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Job No. 16-0055

Columbia Development
13110 NE 177th Place, Suite 202
Woodinville, Washington, 98072

Attn: **Mr. Bill Hegger**

Re: Geotechnical Engineering Investigation
Monroe Townhouses
17417 W. Main Street
Monroe, Washington

Dear Mr. Hegger:

As requested, GeoTest Services, Inc. is pleased to submit this report summarizing the results of our geotechnical engineering investigation for the above-referenced project. The purpose of this evaluation was to establish general subsurface conditions beneath the site from which conclusions and recommendations for project design could be formulated. Specifically, our scope of services included the following tasks:

- Exploration of soil and groundwater conditions underlying the site by conducting a total of 5 exploration test pits and 1 Pilot Infiltration Test (PIT) to evaluate subsurface conditions.

- Laboratory testing on representative samples in order to classify and evaluate the engineering characteristics and infiltration potential of the soils encountered.

- Provide this written report containing a description of subsurface conditions, test pit logs, and findings and recommendations pertaining to seismic design, site preparation and earthwork, fill and compaction, wet weather earthwork, foundation recommendations, concrete slab-on-grade construction, foundation and site drainage, stormwater design recommendations, preparation and geotechnical consultation and construction monitoring.

PROJECT DESCRIPTION

We understand that there are plans to construct a new 18 unit residential community at the above referenced project site. GTS anticipates that the new facility will be two-story structures utilizing wood frame construction. GTS anticipates that new construction will have shallow conventional foundations with slab-on-grade floors. Structural loads have not been provided but GTS expects that the loads will be relatively light.

The site is flat with less than a few feet of elevation differential across the property. The planned improvements are expected to require minor grading, but GTS does not expect that more than a few feet of cut or fill will be required to achieve desired finished grades.

GTS anticipates that the conventional infiltration of stormwater through infiltration ponds or raingardens will be incorporated as part of final design.

SITE CONDITIONS

This section discusses the general surface and subsurface conditions observed at the project site at the time of our field investigation. Interpretations of the site conditions are based on the results of our review of available information, site reconnaissance, subsurface explorations, laboratory testing, and our experience in the project vicinity.

Surface Conditions

The site is generally flat, with less than a few feet of elevation differential across the site. The subject lot is rectangular, oriented in a generally east/west direction lengthwise, and located along the north side of West Main Street. Native tree cover has been largely removed from the site, with existing vegetation consisting of mowed lawn with scattered clusters of trees. A single family residence and associated barn are located in the center and eastern portions of the lot. Surrounding areas are generally developed with low density residential structures. No surface water was observed at or in the vicinity of the site at the time of our investigation.

Subsurface Soil Conditions

Subsurface conditions were explored by advancing 5 exploration test pits (TP-1 though TP-5) on February 5, 2016. The explorations were advanced to depths of between 5 and 11 feet below ground surface (BGS) using a tracked excavator subcontracted by GeoTest.

The on-site subsurface soils generally consisted of approximately 4 to 8 inches of topsoil and sod over soft, orange tan to tan, wet, sandy silt (Alluvium). This soft Alluvium extends to depths of 3 to 5 feet BGS across the site, with medium dense to dense very gravelly, sand (Glacial Outwash) below and to the base of all explorations. The soft Alluvium appeared to be generally thickest to the east, and thinnest to the west.

See the attached Site and Exploration Map (Figure 2) and the Log of Test Pits (Figures 5 through 7) for more information regarding the approximate locations of the exploration pits and subsurface soil conditions encountered.

General Geologic Conditions

Geologic information for the project site was obtained from the interactive *Geologic Map of Washington State*, published by the Washington State Department of Natural Resources (DNR). According to the referenced maps, subsurface soils mapped near the project area consist of Quaternary Alluvium (Qa) at the project site and Glacial Outwash deltaic deposits (Qgod) to the east of the site.

Soils defined as Alluvium typically consist of irregularly layered sands and gravels deposited in river and stream channels, with silts, clays and peats deposited in the surrounding floodplain. Glacial Outwash deltaic deposits are described as sands and gravels deposited by meltwater flowing from glacial ice north of Monroe into Glacial Lake

Skykomish. Soils consistent with the mapped deposits were encountered during the subsurface exploration program.

Geologic Hazards and Recommended Mitigation

The site is flat and does not meet the criteria established in the Monroe Municipal Code for slope or erosion hazards and no specific mitigations for these hazards are required for this project

Site development is anticipated to include a Washington State Department of Ecology Construction Storm Water General Permit to mitigate the erosion potential of soils exposed during construction or site grading activities. In order to meet the criteria established by the Department of Ecology, an erosion control plan consistent with the governing municipal standards and best management practices will be required for this project. The contractor will be responsible for implementing the erosion control plan as established in the plans and specifications approved by the governing municipality for the project.

Seismic Hazard

Portions of the project site are located within a mapped liquefaction hazard area. The mapped potential for liquefaction is considered moderate to high throughout site. We interpret these classifications to be due to alluvial soils being mapped at the site. Alluvial soils are generally considered to be at greater risk of liquefaction due to typically lower densities. Medium dense to dense Glacial Outwash is generally considered to be at lower risk of liquefaction due to its higher densities.

Liquefaction is a process through which unconsolidated soil loses strength during a seismic event. Intense vibratory shaking can decrease soil shear strength through the disruption of grain-to-grain soil contact and an increase in the soil pore pressure. A soil is liquefied when the majority of the soil weight is supported by the pore pressure. Liquefaction can result in soil deformations and settlement of structures. Areas that are liquefiable typically include those areas underlain by low density sands or silts with high ground water conditions.

Geotest's experience with other properties in the area suggests a low liquefaction potential. The on-site explorations did, however, encounter an elevated ground water table in what we interpret to be dense Glacial Outwash. Based on regional conditions, encountered subsurface soil conditions, and the presence of an elevated groundwater table, it is our opinion that the liquefaction potential for this site is low under a design level earthquake, and as such, no specific mitigation of liquefaction potential is recommended. Conventional construction techniques in the area do not typically include mitigation for liquefaction hazards based on the mapped site rating or the type of anticipated construction.

Groundwater

At the time of our subsurface investigation in February of 2016, moderate to rapid groundwater seepage was encountered in all explorations at depths of 7 to 10.5 feet below existing site grades, with groundwater generally at shallower depth relative to the

ground surface at the east end of the site. We anticipate this seepage to be indicative of a region wide groundwater table.

The groundwater conditions reported on the exploration logs are for the specific locations and date indicated, and therefore may not necessarily be indicative of other locations and/or times. Groundwater levels are not static and groundwater conditions will vary depending on local subsurface conditions, precipitation, changes in site use, both on and off site, and other factors.

CONCLUSIONS AND RECOMMENDATIONS

Based upon evaluation of the data collected during this investigation, it is our opinion that subsurface conditions at the site are suitable for the proposed improvements, provided the recommendations contained herein are incorporated into the project design.

The near surface native Alluvium (sandy, silt) was observed to be in a soft and wet condition. It is GeoTest's opinion the fine-grained Alluvium is not suitable for foundation support due to risks associated with excessive long-term settlement. We recommend that all native Alluvium be removed from below foundation elements and building foundations derive their support from the medium dense to dense Glacial Outwash (very gravelly sand) encountered at depths of 3 to 5 feet below the ground surface (BGS). Provided relatively simple foundation layouts are incorporated into the project design, we anticipate removal and replacement with Controlled Density Fill (CDF) may be most economical option for foundation support. Alternatively, removal and replacement with structural fill or extension of the foundations to bear on the Glacial Outwash may also be feasible. Please refer to the Foundation Support and Settlement section below for further detail regarding these options.

We anticipate the native Alluvium will be suitable to support floor slabs and typical pavements. However, due to the unknowns associated weather conditions during construction, we recommend the client incorporate contingencies for localized overexcavation and/or subgrade reinforcement into the construction documents.

To protect against subgrade degradation due to construction traffic we recommend a "working mat" of structural fill be placed over prepared subgrades. We recommend this "working mat" consist of 12 inches of free draining structural fill as outlined later in this report. This "working mat" can be incorporated into the building slab and/or pavement sections as appropriate. Construction traffic should be limited to these "working mat" areas.

The Alluvium will be particularly susceptible to degradation during wet weather conditions due to its high silt content. During the wet winter and spring months, the contractor and owner should be prepared to manage over-optimum moisture content soils and subgrade conditions. To protect against subgrade degradation we recommend any earthwork be limited to the generally drier summer months (May through September). If building construction is anticipated to continue into the winter months we recommend pavements be completed prior to the winter months or a woven geotextile fabric (Mirafi 500X or performance equivalent) be placed over pavement subgrades during initial preparation.

The stormwater infiltration potential of Glacial Outwash is favorable, however, maintaining appropriate separation between the base of stormwater systems and groundwater may present challenges in portions of the site. We have conducted a limited groundwater mounding analysis below to provide the stormwater designer with reduced rates for use in areas of anticipated reduced separation. In addition, site soils may need to be amended to provide pollutant treatment capacity or pre-treated prior to infiltration.

Site Preparation and Earthwork

The portions of the site to be occupied by the proposed building foundations or pavements should be prepared by removing existing topsoil, fill, relic topsoil and loose/soft, upper portions of the native soil.

Prior to the placement of structural fill, the exposed subgrade under all areas should be recompacted to a dense and unyielding condition and proof rolled with a loaded dump truck, large self-propelled vibrating roller, or equivalent piece of equipment applicable to the size of the excavation. The purpose of this effort is to identify possible loose or soft soil deposits and recompact the soil exposed during site excavation activities.

Proof rolling should be carefully observed by qualified geotechnical personnel. Areas exhibiting significant deflection, pumping, or over-saturation that cannot be readily compacted should be overexcavated to firm soil. Overexcavated areas should be backfilled with compacted granular material placed in accordance with subsequent recommendations for structural fill. During periods of wet weather or if excavation grades are in close proximity to groundwater elevations, proof rolling could damage the exposed subgrade. Under these conditions, qualified geotechnical personnel should observe subgrade conditions to determine if proof rolling is feasible.

Fill and Compaction

Structural fill used to obtain final elevations for footings, soil-supported floor slabs or pavements must be properly placed and compacted. In general, any suitable, non-organic, predominantly granular soil may be used for fill material provided the material is properly moisture conditioned prior to placement and compaction, and the specified degree of compaction is obtained. Excavated site material containing topsoil, wood, trash, organic material, or construction debris will not be suitable for reuse as structural fill and should be properly disposed offsite or placed in nonstructural areas.

Reuse of Onsite Soil

We do not recommend the near surface Alluvium (sandy, silt) be re-used as structural fill due to its very high moisture content, very high fines content, and anticipated extreme moisture sensitivity. Though re-use as structural fill may strictly be possible, the native Alluvium would be anticipated to require significant moisture conditioning to lower the in-place moisture to within 2 percent of the optimum moisture content, as determined by ASTM D 1557. Moisture conditioning programs typically require significant periods of time, dry weather conditions, large areas, and considerable effort to appropriately implement. We can provide further recommendations pertaining to moisture conditioning upon request, however, we do not anticipate there to be sufficient space available onsite to reasonably implement a moisture conditioning program.

The native Glacial Outwash (very gravelly, sand), encountered at depth across the site, could be used be used in structural fill applications provided it is moisture conditioned, suitably compacted, and allowed for use as structural fill in the project plans and specifications. Soils excavated in proximity to the groundwater table, however, are anticipated to be over optimum moisture content and may require moisture conditioning to lower the in-place moisture to within 2 percent of the optimum moisture content, as determined by ASTM D 1557.

Soils containing more than approximately 5 percent fines are considered moisture sensitive, and are very difficult to compact to a firm and unyielding condition when over the optimum moisture content by more than approximately 2 percent. The optimum moisture content is that which allows the greatest dry density to be achieved at a given level of compactive effort.

Imported Structural Fill

We recommend that imported structural fill consist of clean, well-graded sandy gravel, gravelly sand, or other approved naturally occurring granular material (pit run) with at least 30 percent retained on the No. 4 sieve, or a well-graded crushed rock. Structural fill for dry weather construction may contain on the order of 10 percent fines (that portion passing the U.S. No. 200 sieve) based on the portion passing the U.S. No. 4 sieve. Soil containing more than about 5 percent fines cannot consistently be compacted to a dense, non-yielding condition when the water content is greater than optimum. Accordingly, we recommend that imported structural fill with less than 5 percent fines be used during wet weather conditions. Due to wet weather or wet site conditions, soil moisture contents could be high enough that it may be very difficult to compact even “clean” imported select granular fill to a firm and unyielding condition. Soils with over-optimum moisture contents should be either scarified and dried back to more suitable moisture contents during periods of dry weather or removed and replaced with fill soils at a more suitable range of moisture contents.

Backfill and Compaction

Structural fill should be placed in horizontal lifts 8 to 10 inches in loose thickness and thoroughly compacted. All structural fill placed under load bearing areas should be compacted to at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557. Structural fill should be placed in horizontal lifts 8 to 10 inches in loose thickness and thoroughly compacted.

All structural fill placed under load bearing areas should be compacted to at least 95 percent of the maximum dry density, as determined using test method ASTM D1557. The top of the compacted structural fill should extend outside all foundations and other structural improvements a minimum distance equal to the thickness of the fill. We recommend that compaction be tested periodically throughout the fill placement.

Wet Weather Earthwork

The near surface Alluvium (sandy, silt) is anticipated to be highly moisture sensitive. It is our experience that the near-surface Alluvium will be highly susceptible to degradation during wet weather. As a result, it may be difficult to control the moisture content of the

site soils during the wet season. If construction is accomplished during wet weather, we recommend that structural fill consist of imported, clean, well-graded sand or sand and gravel as described above. If fill is to be placed or earthwork is to be performed in wet weather or under wet conditions, the contractor may reduce soil disturbance by:

- Limiting the size of areas that are stripped of topsoil and left exposed
- Accomplishing earthwork in small sections
- Limiting construction traffic over unprotected soil
- Sloping excavated surfaces to promote runoff
- Limiting the size and type of construction equipment used
- Providing gravel "working mats" over areas of prepared subgrade
- Removing wet surficial soil prior to commencing fill placement each day
- Sealing the exposed ground surface by rolling with a smooth drum compactor or rubber-tired roller at the end of each working day
- Providing upgradient perimeter ditches or low earthen berms and using temporary sumps to collect runoff and prevent water from ponding and damaging exposed subgrades.

Temporary and Permanent Slopes

Actual construction slope configurations and maintenance of safe working conditions, including temporary excavation stability, should be the responsibility of the contractor, who is able to monitor the construction activities and has direct control over the means and methods of construction. All applicable local, state, and federal safety codes should be followed. All open cuts should be monitored during and after excavation for any evidence of instability. If instability is detected, the contractor should flatten the side slopes or install temporary shoring.

Temporary excavations in excess of 4 ft should be shored or sloped in accordance with Safety Standards for Construction Work Part N, WAC 296-155-657.

Temporary unsupported excavations in the Alluvium and/or Glacial Outwash soils encountered onsite should be classified as a Type C soil according to WAC 296-155-657 and may be sloped as steep as 1.5H:1V (Horizontal: Vertical). All soils encountered are classified as Type C soil in the presence of groundwater seepage. Flatter slopes or temporary shoring may be required in areas where groundwater flow is present and unstable conditions develop.

Temporary slopes and excavations should be protected as soon as possible using appropriate methods to prevent erosion from occurring during periods of wet weather.

We recommend that permanent cut or fill slopes be designed for inclinations of 2H:1V or flatter. Permanent cuts or fills used in detention ponds, retention ponds, or earth slopes intended to hold water should be 3H:1V or flatter. All permanent slopes should be vegetated or otherwise protected to limit the potential for erosion as soon as practical after construction.

Seismic Design Considerations

The Pacific Northwest is seismically active and the site could be subject to ground shaking from a moderate to major earthquake. Consequently, moderate levels of earthquake shaking should be anticipated during the design life of the project, and the proposed structure should be designed to resist earthquake loading using appropriate design methodology.

Site Class Definition

For structures designed using the seismic design provisions of the 2012 International Building Code, the underlying Glacial Outwash soils interpreted to underlie the site within the upper 100 feet classifies as Site Class D according to 2010 ASCE -7 Standard – Table 20.3-1, Site Class Definitions. The corresponding values for calculating a design response spectrum for the assumed soil profile type is considered appropriate for the site.

Please use the following values for seismic structural design purposes:

Conterminous 48 States – 2012 International Building Code
Zip Code 98272
Central Latitude = 47.85039, Central Longitude = -122.99633

<u>Short Period (0.2 sec) Spectral Acceleration</u>

Maximum Considered Earthquake (MCE) Value of S_s = 1.229 (g)
Site Response Coefficient, F_a = 1.008 (Site Class D)
Adjusted spectral response acceleration for Site Class D, $S_{MS} = S_s \times F_a$ = 1.239 (g)
Design spectral response acceleration for Site Class D, $S_{DS} = 2/3 \times SM_s$ = 0.826 (g)

<u>One Second Period (1 sec) Spectral Acceleration</u>

Maximum Considered Earthquake (MCE) Value of S_1 = 0.464 (g)
Site Response Coefficient, F_v = 1.536 (Site Class D)
Adjusted spectral response acceleration for Site Class D, $S_{M1} = S_1 \times F_v$ = 0.713 (g)
Design spectral response acceleration for Site Class D, $S_{D1} = 2/3 \times SM_1$ = 0.475(g)

Foundation Support and Settlement

We recommend that all topsoil, organic soil, or deleterious material and the native Alluvium (sandy, silt) be removed from below footing areas. Loose/soft native soils that cannot be recompacted to the conditions of structural fill should be removed below footing areas. Based upon our explorations, 3 to 5 feet of native Alluvium may need to be removed to reach suitable foundation bearing conditions.

Foundation support for the proposed improvements may be provided by continuous or isolated spread footings founded on the undisturbed, firm and unyielding Glacial Outwash (very gravelly, sand), or on controlled density fill (CDF) placed above firm and unyielding Glacial Outwash. Alternatively, overexcavations could be backfilled to the design footing elevation with compacted structural fill or foundations may be extended to bear on the Glacial Outwash encountered at depth.

If CDF is used to backfill foundation overexcavation, the limits of the overexcavation need only extend a nominal distance beyond the width of the footing. In overexcavations backfilled with structural fill, the limits of the overexcavation should extend laterally beyond the edge of each side of the footing a distance equal to the depth of the fill.

All continuous and isolated spread footings should be founded a minimum of 18 inches below the lowest adjacent final grade for freeze/thaw protection.

Allowable Bearing Capacity

Assuming the above foundation support criteria are satisfied, continuous or isolated spread footings founded directly on firm and unyielding Glacial Outwash (very gravelly, sand), CDF placed directly over firm Glacial Outwash, or compacted structural fill over firm Glacial Outwash, may be proportioned using a maximum net allowable soil bearing pressure of 2,500 pounds per square foot (psf). The term "net allowable bearing pressure" refers to the pressure that can be imposed on the soil at foundation level resulting from the total of all dead plus live loads, exclusive of the weight of the footing or any backfill placed above the footing. The net allowable bearing pressure may be increased by one-third for transient wind or seismic loads.

Foundation Settlement

Settlement of shallow foundations depends on foundation size and bearing pressure, as well as the strength and compressibility characteristics of the underlying soil. Assuming construction is accomplished as previously recommended and for the maximum allowable soil bearing pressure recommended above, we estimate the total settlement of building foundations should be less than about 1 inch and differential settlement between two adjacent load-bearing components supported on competent soil should be less than about one half the total settlement. The soil response to applied stresses caused by building and other loads is expected to be predominantly elastic in nature, with most of the settlement occurring during construction as loads are applied.

Concrete Slabs-on-Grade

Conventional slab-on-grade floor construction is considered feasible for the site when placed upon firm native soil. Floor slabs may be supported on properly prepared native subgrade or on structural fill placed over properly prepared native soil. New floor slabs should not be founded on topsoil, existing fill, or soft native soils. Prior to placement of structural fill, the native soil should be observed by the Geotechnical Engineer or his representative to confirm if the sub-slab soils are as expected. GTS recommends that the Owner have contingencies for localized overexcavation and/or subgrade reinforcement with a geofabric in the event that subgrade soils are found to be unsuitable for the support of concrete slabs.

For design purposes, a vertical modulus of subgrade reaction of 100 pounds per cubic inch (pci) should be expected for slab-on-grade floors constructed over firm native subgrades or structural fill placed over native subgrades.

We recommend that interior concrete slab-on-grade floors be underlain by a minimum of 6 inches of compacted, clean, crushed free-draining gravel with less than 3 percent passing the U.S. Standard No. 200 sieve. The purpose of this layer is to provide uniform support for the slab, provide a capillary break, and act as a drainage layer. GTS recommends that material conforming to Washington State Department of Transportation Standard Specification 9-03.12(4), "Gravel Backfill for Drains", with the added requirement that the material consist of a crushed, angular aggregate material be used as capillary break material.

To help reduce the potential for water vapor migration through floor slabs, a continuous impermeable membrane of 10- to 15-mil polyethylene sheeting should be installed and sealed in accordance with the manufactures instructions below the slab. If moisture control within the building is critical, we recommend an inspection of the vapor retarding membrane to verify that all openings have been properly sealed.

The American Concrete Institute (ACI) guidelines suggest that the slab may either be poured directly on the vapor retarding membrane or on a granular curing layer placed over the vapor retarding membrane depending on conditions anticipated during construction. We recommend that the architect or structural engineer specify if a curing layer should be used. Use of a curing layer is generally only recommended during drier months of the year and/or when limited rain is expected during the slab-on-grade construction process. If the slab will be constructed during the wet season, exposed to rain after construction or the site may be potentially wet, we do not recommend the use of curing layer as excessive moisture emissions through the slab may occur.

Exterior concrete slabs-on-grade, such as sidewalks, may be supported directly on undisturbed native or on properly placed and compacted structural fill; however, long-term performance will be enhanced if exterior slabs are placed on a layer of clean, durable, well-draining granular material.

Foundation and Site Drainage

To reduce the potential for groundwater and surface water to seep into interior spaces we recommend that an exterior footing drain system be constructed around the perimeter of new building foundations as shown in the Typical Footing and Wall Drain Section, Figure 3. The drain should consist of a minimum 4-inch diameter perforated PVC pipe, surrounded by a minimum 12 inches of filtering media with the discharge sloped to carry water to a suitable collection system. The filtering media may consist of open-graded drain rock wrapped by a nonwoven geotextile fabric (such as Mirafi 140N or equivalent) or a graded sand and gravel filter. The drainage backfill should be carried up the back of the wall and contain less than 3 percent by weight passing the U.S. Standard No. 200 sieve (based on a wet sieve analysis of that portion passing the U.S. Standard No. 4 sieve). The invert of the footing drain pipe should be placed at approximately the same elevation as the bottom of the footing or 12 inches below the adjacent floor slab grade, whichever is deeper, so that water will not seep through walls or floor slabs. The footing drain should discharge to an approved drain system and include cleanouts to allow periodic maintenance and inspection.

Positive surface gradients should be provided adjacent to the proposed building to direct surface water away from the foundation and toward suitable drainage facilities. Roof drainage should not be introduced into the perimeter footing drains, but should be

separately discharged directly to the stormwater collection system or other appropriate outlet. Pavement and sidewalk areas should be sloped and drainage gradients should be maintained to carry all surface water away from the building towards the local stormwater collection system. Surface water should not be allowed to pond and soak into the ground surface near buildings or paved areas during or after construction. Construction excavations should be sloped to drain to sumps where water from seepage, rainfall, and runoff can be collected and pumped to a suitable discharge facility.

Resistance to Lateral Loads

The lateral earth pressures that develop against retaining walls will depend on the method of backfill placement, degree of compaction, slope of backfill, type of backfill material, provisions for drainage, magnitude and location of any adjacent surcharge loads, and the degree to which the wall can yield laterally during or after placement of backfill. If the wall is allowed to rotate or yield so the top of the wall moves an amount equal to or greater than about 0.001 to 0.002 times its height (a yielding wall), the soil pressure exerted will be the active soil pressure. When a wall is restrained against lateral movement or tilting (a nonyielding wall), the soil pressure exerted is the at-rest soil pressure. Wall restraint may develop if a rigid structural network is constructed prior to backfilling or if the wall is inherently stiff.

We recommend that yielding walls under drained conditions be designed for an equivalent fluid density of 30 pounds per cubic ft (pcf) for structural fill in active soil conditions. Nonyielding walls under drained conditions should be designed for an equivalent fluid density of 50 pcf for structural fill in at-rest conditions. Design of walls should include appropriate lateral pressures caused by surcharge loads located within a horizontal distance equal to or less than the height of the wall. For uniform surcharge pressures, a uniformly distributed lateral pressure equal to 35 percent and 50 percent of the vertical surcharge pressure should be added to the lateral soil pressures for yielding and nonyielding walls, respectively. GeoTest assumes that retaining walls or below-grade structures will not extend below the groundwater table. If walls or structures extend below the water table, GTS should be contacted so that we may provide lateral earth pressures for submerged conditions.

Considering the site soils and the recommended wall backfill materials, we recommend a seismic surcharge pressure of 12H where H is the wall height in feet. The seismic surcharge should be modeled as a rectangular distribution with the resultant applied at the midpoint of the wall.

Passive earth pressures developed against the sides of building foundations, in conjunction with friction developed between the base of the footings and the supporting subgrade, will resist lateral loads transmitted from the structure to its foundation. For design purposes, the passive resistance of well-compacted fill placed against the sides of foundations may be considered equivalent to a fluid with a density of 250 pounds per cubic ft. The recommended value includes a safety factor of about 1.5 and is based on the assumption that the ground surface adjacent to the structure is level in the direction of movement for a distance equal to or greater than twice the embedment depth. The recommended value also assumes drained conditions that will prevent the buildup of hydrostatic pressure in the compacted fill. Retaining walls should include a drain system constructed in general accordance with the recommendations presented in the

Foundation and Site Drainage section of this report. In design computations, the upper 12 inches of passive resistance should be neglected if the soil is not covered by floor slabs or pavement. If future plans call for the removal of the soil providing resistance, the passive resistance should not be considered.

An allowable coefficient of base friction of 0.30, applied to vertical dead loads only, may be used between the underlying native soils or imported granular structural fill and the base of the footing. If passive and frictional resistance are considered together, one half the recommended passive soil resistance value should be used since larger strains are required to mobilize the passive soil resistance as compared to frictional resistance. We do not recommend increasing the coefficient of friction to resist seismic or wind loads.

Pavement Subgrade Preparation

Selection of a pavement section is typically a compromise between higher initial cost and lower maintenance and lower initial cost and more maintenance over the life of the pavement. For this reason, we recommend that the owner participate in the selection of a pavement section for the site. Site grading plans should include provisions for sloping of the subgrade soils in proposed pavement areas, so that passive drainage of the pavement section(s) can proceed uninterrupted during the life of the project.

GeoTest does not recommend placing new pavements on existing pavements, topsoil, existing fill, or loose/soft native soils. New pavement sections should be installed over stripped, compacted, and/or otherwise firm and unyielding subgrades. It is our opinion that the near surface Alluvium (sandy, silt) will be particularly susceptible to degradation during wet weather due to an elevated fines content. To protect against degradation that would otherwise require over-excavation of loose or yielding soils, we recommend a minimum 12 inch thick “working mat” of structural fill be placed over prepared native grades in areas of anticipated construction traffic. We recommend other areas be left un-stripped and unprepared as long as feasible.

This “working mat” can be incorporated into the pavement section as appropriate. If work on the pavement section is to be conducted during the generally wet winter months, we recommend woven geotextile fabric (Mirafi 500X or performance equivalent) be placed over the native soils, below the gravel “working mat.”

Utilities

It is important that utility trenches be properly backfilled and compacted to reduce cracking or localized loss of foundation, slab, or pavement support. It is anticipated that excavations for new shallow underground utilities will be in soft Alluvium (sandy, silt). Utilities requiring more than a couple of feet of excavation will be in Glacial Outwash (very gravelly, sand).

Trench backfill in improved areas (beneath structures, pavements, sidewalks, etc.) should consist of structural fill as defined earlier in this report. Outside of improved areas, trench backfill may consist of re-used native fill provided it is allowed for in, and can be compacted to the requirements of, the project plans and specifications. Trench backfill should be placed and compacted in general accordance with the recommendations presented in the *Fill and Compaction* section of this report.

Surcharge loads on trench support systems due to construction equipment, stockpiled material, and vehicle traffic should be included in the design of any anticipated shoring system. The contractor should implement measures to prevent surface water runoff from entering trenches and excavations. In addition, vibration as a result of construction activities and traffic may cause caving of the trench walls.

Actual trench configurations are the responsibility of the contractor. All applicable local, state, and federal safety codes should be followed. All open cuts should be monitored by the contractor during excavation for any evidence of instability. If instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater or groundwater seepage is present, and the trench is not properly dewatered, the soil within the trench zone may be prone to caving, channeling, and running. Trench widths may be substantially wider than under dewatered conditions.

IN-SITU INFILTRATION TESTING

We conducted Pilot Infiltration Testing at location TP/PIT-2 to determine in-situ long term design infiltration rate recommended for use at the project site. Due to an unanticipated elevated groundwater condition at the test location, a 4.25 foot separation between the base of the PIT excavation and groundwater was maintained. Please refer to Figure 2, Site and Exploration Plan, for the location of the Pilot Infiltration Testing at the project site

Pilot infiltration testing (PIT) was conducted using a method in general accordance with the procedure described for in the 2016 *Snohomish County Drainage Manual*. Infiltration testing was conducted by discharging water into a flat-bottomed pit of known dimensions. The intent of the PIT test was to allow sufficient flow into the excavated area to allow the soils in the immediate vicinity of the excavation to become saturated. During introduction of water into the excavation, a water meter was used to monitor and adjust flow rates. Water was brought onto the site using 2½ inch fire hose attached to a City hydrant located on an adjacent property to the east. Testing took approximately five hours, four hours of which consisted of pre-soak and flow stabilization followed by one hour of data collection.

During the test, water was discharged into the pit through a diffuser to reduce turbulence and scouring in the bottom of the pit. Water discharge rates were calculated by recording the volume of water passing through a water meter over a recorded time. The rate of water discharge was adjusted such that approximately 12 inches of water was maintained in the pit, thus maintaining a “constant head” in the pit during testing. Following the completion of the “constant head” portion of the test, the water flow was halted and 30 minutes of “falling head” infiltration data was collected.

Pilot infiltration test PIT-2 was conducted at a depth of 4.25 feet below the existing ground surface with a 4.5 foot by 9.5 foot wide test area (bottom surface of pit). Undisturbed native Glacial Outwash (very gravelly, sand) was exposed at the base of the PIT excavation. The infiltration capacity of the native Alluvium (sandy, silt) was not tested as it is not anticipated to be suitable for infiltration.

Design Infiltration Rates

Based on our observed short-term infiltration rate of 16.5 inches per hour, in conjunction with reduction factors in accordance with the 2016 *Snohomish County Drainage Manual,* we recommend that **a long-term design infiltration rate of 3.7 inches per hour be incorporated into the design of infiltration systems founded in Glacial Outwash (very gravelly, sand) with a minimum of 5 feet of separation from groundwater**. GTS strongly recommends that we be allowed to view the bottom of infiltration facilities, after excavation, to confirm that the soils exposed within the facility are as anticipated.

If significant modifications in location, depth or style of stormwater management are proposed, we recommend we be allowed to review the proposed changes and revise our recommendation as appropriate. It is recommended that GTS be allowed to view the excavation of the planned facilities during construction to determine if the subsurface soils within individual facilities are consistent with conditions encountered at our test locations.

Infiltration areas should be protected from construction traffic and compaction activities. Densification of the native soils due to construction activities has the potential to significantly reduce the infiltration capacity of the native soils. We recommend the client and/or contractor consider protecting infiltration area soils from unintended densification by surrounding these areas with temporary construction fencing or similar temporary obstructions.

Limited Groundwater Mounding Analysis

Since suitable separation between the base of infiltrations systems and groundwater may be challenging to achieve in portions of the site, GTS has performed a limited groundwater mounding analysis.

The following calculations and information have been referenced from the 2005 Washington State Department of Ecology's *Stormwater Management Manual for Western Washington* (DOE Manual) and the United States Department of Agriculture Natural Resources Conservation Service's (NRCS) *Saturated Hydraulic Conductivity: Water Movement Concepts and Class History* website.

As a basis of design, GTS has assumed a minimum separation between the base of infiltration facilities and the groundwater table of between 2 and 3 feet. At the time of this report, GTS does not have plans or specifications that detail the type or depth of infiltration facilities. The assumed 2 or 3 foot of separation between the bottom of the facility and groundwater table is an estimate based on the observation of Alluvium extending to 5 feet BGS if exploration TP-5, with groundwater present at 7 feet BGS, but may not reflect finished construction grades. GTS recommends that a plan review be performed to confirm the amount of separation between designed infiltration facilities and the groundwater table. Greater reduction may be possible with certain types of stormwater management systems, such as pervious pavements and raingardens. We are available to provide revised recommendations should these types of stormwater management systems be considered in design.

The movement of water through soil under saturated conditions can be calculated according to Darcy's Law. According to the referenced DOE Manual, Darcy's law may be expressed as follows:

$f = Ki$

Where (f) is the specific discharge or infiltration rate of water through the infiltration facility, (K) is the saturated hydraulic conductivity, and (i) is the hydraulic gradient.

Saturated Hydraulic Conductivity:

Saturated hydraulic conductivity is a quantitative measure of a saturated soil's ability to transmit water when subjected to a hydraulic gradient. It can be thought of as the ease with which pores of a saturated soil permit water movement. Saturated Hydraulic Conductivity is expressed as follows:

$$\text{Log}_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

Where D_{10}, D_{60}, and D_{90} are the grain sizes in mm for which 10 percent, 60 percent, and 90 percent is more fine and f_{fines} is the fraction of the soil (by weight) that passes the U.S. No. 200 sieve. K_{sat} is measured in cm/sec. With this equation, GTS has calculated the saturated hydraulic conductivity for a selection of the previously referenced soil samples as follows.

Test Pit 2 at 4.25 feet BGS: K_{sat} = 0.1168 cm/s or approximately 168 inches/hour

Hydraulic Gradient

The hydraulic gradient describes the effectiveness of the driving force behind water movement. The hydraulic gradient is expressed as follows:

$$i = \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} \cdot CF_{size}$$

Where D_{wt} is the depth from the base of the infiltration facility to the water table in feet, K is the saturated hydraulic conductivity in feet/day, D_{pond} is the depth of water in the facility in feet, and CF_{size} is the correction for pond size.

For the purpose of this analysis, we have assumed a maximum of 1.0 feet of water within the proposed infiltration facility during a peak stormwater event. It is assumed that the infiltration facility will be relatively shallow and that the depth of the facility or the presence of overflow protections or spillways would prevent more than 1.0 feet of water from collecting in the facility. Because the proposed infiltration facility is not expected to exceed 2/3 acre in size, a correction for the size of the facility was not utilized. The hydraulic gradient for each of our samples is presented below:

Test Pit 2 at 4.25 feet BGS:
3 foot separation: I = 0.0161
2 foot separation: i = 0.0120

Note: Hydraulic gradients are unitless.

Calculating the Infiltration Rate Using Darcy's Law

Now that the saturated hydraulic conductivity and hydraulic gradients have been calculated, the respective coefficients can be used to determine the infiltration rates with the reduced amount of separation between the bottom of the facility and the groundwater. Darcy's Law is expressed as follows:

$f = Ki$

The infiltration rates for each sample are presented as follows:

Test Pit 2 at 4.25 feet BGS:
3 foot separation: f = 2.7 inches/hour
2 foot separation: f = 2.0 inches/hour

For the purposes of design, GTS recommends using **a design infiltration rate of 2.7 inches per hour for infiltration facilities founded in Glacial Outwash with a minimum of 3 feet of separation from groundwater and 2.0 inches per hour for infiltration facilities founded in Glacial Outwash with a minimum of 2 feet of separation from groundwater**. This infiltration rate takes into account the reduced amount of separation between the bottom of planned infiltration facilities and groundwater elevations. GTS has assumed a minimum separation of between 2 and 3 feet between the bottom of the facility and groundwater elevations. In all cases, infiltration facilities founded in near surface silty Alluvial deposits will not perform as indicated.

Stormwater Treatment Capacity

Cation Exchange Capacity (CEC), organic content and pH tests were performed by Northwest Agricultural Consultants on two samples collected during this investigation. These samples were considered representative of the geologic units encountered across the site. A copy of the laboratory test results is attached at the end of this report. A summary of the test results is presented in Table 1 on the following page.

Table 1
Testing of Treatment Capacity Parameters

Test Pit Number	Sample Depth (Feet)	Geologic Unit	pH (unitless)	CEC (meq/100g)	Organic Content (percent)
TP-1	3.0	Glacial Outwash	6.1	4.7	2.65
TP/PIT-2	4.25	Glacial Outwash	6.2	2.1	1.65

The 2016 *Snohomish County Drainage Manual*, SSC-6 *Soil Physical and Chemical Suitability for Treatment,* states that the Cation Exchange Capacity (CEC) of the treatment soil must be greater than or equal to 5 milliequivalents CEC/100g dry soil. SSC-6 also recommends a minimum organic content of 1 percent of the dry weight.

Testing indicates that the Glacial Outwash, encountered at depths of 3 to 5 feet below the site, is not suitable for stormwater treatment purposes due to Cation Exchange Capacities observed to be below 5.0 meg/100g.

The Glacial Outwash could conceivably be amended to have properties recommended in the Drainage Manual for an amended soil. Amendment could include mixing higher fines and organic content soils or adding mulch (or other admixtures) to elevate the cation exchange capacity. It has been our experience, however, that it is challenging to obtain a uniformly blended amended soil using conventional construction equipment to mix on-site soils and imported materials. On-site amended soil would require additional testing of the amended soil to confirm compliance with recommended soil properties. Additionally, amendment of the Glacial Outwash has the potential to reduce the infiltration potential the soil. GTS is available to perform additional laboratory testing and provide revised recommendations as part of an expanded scope of services if the soil is to be amended.

Alternatively, the Owner may elect to import amended soils with the desired properties for planned treatment facilities.

Based on our review of the Snohomish County Aquifer Recharge/Wellhead Protection Area Map dated October 1, 2007, the subject site is not located within a well head protection zone.

Geotechnical Consultation and Construction Monitoring

We recommend that geotechnical construction monitoring services be provided. These services should include observation by geotechnical personnel during fill placement/compaction activities and subgrade preparation operations to verify that design subgrade conditions are obtained beneath the proposed building. We also recommend that periodic field density testing be performed to verify that the appropriate degree of compaction is obtained. The purpose of these services would be to observe compliance with the design concepts, specifications, and recommendations of this report, and in the event subsurface conditions differ from those anticipated before the start of construction, provide revised recommendations appropriate to the conditions revealed during construction. GeoTest Services would be pleased to provide these services for you.

GeoTest Services is also available to provide a full range of materials testing and special inspection during construction as required by the local building department and the International Building Code. This may include specific construction inspections on materials such as reinforced concrete, reinforced masonry, and structural steel. These services are supported by our fully accredited materials testing laboratory.

USE OF THIS REPORT

GeoTest Services has prepared this report for the exclusive use of Columbia Development and their design consultants for specific application to the design of the Hegger Townhomes project to be located at 17417 W. Main Street in Monroe, Washington. Use of this report by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, our services have been conducted in accordance with generally accepted practices of the geotechnical engineering

profession; no other warranty, either express or implied, is made as to the professional advice included in this report.

Our site explorations indicate subsurface conditions at the dates and locations indicated. It is not warranted that they are representative of subsurface conditions at other locations and times. The analyses, conclusions, and recommendations contained in this report are based on site conditions to the limited depth of our explorations at the time of our exploration program, a brief geological reconnaissance of the area, and review of published geological information for the site. We assume that the explorations are representative of the subsurface conditions throughout the site during the preparation of our recommendations. If variations in subsurface conditions are encountered during construction, we should be notified for review of the recommendations of this report, and revision of such if necessary. If there is a substantial lapse of time between submission of this report and the start of construction, or if conditions change due to construction operations at or adjacent to the project site, we recommend that we review this report to determine the applicability of the conclusions and recommendations contained herein.

The earthwork contractor is responsible to perform all work in conformance with all applicable WISHA/OSHA regulations. GeoTest Services, Inc. should not be assumed to be responsible for job site safety on this project, and this responsibility is specifically disclaimed.

We appreciate the opportunity to provide geotechnical services on this project and look forward to assisting you during the construction phase. If you have any questions or comments regarding the information contained in this report, or if we may be of further service, please call.

Respectfully Submitted,
GeoTest Services, Inc.

State of Washington
Engineering Geologist
2945
Licensed Geologist
Justin Brooks

EDWARDO A. GARCIA
STATE OF WASHINGTON
40819
REGISTERED
PROFESSIONAL ENGINEER
3-2-16

Justin Brooks, L.E.G.
Engineering Geologist

Edwardo Garcia, P.E.
Project Geotechnical Engineer

Attachments:	Figure 1	Vicinity Map
	Figure 2	Site and Exploration Plan
	Figure 3	Typical Footing and Wall Drain Section
	Figure 4	Soil Classification System and Key
	Figures 5-7	Exploration Logs
	Figures 8-9	Grain Size Test Data
	Attached	Laboratory Data: CEC Results (1 page)
	Attached	Report Limitations and Guidelines (3 pages)

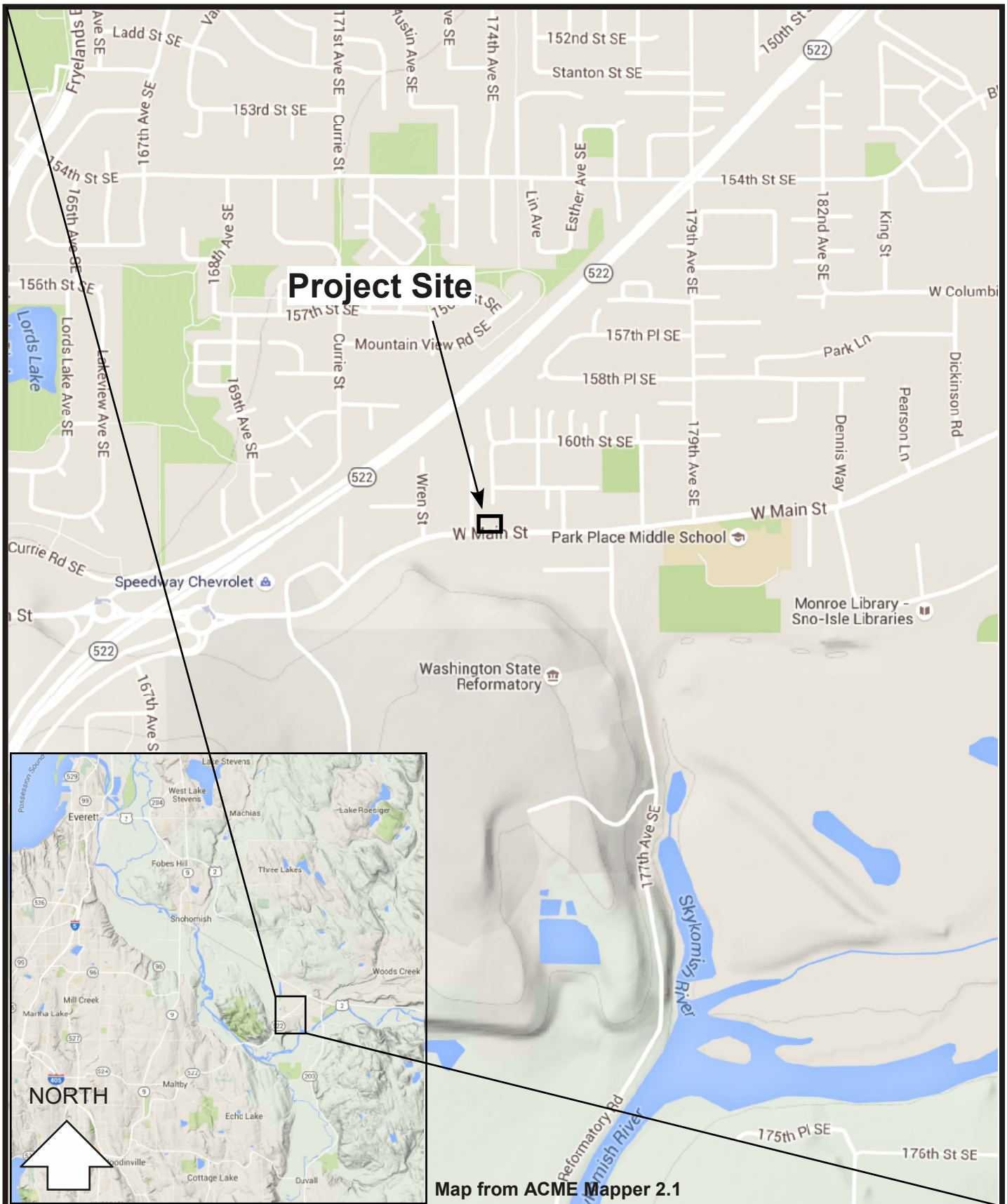
REFERENCES

Aquifer Recharge/Wellhead Protection, 10-1-2007, by Snohomish County Planning and Development Services

Interactive Geologic Map of Washington State. Online interactive services provided by the Washington State Department of Natural Resources, viewed 2-23-16.

Snohomish County, January 2016, Snohomish County Drainage Manual, Volume III – Hydrologic Analysis and Flow Control BMPs, http://snohomishcountywa.gov/1130/Drainage-Manual

Washington State Department of Ecology Water Quality Program. August 2005. *Stormwater Management Manual for Western Washington.* Publication Number 05-10-029 through 05-10-033.



Map from ACME Mapper 2.1

GEOTEST SERVICES, INC. 741 Marine Drive Bellingham, WA 98225 phone: (360) 733-7318 fax: (360) 733-7418	Date: 2-18-16	By: JB	Scale: none
	VICINITY MAP **HEGGER TOWNHOMES** **17417 WEST MAIN STREET** **MONROE, WASHINGTON**		Project **16-0055** Figure **1**

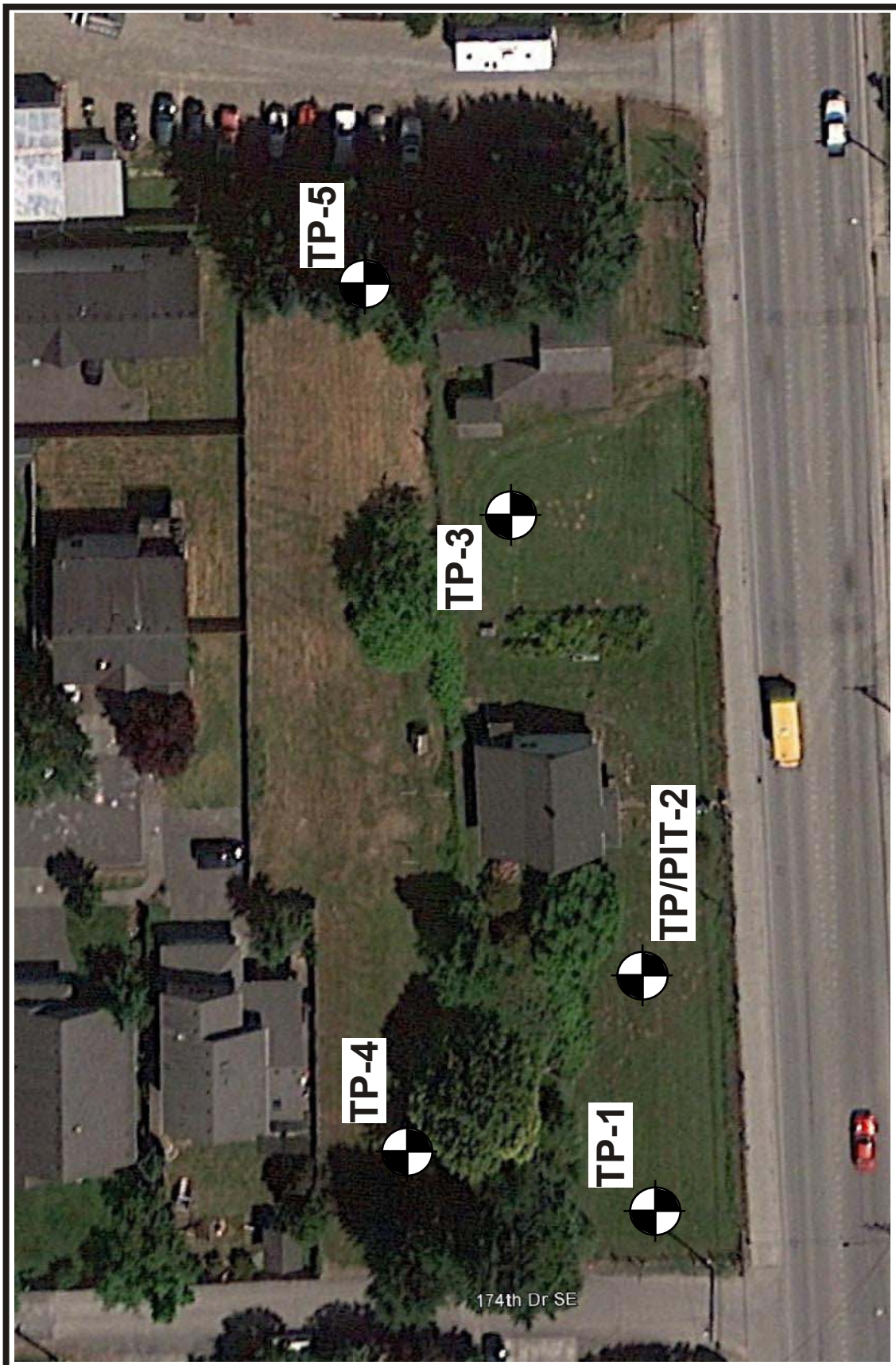


Image from Google Earth

TP/PIT # = Test Pit/Pilot Infiltration Test Exploration Location

~ 50 feet

NORTH

GEOTEST SERVICES, INC.
741 Marine Drive
Bellingham, WA 98225
phone: (360) 733-7318
fax: (360) 733-7418

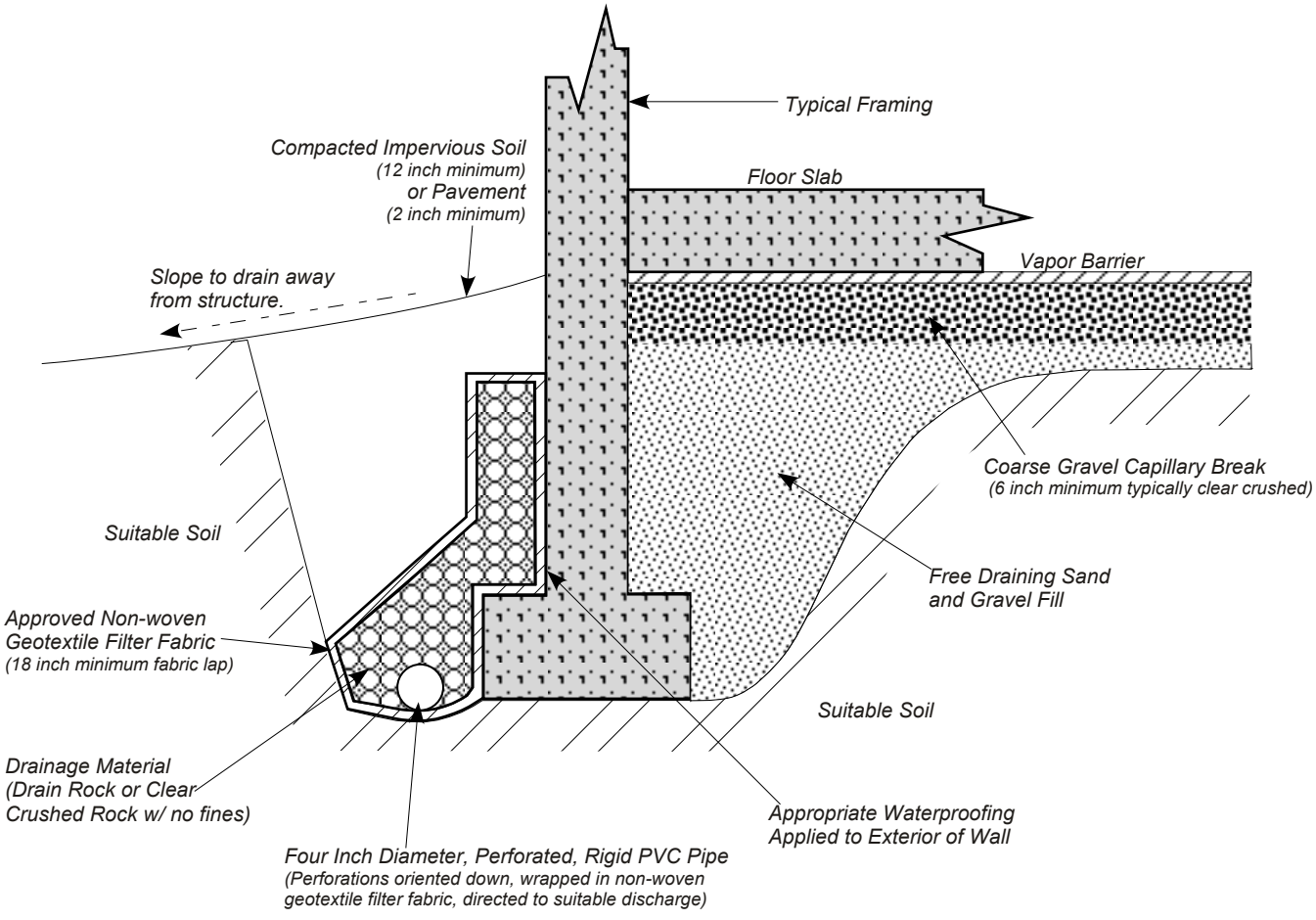
Date: 2-18-16	By: JB	Scale: As Shown	Project
			16-0055

SITE AND EXPLORATION PLAN

HEGGER TOWNHOMES
17417 WEST MAIN STREET
MONROE, WASHINGTON

Figure
2

SHALLOW FOOTINGS WITH INTERIOR SLAB-ON-GRADE



Notes:
Footings Should be properly buried for frost protection in accordance with International Building Code or local building codes (Typically 18 inches below exterior finished grades)

GEOTEST SERVICES, INC.
741 Marine Drive
Bellingham, WA 98225
phone: (360) 733-7318
fax: (360) 733-7418

Date: 2-18-16	By: JB	Scale: None	Project
TYPICAL FOOTING & WALL DRAIN SECTION			**16-0055**
HEGGER TOWNHOMES			Figure
17417 WEST MAIN STREET			3
MONROE, WASHINGTON			

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL	TYPICAL DESCRIPTIONS[1][2]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

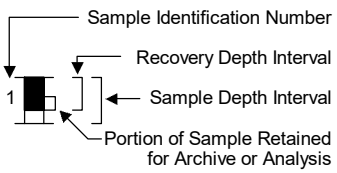
Notes: 1. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.

2. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
> 12% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents: > 5% and ≤ 12% - "slightly gravelly," "slightly sandy," "slightly silty," etc.
≤ 5% - "trace gravel," "trace sand," "trace silt," etc., or not noted.

Drilling and Sampling Key

SAMPLE NUMBER & INTERVAL



SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Other - See text if applicable

Groundwater

▽ ATD — Approximate water elevation at time of drilling (ATD) or on date noted. Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

GEOTEST

Hegger Townhomes
17417 West Main Street
Monroe, Washington

Soil Classification System and Key

Figure 4

TP-1

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): ~48.5 Excavated By: Gillen Construction Inc.
0	1	d	W = 44		OL	Soft, dark brown, moist, very organic, sandy, SILT (Topsoil and Sod)
	2	d	W = 53		ML	Soft to medium stiff, orange tan becoming tan, wet, sandy, SILT (Alluvium) PP=0.75 tsf
2	3	d	W = 45 GS			
	4	d	W = 9 GS		GP/ SP	Medium dense to dense, grey, moist, very sandy, GRAVEL to very gravelly, SAND (Glacial Outwash) with slight mottling in upper few feet and trace cobbles
4						
	5	d	W = 6 GS			
6						
8						
10	6	d	W = 7			▽ Rapid groundwater seepage encountered at 10.5 ft.
12						

Test Pit Completed 02/05/16
Total Depth of Test Pit = 11.0 ft.

TP-2

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): ~48.5 Excavated By: Gillen Construction Inc.
0					OL	Soft, dark brown, moist, very organic, sandy, SILT (Topsoil and Sod)
					ML	
2					ML	Soft to medium stiff, orange tan, wet, sandy, SILT (Alluvium)
						Soft to medium stiff, tan, wet, sandy, SILT (Alluvium)
4	7	d	GS		GP/ SP	Medium dense to dense, tan grey, moist, very sandy, GRAVEL to very gravelly, SAND (Glacial Outwash) with slight mottling in upper few feet and trace cobbles
6						
8						▽ Rapid groundwater seepage encountered at 8.5 ft.
10						
12						

Test Pit Completed 02/05/16
Total Depth of Test Pit = 9.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

16-0055 2/18/16 C:\USERS\JUSTIN\DESKTOP\JOB FILES\16-0055 - HEGGER TOWNHOMES\16-0055 - HEGGER TOWNHOMES.GPJ TEST PIT LOG

GEOTEST

Hegger Townhomes
17417 West Main Street
Monroe, Washington

Log of Test Pits

Figure
5

TP-3

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): ~47.5 Excavated By: Gillen Construction Inc.
0					OL	Soft, dark brown, moist, very organic, sandy, SILT (Topsoil and Sod)
					ML	Soft to medium stiff, orange tan, wet, sandy, SILT (Alluvium) with scattered rootlets
2					ML	
4	8	d	W = 40 GS			Soft to medium stiff, tan, wet, sandy, SILT (Alluvium) PP=1.0 tsf, TSS=0.1 tsf
6					GP/ SP	Medium dense to dense, tan grey, moist, very sandy, GRAVEL to very gravelly, SAND (Glacial Outwash) with slight mottling in upper few feet and trace cobbles
8						Rapid groundwater seepage encountered at 8.0 ft.
10						
12						

Test Pit Completed 02/05/16
Total Depth of Test Pit = 8.5 ft.

TP-4

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): ~48 Excavated By: Gillen Construction Inc.
0					OL	Soft, dark brown, moist, very organic, sandy, SILT (Topsoil and Sod)
					ML	Soft to medium stiff, orange tan, wet, sandy, SILT (Alluvium)
2					ML	
4					GP/ SP	Soft to medium stiff, tan, wet, sandy, SILT (Alluvium) with scattered tree roots Medium dense to dense, tan grey, moist, very sandy, GRAVEL to very gravelly, SAND (Glacial Outwash) with slight mottling in upper few feet and trace cobbles
6						
8						
10						
12						

Groundwater not encountered.

Test Pit Completed 02/05/16
Total Depth of Test Pit = 5.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

16-0055 2/18/16 C:\USERS\JUSTIN\DESKTOP\JOB FILES\16-0055 - HEGGER TOWNHOMES\16-0055 - HEGGER TOWNHOMES.GPJ TEST PIT LOG

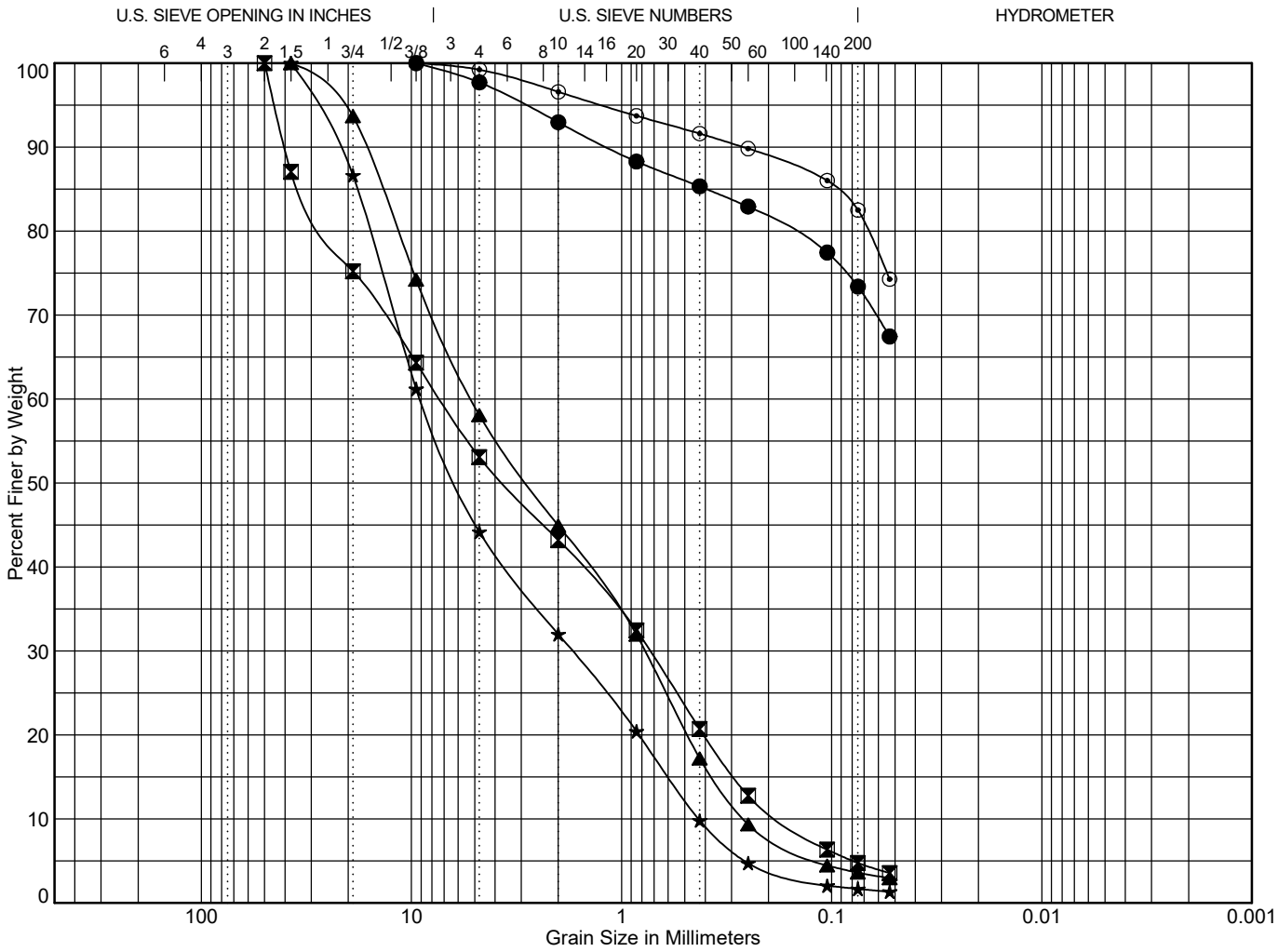
TP-5

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): ~47 Excavated By: Gillen Construction Inc.
0					OL	Soft, dark brown, moist, very organic, sandy, SILT (Topsoil and Sod)
					GP-GM	Medium dense, grey, moist, slightly silty, very sandy, GRAVEL (Import Crushed Rock)
2					ML	
	9	d	W = 34 GS		ML	Medium stiff to stiff, orange tan, wet, sandy, SILT (Alluvium) with scattered rootlets
4						Soft to medium stiff, tan, wet, sandy, SILT Alluvium) PP=1.0 tsf, TSS=0.1 tsf
6	10	d	W = 10 GS		GP/SP	Medium dense to dense, tan grey, moist to saturated, very sandy, GRAVEL to very gravelly, SAND (Glacial Outwash) with slight mottling in upper few feet and trace cobbles
8						▽ Rapid groundwater seepage encountered at 7.0 ft.
10						
12						

Test Pit Completed 02/05/16
Total Depth of Test Pit = 8.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

16-0055 2/18/16 C:\USERS\JUSTIN\DESKTOP\JOB FILES\16-0055 - HEGGER TOWNHOMES\16-0055 - HEGGER TOWNHOMES.GPJ TEST PIT LOG



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Point	Depth	Classification	LL	PL	PI	C_c	C_u
●	TP-1	2.0	Sandy, SILT (ML)					
⊠	TP-1	3.0	Very gravelly, fine to coarse SAND (SP)				0.43	42.31
▲	TP-1	5.0	Very gravelly, fine to coarse SAND (SP)				0.45	19.74
★	TP-2	4.3	Very sandy, fine to coarse GRAVEL (GP)				0.77	21.02
⊙	TP-3	3.0	Sandy, SILT (ML)					

	Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	TP-1	2.0	9.5					0.0	2.3	4.7	7.6	11.9	73.4
⊠	TP-1	3.0	50	7.277	3.626	0.735	0.172	24.8	22.1	9.9	22.5	15.9	4.8
▲	TP-1	5.0	37.5	5.157	2.791	0.775	0.261	6.3	35.6	13.2	27.7	13.6	3.6
★	TP-2	4.3	37.5	9.043	6.02	1.726	0.43	13.4	42.5	12.2	22.2	8.1	1.7
⊙	TP-3	3.0	9.5					0.0	0.8	2.6	5.0	9.1	82.5

$C_c = D_{30}^2/(D_{60} * D_{10})$

$C_u = D_{60}/D_{10}$

To be well graded: $1 < C_c < 3$ and $C_u > 4$ for GW or $C_u > 6$ for SW

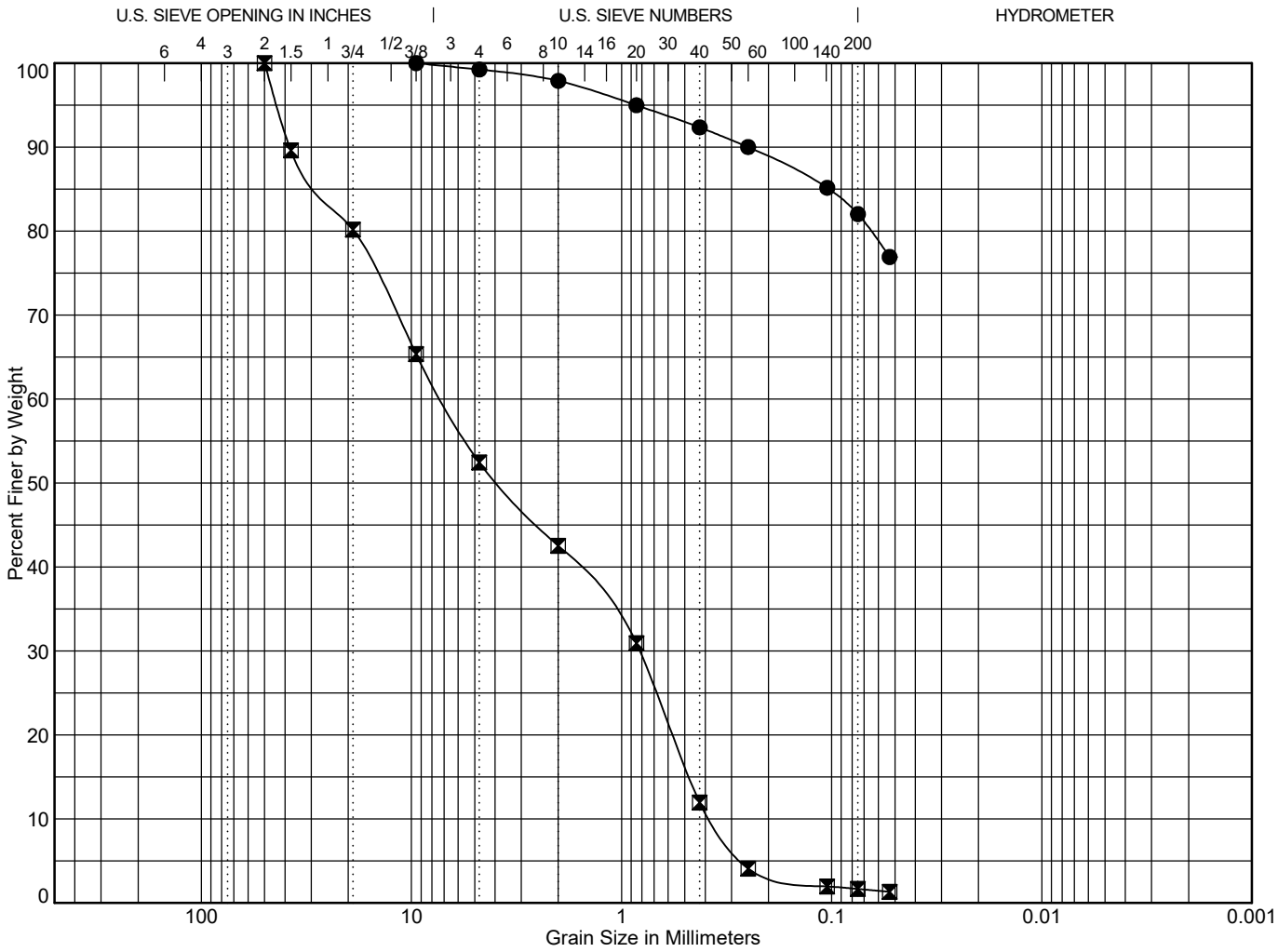
GEOTEST

Hegger Townhomes
17417 West Main Street
Monroe, Washington

Grain Size Test Data

Figure 8

16-0055 2/18/16 C:\USERS\JUSTIN\DESKTOP\JOB FILES\16-0055 - HEGGER TOWNHOMES\16-0055 - HEGGER TOWNHOMES.GPJ GRAIN SIZE W/STATS



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Point	Depth	Classification	LL	PL	PI	C_c	C_u
●	TP-5	3.0	Sandy, SILT (ML)					
⊠	TP-5	6.0	Very gravelly, fine to coarse SAND (SP)				0.25	19.14

	Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	TP-5	3.0	9.5					0.0	0.8	1.4	5.5	10.3	82.0
⊠	TP-5	6.0	50	7.129	3.837	0.822	0.372	19.8	27.7	9.9	30.6	10.3	1.7

$C_c = D_{30}^2/(D_{60} * D_{10})$

$C_u = D_{60}/D_{10}$

To be well graded: $1 < C_c < 3$ and $C_u > 4$ for GW or $C_u > 6$ for SW

GEOTEST

Hegger Townhomes
17417 West Main Street
Monroe, Washington

Grain Size Test Data

Figure 9

16-0055 2/18/16 C:\USERS\JUSTIN\DESKTOP\JOB FILES\16-0055 - HEGGER TOWNHOMES\16-0055 - HEGGER TOWNHOMES.GPJ GRAIN SIZE W/STATS

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NAPT
2015

GEOTEST SERVICES INC
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BELLINGHAM, WA 98225

SOIL
Client No.: 9678 Date Received: 02-10-2016
Report No.: 37171 Page: 1 of 1
da0de7-30990

Grower	Sampler	Field No.	Field Name	Crop Year	Crop	Yield Goal
		Project No. 16-0055				

Depth (ft.)	Available Inches	NO3-N lbs/acre	NH4-N lbs/acre	Sulfur ppm	pH	Soluble Salts (mmhos /cm)	Organic Matter Percent	P(bic) ppm	K(bic) ppm	P(ace) ppm	K(ace) ppm	Calcium (meq. per 100 grams)	Magne-sium (meq. per 100 grams)	Sodium (meq. per 100 grams)	Eff.	Boron ppm	Zinc ppm	Manga-nese ppm	Iron ppm	Copper ppm	CEC (meq. per 100 grams)	% Base Sat.	Chloride lbs. per. acre	Bray 1P ppm	Total Bases (meq. per 100 grams)	SampleI D
1					6.1		2.65														4.7					
2					6.2		1.65														2.1					
Total	0.00																									

Estimated Nitrogen Release from Organic Matter Estimated Total Nitrogen Available to Crop Last Year's Crop Fertilizer

Comments

Sample ID	pH	Loss on Ignition OM	Cation Exchange Capacity
TP1 - 3 ft	6.1	2.65%	4.7 meq/100g
TP2 - 4.25 ft	6.2	1.65%	2.1 meq/100g

CEC Method: EPA 9081

REPORT LIMITATIONS AND GUIDELINES FOR ITS USE[1]

Subsurface issues may cause construction delays, cost overruns, claims, and disputes. While you cannot eliminate all such risks, you can manage them. The following information is provided to help:

Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

At GeoTest our geotechnical engineers and geologists structure their services to meet specific needs of our clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of an owner, a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineer who prepared it. And no one – not even you – should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report is Based on a Unique Set of Project-Specific Factors

GeoTest's geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the clients goals, objectives, and risk management preferences; the general nature of the structure involved its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless GeoTest, who conducted the study specifically states otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed, for example, from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed construction,
- alterations in drainage designs; or
- composition of the design team; the passage of time; man-made alterations and construction whether on or adjacent to the site; or by natural alterations and events, such as floods, earthquakes or groundwater fluctuations; or project ownership.

Always inform GeoTest's geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

[1]Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. Do not rely on the findings and conclusions of this report, whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact GeoTest before applying the report to determine if it is still relevant. A minor amount of additional testing or analysis will help determine if the report remains applicable.

Most Geotechnical and Geologic Findings are Professional Opinions

Our site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoTest's engineers and geologists review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ – sometimes significantly – from those indicated in your report. Retaining GeoTest who developed this report to provide construction observation is the most effective method of managing the risks associated with anticipated or unanticipated conditions.

A Report's Recommendations are *Not* Final

Do not over-rely on the construction recommendations included in this report. Those recommendations are not final, because geotechnical engineers or geologists develop them principally from judgment and opinion. GeoTest's geotechnical engineers or geologists can finalize their recommendations only by observing actual subsurface conditions revealed during construction. GeoTest cannot assume responsibility or liability for the report's recommendations if our firm does not perform the construction observation.

A Geotechnical Engineering or Geologic Report may be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. Lower that risk by having GeoTest confer with appropriate members of the design team after submitting the report. Also, we suggest retaining GeoTest to review pertinent elements of the design teams plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having GeoTest participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do not Redraw the Exploration Logs

Our geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors of omissions, the logs included in this report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable; but recognizes that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In that letter, consider advising the contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the GeoTest and/or to conduct

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additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. In addition, it is recommended that a contingency for unanticipated conditions be included in your project budget and schedule.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering or geology is far less exact than other engineering disciplines. This lack of understanding can create unrealistic expectations that can lead to disappointments, claims, and disputes. To help reduce risk, GeoTest includes an explanatory limitations section in our reports. Read these provisions closely. Ask questions and we encourage our clients or their representative to contact our office if you are unclear as to how these provisions apply to your project.

Environmental Concerns Are Not Covered in this Geotechnical or Geologic Report

The equipment, techniques, and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated containments, etc. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk management guidance. Do not rely on environmental report prepared for some one else.

Obtain Professional Assistance to Deal with Biological Pollutants

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts biological pollutants from growing on indoor surfaces. Biological pollutants includes but is not limited to molds, fungi, spores, bacteria and viruses. To be effective, all such strategies should be devised for the express purpose of prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional biological pollutant prevention consultant. Because just a small amount of water or moisture can lead to the development of severe biological infestations, a number of prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of this study, the geotechnical engineer or geologist in charge of this project is not a biological pollutant prevention consultant; none of the services preformed in connection with this geotechnical engineering or geological study were designed or conducted for the purpose of preventing biological infestations.

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