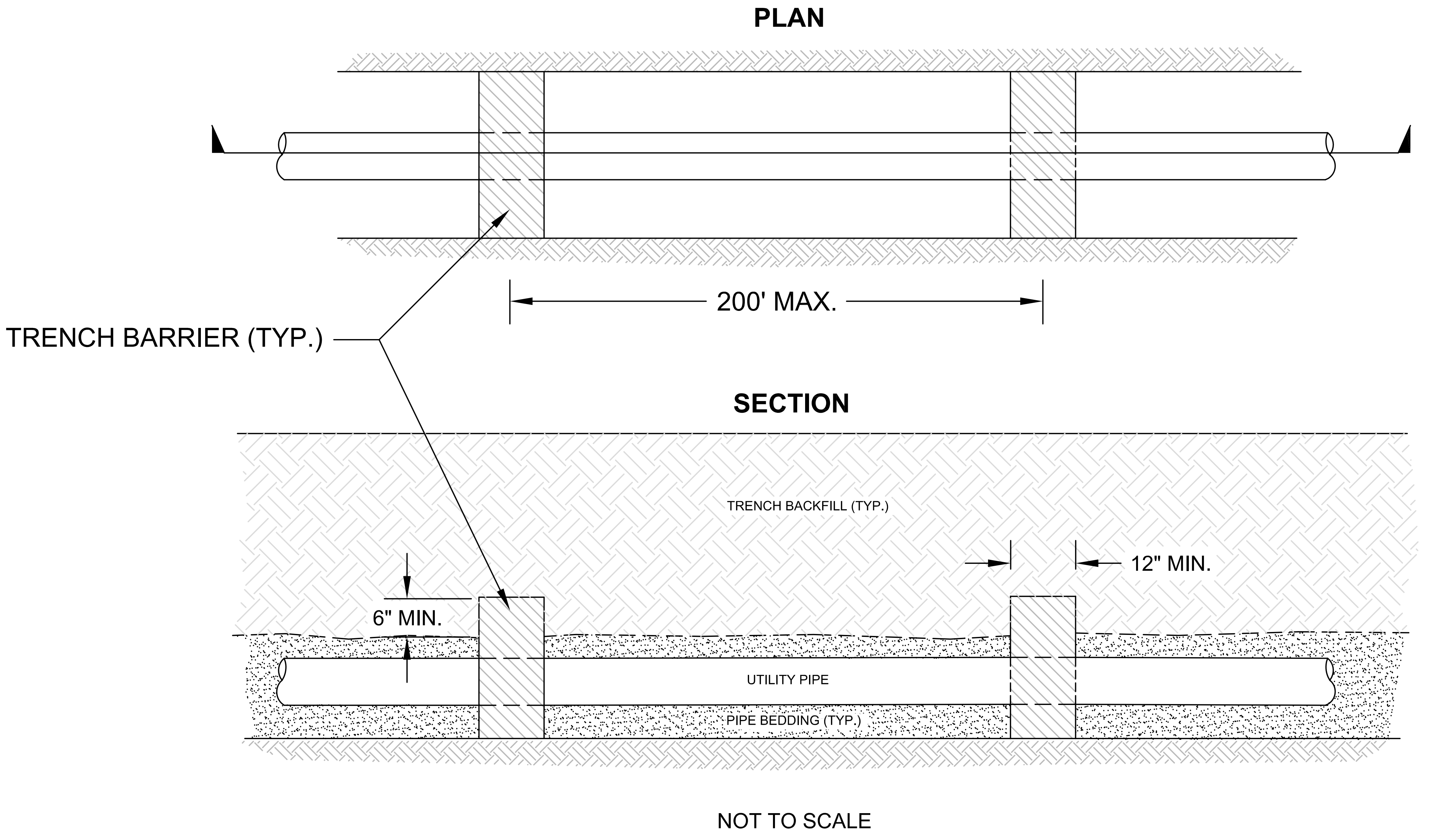
EXPLORATION LOCATION PLAN
HAWKS GLEN
REDMOND, WASHINGTON

Proj. No.T-7103	Date JUN 2016	Figure 2



NOT TO SCALE

NOTE: TRENCH BARRIER TO CONSIST OF MECHANICALLY COMPACTED SOIL HAVING AT LEAST 30 PERCENT FINES.

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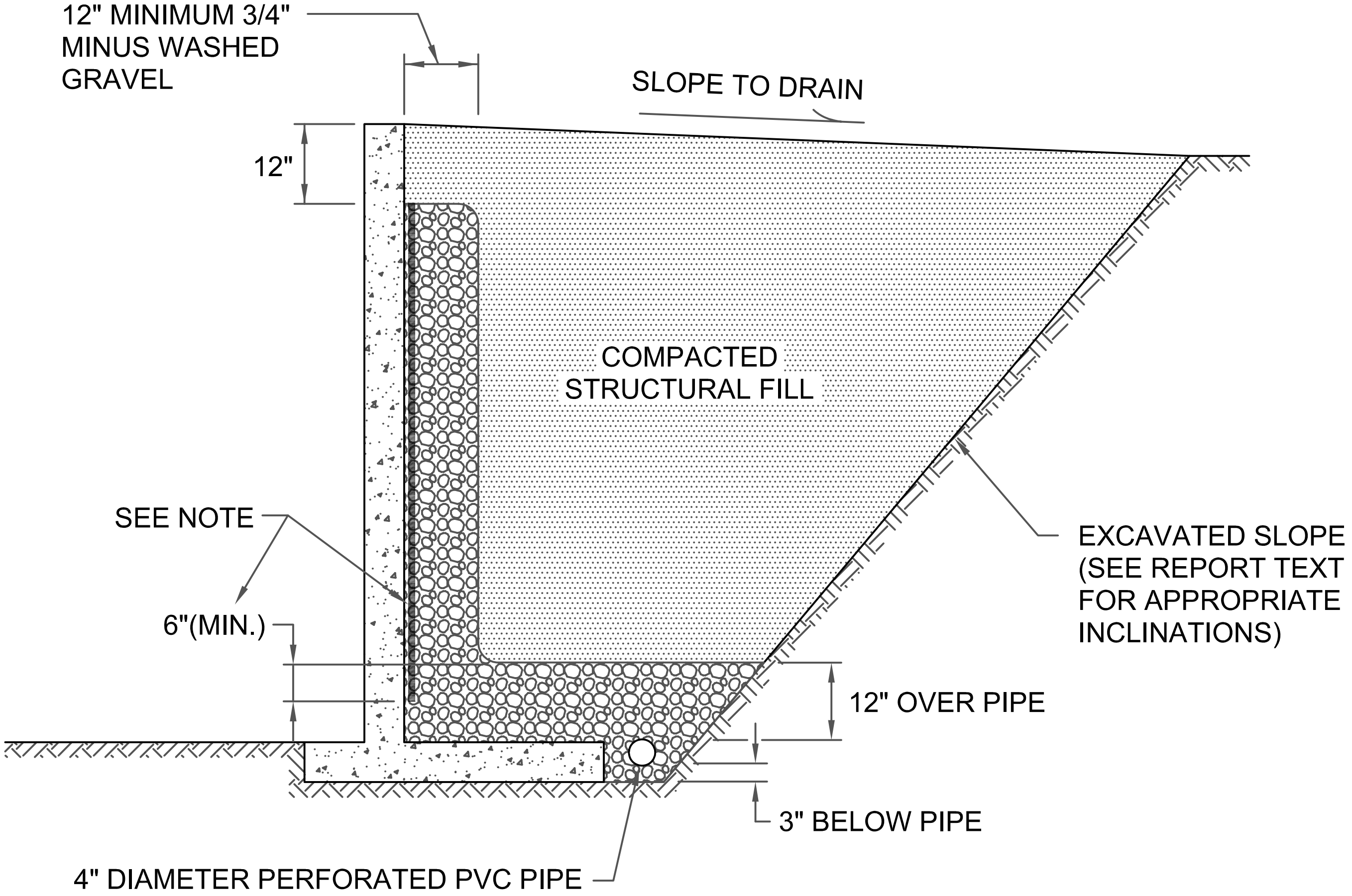
Environmental Earth Sciences

TYPICAL UTILITY TRENCH BARRIER DETAIL
HAWKS GLEN
REDMOND, WASHINGTON

Proj. No.T-7103
Date JUN 2016
Figure 3



NOT TO SCALE

NOTE:

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

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TYPICAL WALL DRAINAGE DETAIL
HAWKS GLEN
REDMOND, WASHINGTON

Proj. No.T-7103	Date JUN 2016	Figure 4

Attachment 18

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Hawks Glen
Redmond, Washington

On August 20, 2014, we investigated subsurface conditions at the site by excavating 8 test pits to maximum depths of about 7 to 8.5 feet below existing surface grades using a track-mounted excavator. The test pit locations are shown on Figure 2. The test pit locations were approximately determined in the field by sighting and pacing from existing surface features. The Test Pit Logs are presented on Figures A-2 through A-9.

An engineering geologist from our office maintained a log of each test pit as it was excavated, classified the soil conditions encountered, and obtained representative soil samples. All soil samples were visually classified in the field in accordance with the Unified Soil Classification System. A copy of this classification is presented as Figure A-1.

Representative soil samples obtained from the test pits were placed in sealed plastic bags and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the Test Pit Logs. Grain size analyses were performed on three of the soil samples. The results are shown on Figure A-10.

Attachment 18

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

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

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

COHESIVE

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

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

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UNIFIED SOIL CLASSIFICATION SYSTEM
HAWKS GLEN
REDMOND, WASHINGTON

Proj. No.T-7103 | Date JUN 2016 | Figure A-1

LOG OF TEST PIT NO. 1

FIGURE A-2

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 186

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		10 inches Sod and Topsoil. Gray to light brown fine sandy SILT, dry to moist, mottled. (ML)			
1					
2					
3				27.9	
			Medium Dense		
4					
		Gray-brown to brown silty fine SAND, moist, mottled. (SM)			
5					
6				18.0	
7		Gray silty SAND with gravel, moist, weakly cemented. (SM) (Till like)			
			Medium Dense to Dense		
8				16.2	
		Test pit terminated at 8.5 feet. No groundwater seepage.			
9					
10					

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

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

Attachment 18

LOG OF TEST PIT NO. 2

FIGURE A-3

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 187

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** 5' **DEPTH TO CAVING:** 6' - 7'

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		9 inches Sod and Topsoil. Gray to light brown fine sandy SILT, dry to moist, mottled. (ML)			
1					
2					
3				26.1	
			Medium Dense		
4					
		Gray SAND to SAND with silt, moist to wet, scattered gravel, trace of cobbles. (SP/SP-SM/SW/SW-SM)			
▼ 5					
				17.1	
6					
7		Gray silty SAND with gravel, moist, weakly cemented. (SM) (Till like)	Medium Dense to Dense	14.9	
8		Test pit terminated at 8 feet. Light groundwater seepage between 5 and 7 feet. Minor sloughing between 6 and 7 feet.			
9					
10					

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

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Consultants in Geotechnical Engineering, Geology and Environmental Earth Sciences

Attachment 18

LOG OF TEST PIT NO. 3

FIGURE A-4

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 186

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		8 inches Sod and Topsoil. Light brown, trace to slightly clayey, fine sandy SILT, dry, mottled, trace to scattered gravel. (ML)			
1					
2				20.0	
		Gray and brown, trace to slightly clayey, fine sandy SILT, moist, mottled, trace to scattered gravel. (ML)	Medium Dense		
3					
4					
5		Gray silty fine SAND with gravel, moist, weakly cemented, mottled between 5 and 7 feet. (SM)			
6			Medium Dense to Dense		
7					
8		Test pit terminated at 8 feet. No groundwater seepage.			
9					
10					

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

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Attachment 18

LOG OF TEST PIT NO. 4

FIGURE A-5

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 188

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
1 2		8 inches Sod and Topsoil. Light brown, trace to slightly clayey, fine sandy SILT, dry, mottled, trace to scattered gravel. (ML)	Medium Dense		
3 4		Gray and brown, trace to slightly clayey, fine sandy SILT, moist, mottled, trace to scattered gravel. (ML)			
5 6		Gray silty fine SAND with gravel, moist, weakly cemented, mottled between 5 and 7 feet, trace of fine charcoal fragments. (SM)	Medium Dense to Dense		
7 8 9 10		Test pit terminated at 7 feet. No groundwater seepage.			

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

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Attachment 18

LOG OF TEST PIT NO. 5

FIGURE A-6

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 188

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		7 inches Sod and Topsoil. Light brown to light gray-brown, trace to slightly clayey, silty fine SAND with gravel to trace to slightly clayey, fine sandy SILT with gravel, dry, mottled, trace of cobbles. (SM/ML)			
1					
2					
3				11.5	
		- Becomes moist below 3.5 feet.	Medium Dense		
4					
5					
6					
7					
		Test pit terminated at 7.5 feet. No groundwater seepage.			
8					
9					
10					

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

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and Environmental Earth Sciences

Attachment 18

LOG OF TEST PIT NO. 6

FIGURE A-7

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 187

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		7 inches Sod and Topsoil. Light brown to light gray-brown, trace to slightly clayey, silty fine SAND with gravel to trace to slightly clayey, fine sandy SILT with gravel, dry, mottled, trace of cobbles. (SM/ML)			
1					
2		- Becomes moist below 2 feet.			
3					
4			Medium Dense		
5					
6					
7					
8		Test pit terminated at 8 feet. No groundwater seepage.			
9					
10					

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

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Attachment 18

LOG OF TEST PIT NO. 7

FIGURE A-8

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 190

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		6 inches Sod and Topsoil. Brown silty SAND with gravel, dry. (SM)			
1			Medium Dense		
2		Gray-brown to gray, trace to slightly clayey, silty fine SAND to trace to slightly clayey, fine sandy SILT, moist, mottled, scattered gravel, trace of cobbles and 1.5-foot diameter boulders. (SM/ML)			
3					
4				21.1	
5			Medium Dense to Dense		
6		Gray to gray-brown silty fine SAND with gravel, moist, mottled. (SM)		16.0	
7					
8		Test pit terminated at 7.5 feet. No groundwater seepage.			
9					
10					

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

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and Environmental Earth Sciences

Attachment 18

LOG OF TEST PIT NO. 8

FIGURE A-9

PROJECT NAME: Hawks Glen **PROJ. NO:** T-7103 **LOGGED BY:** JCS

LOCATION: Redmond, Washington **SURFACE CONDS:** Grass **APPROX. ELEV:** 201

DATE LOGGED: 8-20-14 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

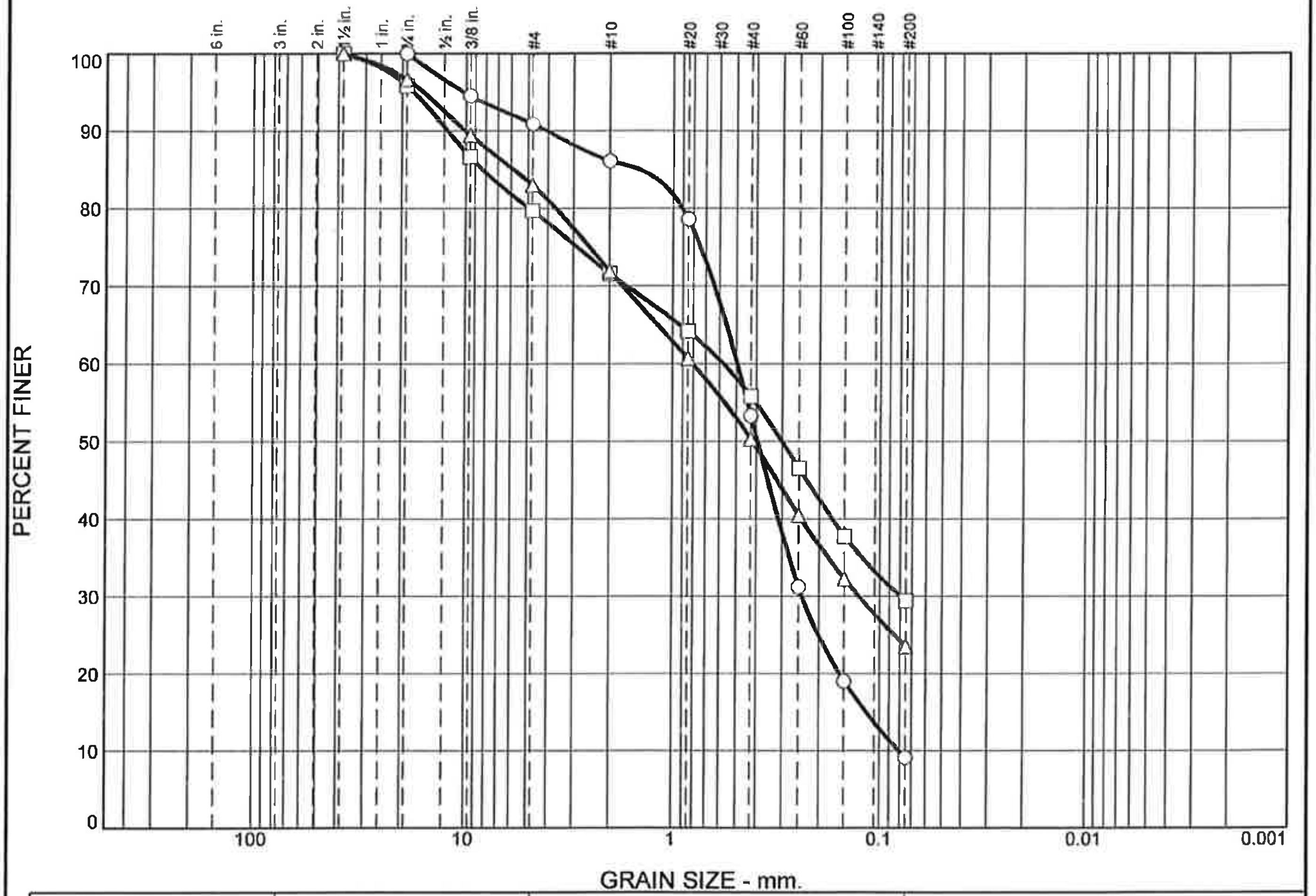
DEPTH (FT.)	SOIL SAMPLE	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)
		6 inches Sod and Topsoil. Red-brown silty SAND with gravel, dry. (SM)			
1					
		Gray to light brown silty SAND with gravel, moist, mottled, scattered cobbles. (SM)	Medium Dense		
2					
3		Gray to light brown, trace to slightly clayey, silty fine SAND to trace to slightly clayey, fine sandy SILT, moist, mottled, scattered cobbles. (SM/ML)			
4			Medium Dense to Dense		
5		Gray to brown-gray silty SAND with gravel, moist, weakly cemented. (SM) (Till like)		11.1	
6			Dense		
7		Test pit terminated at 7 feet. No groundwater seepage.			
8					
9					
10					

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

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

Attachment 18

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	9.1	4.8	32.8	44.2	9.1	
□	0.0	4.2	16.1	8.1	15.8	26.4	29.4	
△	0.0	3.4	13.6	11.1	21.6	26.8	23.5	

╳	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			1.4499	0.4953	0.3948	0.2410	0.1166	0.0805	1.46	6.15
□			8.3117	0.5763	0.3024	0.0794				
△			5.8466	0.8067	0.4179	0.1277				

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

Project No. T-7103 **Client:** Quadrant Homes

Project: Hawks Glen

○ **Location:** TP-2 **Depth:** 5.5'
□ **Location:** TP-5 **Depth:** 3'
△ **Location:** TP-8 **Depth:** 5.5'

Terra Associates, Inc.

Kirkland, WA

Remarks:
○Tested 8-28-14
□Tested 8-28-14
△Tested 8-28-14

Figure A-10

Tested By: FQ

Attachment 18

APPENDIX B

EXISTING SHALLOW DRAINAGE REVIEW

Attachment 18

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

January 26, 2016
Project No. T-7103

Mr. Matt Perkins
Quadrant Homes
14725 SE 36th Street, Suite 200
Bellevue, Washington 98006

Subject: Existing Shallow Drainage Review
Hawks Glen
17656 NE 116th Street
Redmond, Washington

References:
1. Critical Aquifer Recharge Areas Report, Project No. T-7103, prepared by Terra Associates, Inc., dated September 8, 2015
2. Geotechnical Report, Ray Meadows, Project No. T-7103, prepared by Terra Associates, Inc., dated August 29, 2014

Dear Mr. Perkins:

As requested, we visited the subject site to view existing shallow drainage measures installed by the former property owner. The purpose of our work is to evaluate potential impacts to the shallow groundwater regime at the site if the existing drainage measures were removed.

Based on our observations, it appears that all of the on-site drainage measures were intended to intercept surface water and shallow perched interflow, and to convey the collected water to the downgradient eastern side of the property. Passive drainage measures that we observed include several shallow ditches dug along the western site margin; several rows of sand bags placed on the ground surface along the western site margin; and a network of shallow interceptor drains/conveyance pipes in the pasture areas located in the southern approximately 620 feet of the site.

We did not observe any pipes installed to drain water from ditches along the western site margin. However, we observed a 2-foot long vertical section of 2-foot diameter plastic pipe in the ditch located west of the detached garage/shop building that likely served as a sump for periodic pumping. We did not observe any indications of permanent pipes or pump installations in this area.

The ditches we observed on the western site margin contained standing water to the adjacent ground surface or just below the ground surface. We observed an accumulation of surface water on the upgradient western side of the detached garage/shop building and in a localized topographic depression in the pasture, near the eastern site margin. We also observed localized areas of surface water in the undeveloped property immediately west of the subject site. We were unable to locate the discharge locations of the shallow interceptor drains/conveyance pipes to verify that the drains/conveyance pipes were functioning.

Attachment 18

We hand excavated several shallow test holes upgradient from the localized accumulation of surface water in the eastern portion of the pasture. The observed soils consist of about 7 to 8 inches of sod and moist to wet topsoil overlying medium dense to dense silt. Groundwater seepage observed in the test holes is perched above the silt within the topsoil layer. This is consistent with the findings of our previous studies.

Based on our previous studies and recent field observations, it is our opinion that removal of the on-site shallow interceptor drains/conveyance pipes would not have a significant impact on the existing shallow groundwater conditions at the site. Assuming that the shallow interceptor drain/conveyance pipes are functioning properly, it is likely that their removal would result in some increase of the duration of the seasonal perched groundwater condition at the site; however, we do not anticipate that this potential increase in duration would result in seasonal surface ponding that differs significantly from current conditions. This is supported by surface conditions shown on historical aerial photographs that show no indication of persistent surface water at the site in photographs dating to 1936.

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

Sincerely yours,
TERRA ASSOCIATES, INC.

John C Sadler
1-26-16

John C. Sadler, L.E.G., L.H.G.
Project Manager/Engineering Geologist

State of Washington
Engineering Geologist
1218
Licensed Geologist
JOHN C. SADLER

Attachment 18

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

January 26, 2016
Revised February 25, 2016
Project No. T-7103

Mr. Matt Perkins
Quadrant Homes
14725 SE 36th Street, Suite 200
Bellevue, Washington 98006

Subject: Existing Shallow Drainage Review
Hawks Glen
17656 NE 116th Street
Redmond, Washington

References:
1. Critical Aquifer Recharge Areas Report, Project No. T-7103, prepared by Terra Associates, Inc., dated September 8, 2015
2. Geotechnical Report, Ray Meadows, Project No. T-7103, prepared by Terra Associates, Inc., dated August 29, 2014

Dear Mr. Perkins:

As requested, we visited the subject site to view existing shallow agricultural drains installed previously by the property owner. The City of Redmond considers these shallow agricultural drains dewatering devices; therefore, throughout this report, the shallow agricultural drainage measures at the site are referred to as dewatering devices. The purpose of our work is to evaluate potential impacts to the shallow groundwater regime at the site if the existing dewatering devices were removed.

Based on our observations, it appears that all of the existing on-site dewatering devices were intended to intercept and convey surface water and shallow perched interflow to the downgradient eastern side of the property. Passive dewatering devices that we observed include several shallow ditches dug along the western site margin; several rows of sand bags placed on the ground surface along the western site margin; and a network of shallow interceptor drains/conveyance pipes in the pasture areas located in the southern approximately 620 feet of the site.

We did not observe any pipes installed to drain water from ditches along the western site margin. However, we observed a 2-foot long vertical section of 2-foot diameter plastic pipe in the ditch located west of the detached garage/shop building that likely served as a sump for periodic pumping. We did not observe any indications of permanent pipes or pump installations in this area.

The ditches we observed on the western site margin contained standing water to the adjacent ground surface or just below the ground surface. We observed an accumulation of surface water on the upgradient western side of the detached garage/shop building and in a localized topographic depression in the pasture, near the eastern site margin. We also observed localized areas of surface water in the undeveloped property immediately west of the subject site.

Attachment 18

We observed a light flow of water draining into a corrugated metal culvert at the eastern property margin, east-southeast of the residence. We anticipate that the water was discharging from one or more of the shallow dewatering devices/conveyance pipes installed in the southeastern portion of the pasture; however, we were unable to confirm this. We were unable to locate the discharge location(s) of the shallow dewatering devices/conveyance pipes in the northeastern portion of the pasture to verify that they were functioning.

We hand excavated several shallow test holes upgradient from the localized accumulation of surface water in the eastern portion of the pasture. The observed soils consist of about 7 to 8 inches of sod and moist to wet topsoil overlying medium dense to dense silt. Groundwater seepage observed in the test holes is perched above the silt within the topsoil layer. This is consistent with the findings of our previous studies.

Based on our previous studies and recent field observations, it is our opinion that removal of the on-site dewatering devices would not have a significant impact on the existing shallow groundwater conditions at the site. Assuming that the shallow dewatering devices/conveyance pipes are functioning properly, it is likely that their removal would result in some increase of the duration of the seasonal perched groundwater condition at the site; however, we do not anticipate that this potential increase in duration would result in seasonal surface ponding that differs significantly from current conditions. This is supported by surface conditions shown on historical aerial photographs that show no indication of persistent surface water at the site in photographs dating to 1936.

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

Sincerely yours,
TERRA ASSOCIATES, INC.

State of Washington
Engineering Geologist
1218
Licensed Geologist
JOHN C. SADLER

2-25-16

John C. Sadler, L.E.G., L.H.G.
Project Manager/Engineering Geologist

cc: Mr. Brett Pudists, Blueline