LIU & ASSOCIATES, INC.

Geotechnical Engineering | Engineering Geology | Earth Science

June 26, 2016

Mr. Rick Hanson
Hanson Homes
P. O. Box 2289
Snohomish, WA 98291

Dear Mr. Hanson:

Subject: Geotechnical Investigation
Currie Farm
15831 - 171st Avenue SE
Monroe, Washington
L&A Job No. 16-085

INTRODUCTION

We understand the development of a single-family residential project is proposed for the subject property, located at the above address in Monroe, Washington. The proposed development is to plat the property into 20 single-family residential building lots with supporting infrastructure. We also understand that onsite stormwater disposal by infiltration is being considered for the development. At your request, we have completed a geotechnical investigation for the proposed development project.

The purpose of this investigation is to explore and characterize subsurface conditions of the project site and provide geotechnical recommendations on grading, onsite stormwater disposal, erosion mitigation, surface and ground water drainage control, and foundation support to buildings for the proposed development. Presented in this report are our findings of the site conditions, conclusion, and geotechnical recommendations.

19213 Kenlake Place NE · Kenmore, Washington 98028
Phone (425) 483-9134 · Fax (425) 486-2746

PROJECT DESCRIPTION

For our use in this investigation, you provided us with a site and plat plan of the proposed development. According to this plan the site, elongated in the east-west direction, is to be divided into 20 building lots with a open tract (Tract 999) at its east end. The lots are to be accessed with an L-shaped paved road swing through the site between 171st Avenue SE to the west and Mountain View Road to the north. Stormwater collected over impervious surfaces of the project will be disposed with infiltration trenches or galleries installed in Tract 999 and/or under the access road. The proposed residences will be two-story, above-grade, wood-framed structures supported on perimeter concrete foundation walls and interior load-bearing walls, beams, and columns. Due to the nearly flat terrain of the site, grading and construction of the residences will require minimal cut and fill.

SCOPE OF SERVICES

Our scope of services for this study comprises specifically the following:

1 Review the geologic and soil conditions at the site based on a published geologic map.

2. Explore the site for subsurface conditions with backhoe test pits to depth where a firm bearing soil stratum or a soil layer suitable for disposing stormwater by infiltration is encountered, or to the maximum depth (about 12 feet) capable by the backhoe used in excavating the test pits, whichever occurs first.

3. Conduct soil particle distribution test on soil samples obtained from targeted soil layer in test pits in accordance with Washington State Department of Ecology <u>2012 Stormwater Management Manual for Western Washington</u> to determine infiltration rate of the targeted soil layer.

4. Perform geotechnical analyses and provide geotechnical recommendations on onsite stormwater disposal, erosion mitigation, surface and ground water drainage control, and foundation support to buildings for the proposed development based on subsurface conditions encountered by the test pits and results of our geotechnical analyses and laboratory tests on soil samples.

5. Prepare a written report to present our findings, conclusions, and recommendations.

SITE CONDITIONS

SURFACE CONDITION

The general location of the project site is shown on Plate 1 – Vicinity Map. The site is situated in a flood plain of the nearby Skykomish River and its tributary creeks. It is bounded by 171st Avenue SE to the west, the right-of-way of State Highway 522 to the east, and adjoined by residential development to the north and south.

The terrain within the site is nearly flat. It is currently an open cultivated land utilized for plant nursery.

GEOLOGIC SETTING

The Surficial Geologic Map of the Skykomish and Snoqualmie Rivers Area, Snohomish and King Counties, Washington, by Derek B Booth, published by U. S. Geological Survey in 1990, was referenced for the geologic condition of the project site. According to this publication, the surficial soil unit at and in the vicinity of the project site is mapped as Younger Alluvium Deposits (Q_{yal}).

The younger alluvium deposits were geologically recent sediment transported and deposited by flooding water of the nearby Skykomish River and its tributary creeks, following the retreat of the last glacier, the Vashon Stade of the Fraser Glaciation, which occurred during the later stages of the Pleistocene Epoch and retreated from the region some 12,500 years ago. The coarser materials of the alluvium deposits, such as coarse sand, gravel, cobble and boulder, were deposited closer to the river and tributary creek channels and are highly permeable, while the finer materials of the alluvium deposits, such as clay, silt and fine sand, were laid down farther away from the river/tributary creek channels and are less permeable. The younger alluvium deposits had not been over-ridden by glacier and are generally loose to medium-dense in their natural, undisturbed state.

SOIL CONDITION

Subsurface conditions of the project site were explored with four test pits. The test pits were excavated on June 15, 2016, with a rubber-tired backhoe to depths from 9.0 to 11.0 feet. The approximate locations of the test pits are shown on Plate 2 - Site and Exploration Location Plan. The test pits were located with either a tape measure or by visual reference to existing topographic features in the field and on the site survey map, and their locations should be considered as only accurate to the measuring method used.

A geotechnical engineer from our office was present during subsurface exploration, examined the soil and geologic conditions encountered, and completed logs of the test pits. Soil samples obtained from each soil layer in the test pits were visually classified in general accordance with United Soil Classification System, a copy of which is presented on Plate 3. Detailed descriptions of soils encountered during site exploration are presented in test pit logs on Plates 4 and 5.

The test pits generally encountered a layer of loose, organic topsoil, from about 10 to 15 inches thick, mantling the project site. The topsoil is underlain by a layer of weathered soil of brown to yellowish-brown, loose, silty fine sand, from 1.5 to 3.0 feet thick. This weathered soil layer is underlain by a layer of light-gray, stiff to very-stiff, silty fine sand to fine-sandy silt, from 1.1 to 4.8 feet thick, increasing in thickness to the west. Underlying this layer of fine-grained soils to the depths explored is a light-gray, medium-dense to dense, gravelly sand deposit, which appears to be an alluvium deposit.

GROUNDWATER CONDITION

Groundwater was not encountered by any of the four test pits excavated on the site. The stiff to very-stiff, silty fine sand to fine-sandy silt soil layer is of low permeability and would perch stormwater infiltrating into the more permeable surficial soils. The amount of and the depth to the near-surface perched groundwater would fluctuate seasonally, depending on precipitation, surface runoff, ground vegetation cover, site utilization, and other factors. The perched groundwater may dry up completely during the dryer summer and fall months and would accumulate and rise in the wet winter and early spring months. The underlying alluvium deposit of gravelly sand is of very-high permeability and would allow water to seep through very easily.

GEOLOGIC HAZARDS AND MITIGATION

Erosion and Landslide Hazard

The site is nearly flat and is underlain at shallow depth by a medium-dense to dense gravelly sand deposit of moderately high shear strength. Therefore, there should be little or no hazard for soil erosion and landslide to occur on the project site. To further minimize erosion hazard of the site, vegetation cover outside of construction areas should be protected and maintained. Concentrated stormwater should not be discharged uncontrolled onto the ground within the site. Stormwater over impervious surfaces, such as roofs and paved roadway, driveways and parking areas, should be captured by underground drain line systems connected to roof downspouts and catch basins installed in paved areas. Water collected into these drain line systems should be tightlined to discharge into a storm sewer or suitable stormwater disposal facilities.

Seismic Hazard

The Puget Sound region is in an active seismic zone. The project site is underlain at shallow depth by medium-dense to dense, gravelly sand soil of very-high permeability. Also, the site is nearly level. Therefore, the potential for seismic hazards, such as landslides, liquefaction, lateral soil spreading, to occur on the site should be minimal. The proposed residences, however, should be designed for seismic forces induced by strong earthquakes. Based on the soil conditions encountered by the test pits, it is our opinion that Seismic Use Group I and Site Class D should be used in the seismic design of the proposed residences in accordance with the 2012 International Building Code (IBC).

DISCUSSION AND RECOMMENDATIONS

GENERAL

Based on the soil conditions encountered by test pits excavated on the project site, it is our opinion that the project site is suitable for the proposed development from the geotechnical engineering viewpoint, provided that the recommendations in this report are fully implemented and observed during and following completion of construction. Conventional footing foundations constructed on or into the underlying medium-dense to dense alluvium deposit of gravelly sand deposit underlying the site at shallow depth may be used to support proposed residences. Unsuitable surficial topsoil and weak surficial weathered soil should be stripped within footprint of roadway, driveways, parking areas, and areas of structural fill.

The surficial topsoil and weathered soils contain a high percentage of fines and can be easily disturbed when saturated. Grading work in wet winter months may cause complications and difficulties. Therefore, earth work should be scheduled and completed between April 1 and October 31, if possible. Otherwise, erosion protection and drainage control measures recommended in this report should be implemented for site stabilization and to facilitate earthwork if it is to be carried out beyond the above dryer period.

TEMPORARY DRAINAGE AND EROSION CONTROL

The onsite surficial weak soils are sensitive to moisture and can be easily disturbed by construction traffic. A layer of clean, 2-to-4-inch quarry spalls should be placed over areas of frequent traffic, such as the entrances to and exit from the site, as required, to protect the subgrade soils from disturbance by construction traffic.

A silt fence should be installed along the downhill sides of construction areas to minimize transport of sediment by storm runoff onto neighboring properties or streets. The bottom of the filter cloth of the silt fences should be anchored in a trench filled with onsite soil.

Intercepting ditches or trench drains should be installed around construction areas, as required, to intercept and drain away storm runoff and near-surface groundwater seepage. Water captured by such ditches or trench drains should be stored in temporary holding and settling ponds onsite. Only clear and clean water may be discharged into the alluvium deposit under the site or into a nearby storm inlet. The storm inlet into which collected stormwater is to be discharged should be covered with a non-woven filter fabric sock to prevent sediment from entering the storm sewer system. The filter sock should be cleaned frequently during construction to prevent clogging, and should be removed after completion of construction.

Spoil soils should be hauled off of the site as soon as possible. Spoil soils and imported structural fill material to be stored onsite should be securely covered with plastic tarps, as required, for protection against erosion.

SITE PREPARATION AND GENERAL GRADING

Vegetation within construction limits should be cleared and grubbed. Loose topsoil and unsuitable surficial soils should be completely stripped down to the medium-dense to dense alluvium deposit of gravelly sand soil within building pads of residences and within paved roadway, driveways, and parking areas. Exposed soils after stripping should be compacted to a non-yielding state with a vibratory mechanical compactor and proof-rolled with a piece of heavy earthwork equipment prior to roadway, driveway, and parking area construction.

EXCAVATION AND FILL SLOPES

Under no circumstance should excavation slopes be steeper than the limits specified by local, state and federal safety regulations if workers have to perform construction work in excavated areas. Unsupported temporary cuts greater than 4 feet in height should be no steeper than 1H:1V. Permanent cut banks should be no steeper than 2-1/4H:1V. Soil condition encountered by cuts and stability of cut slopes should be observed and verified by a geotechnical engineer during excavation.

Permanent fill embankments required to support structural or traffic load should be constructed with compacted structural fill placed over undisturbed, proof-rolled, firm, alluvium soils after the surficial unsuitable soils are completely stripped. The slope of permanent fill embankments should be no steeper than 2-1/4H:1V. Upon completion, the sloping face of permanent fill embankments should be thoroughly compacted to a non-yielding state with a hoe-pack. Permanent fill embankments constructed over ground of 20% or more should be structurally supported laterally.

The above recommended cut slopes and fill embankments are under the assumption that groundwater seepage would not be encountered during construction. If groundwater is encountered, the grading work should be immediately halted and the slope stability re-evaluated. The slopes may have to be flattened and other measures taken to stabilize the slopes. Stormwater should not allowed to flow uncontrolled over cut slopes and fill embankments. Permanent cut slopes or fill embankments should be seeded and vegetated as soon as possible for erosion protection and long-term stability, and should be securely covered with clear plastic sheets, as required, to protect them from erosion until the vegetation is fully established.

STRUCTURAL FILL

Structural fill is the fill that supports structural or traffic load. Structural fill should consist of clean granular soils free of organic, debris and other deleterious substances and with particles not larger than three inches. Structural fill should have a moisture content within one percent of its optimum moisture content at the time of placement. The optimum moisture content is the water content in the soils that enable the soils to be compacted to the highest dry density for a given compaction effort. Onsite soils meeting the above requirements may be used as structural fill. Imported material to be used as structural fill should be clean, free-draining, granular soils containing no more than 5 percent by weight finer than the No. 200 sieve based on the fraction of the material passing No. 4 sieve, and should have individual particles not larger than three inches.

The ground over which structural fill is to be placed should be prepared in accordance with recommendations in the SITE PREPARATION AND GENERAL GRADING and EXCAVATION AND FILL SLOPES sections of this report. Structural fill should be placed in lifts no more than 10 inches thick in its loose state, with each lift compacted to a minimum percentage of the maximum dry density determined by ASTM D1557 (Modified Proctor Method) as follows:

Application	% of Maximum Dry Density
Within building pads and under foundations	95%
Roadway/driveway subgrade	95% for top 3 feet and 90% below
Retaining/foundation wall backfill	92%
Utility trench backfill	95% for top 4 feet and 90% below

In-situ density of structural fill should be tested with a nuclear densometer by a testing agency specialized in fill placement and construction work. Testing frequency should be one test per every 250 square feet per lift of fill.

ONSITE STORMWATER DISPOSAL

General

The alluvium soil unit of gravelly sand deposit underlying the site at depths of about 4.0 to 8.0 feet below existing ground surface is of very high permeability and would be able to support onsite stormwater disposal by infiltration easily.

Particle Size Distribution Tests and Estimated Infiltration Rates

Four soil samples, one from each of the four test pits excavated on the site, were obtained from the alluvium deposit and taken to HWA laboratory for Soil Particle Size Distribution test. These soil samples are listed in the table below and their test reports are presented on Plates A1-1 and A1-2 in the attached appendix.

LIST OF SOIL SAMPLES

Sample No.	Test Pit No.	Depth feet	Soil Description
1	TP-1	6.0 - 7.0	Dark yellowish-brown, poorly-graded GRAVEL w/ sand
2	TP-2	5.0 - 6.0	Dark yellowish-brown, poorly-graded SAND w/ gravel
3	TP-3	6.0 - 7.0	Dark yellowish-brown, well-graded GRAVEL w/ sand
4	TP-4	9.0 - 10.0	Dark yellowish-brown, poorly-graded GRAVEL w/ sand

The percentages of clay, silt, and sand/gravel of the soil samples determined from the particle size distribution tests are summarized on Plates A1-1 and A1-2. Based on these percentages the soil samples were classified according to the USDA (U.S. Department of Agriculture) Texture Triangle chart, a copy of which is shown on Plate A2 in the attached Appendix. The classifications of soil samples are presented in the table below.

USDA TEXTURE TRIANGLE CLASSIFICATION OF SOIL SAMPLES

Sample No.	Percentage Clay	Percentage Silt	Percentage Sand/Gravel	USDA Texture Triangle Classification
1	0.3	2.3	97.4	Sand
2	0.2	1.6	98.3	Sand
3	0.3	1.8	97.8	Sand
4	0.3	1.9	97.8	Sand

Volume III, Section 3.3.6, Article 3 - Soil Grain Size Analysis Method, of the Stormwater Management Manual for Western Washington, 2012 Edition, published by Washington State Department of Ecology, is used to determine estimated design infiltration rates of the target alluvium deposit. This method uses D_{10} , D_{60}, D_{90}, and f_{fines} in calculating the saturated infiltration rate (conductivity), K_{sat} in cm/sec; where D_{10} , D_{60}, D_{90} are the sizes in millimeters of soil particles of 10%, 60%, and 90%, respectively, passing by weight, and f_{fines} is the fraction of the fines passing the No. 200 sieve by weight (i.e., the sum of clay and silt). The values of D_{10} , D_{60}, D_{90}, and f_{fines} are shown or obtained from test results on Plates A1-1 and A1-2, and the determination of K_{sat} for the four soil samples are shown in the table below.

ESTIMATED INITIAL INFILTRATION RATES, K_{sat}

Sample No.	Test Pit No.	D_{10} Size	D_{60} Size	D_{90} Size	f_{fines}	[a] K_{sat} cm/sec	K_{sat} in/hour
1	TP-1	0.2831	14.24	27.79	0.026	0.0589	83.48
2	TP-2	0.3043	5.74	19.50	0.018	0.0631	89.43
3	TP-3	0.4759	7.75	20.50	0.021	0.1380	195.59
4	TP-4	0.2870	10.58	28.00	0.022	0.0520	73.70

[a] $\log_{10}(K_{sat}) = -1.57 + 1.90(D_{10}) + 0.015(D_{60}) - 0.013(D_{90}) - 2.08(f_{fines})$

Recommended Design Infiltration Rate

The design infiltration rate for infiltration trenches or galleries to be used for onsite stormwater disposal for the subject project is determined by applying the K_{sat} values shown in the above table with a factor safety of 4.0. We recommend, on the conservative side, that a design infiltration rate of 7.5 iph (inches per hour) be used for design of infiltration trenches or galleries to dispose stormwater into in the alluvium deposits of gravelly sand underlying the site.

INFILTRATION TRENCHES/GALLERIES

General

It is our opinion that based on the soil conditions encountered by the test pits and the results of particle size distribution test on the soil samples, the targeted alluvium deposit underlying the site are capable of supporting infiltration trenches/galleries to be used for onsite stormwater disposal. Infiltration trenches/galleries should be set back at least 5 feet from property lines and 10 feet from adjacent building footing foundations or utility trenches. The bottom of infiltration trenches or galleries should be at least one foot lower than adjacent building footing foundations or utility trenches. Infiltration trenches/galleries should be installed at several locations in Tract 999 and under the access road to disperse disposed water over a wide area under the site to minimize potential problems from concentration of disposed stormwater.

Infiltration Trench/Gallery Construction

Infiltration trenches/galleries should be cut at least 6 inches into the alluvium deposit of gravelly sand soil. To reach this target soil stratum the trenches/galleries would have to be excavated to depths of about 4.5 to 8.5 feet or more. The condition of the soil unit at bottom of trenches/galleries should be verified by a geotechnical engineer. The stability of the trench cut banks should also be verified by a geotechnical engineer during excavation.

The trenches/galleries should be at least 24 inches wide. The side walls (but not the bottom) of the trenches/galleries should be lined with a layer of non-woven filter fabric

(MIRAFI 140NS). The trenches/galleries are then to be filled with clean washed 3/4 to 1-1/2 inch gravel or crushed rock to within about 12 inches of finish grade. The dispersion pipes should be constructed of 4-inch rigid PVC pipes and laid level in the gravel or crushed rock filled trenches/galleries at about 24 inches below the top of trenches/galleries. The dispersion pipes should be spaced at no more than 4 feet apart. The top of the gravel or crushed rock fill should also be covered with the filter fabric liner. The remaining trenches/galleries should then be backfilled in lifts with compacted onsite clean sandy soils. The gravel or crushed rock fill should be placed in lifts no more than 10 inches thick in loose state, with each lift compacted to a non-yielding state with a vibratory mechanical compactor. The compaction and densification of trench fill is critical if it is to support roadway or driveways or parking areas. Stormwater captured over paved roadway, driveways, or parking areas should be routed into a catch basin equipped with an oil-water separator before being released into the infiltration trenches/galleries.

If maintaining groundwater quality is critical, the bottom of trenches/galleries should be filled with a minimum 12-inch layer of uncompacted amended soil for filtering out pollutants. The amended soil should contain 40 percent (by volume) of compost, mixed with clean, medium to coarse, sand, to achieve an organic content of at least 10% by dry weight.

BUILDING FOUNDATIONS

Conventional footing foundations may be used to support the proposed residences. The footing foundations should be constructed on or into the underlying alluvium deposit of medium-dense to dense, gravelly sand soil or on structural fill constructed on alluvium deposit. Water should not be allowed to accumulate in excavated footing trenches. Disturbed soils in footing trenches should be completely removed down to above competent deposit in their native, undisturbed state prior to pouring concrete for the footings.

If the above recommendations are followed, our recommended design criteria for footing foundations are as follows:

- The allowable soil bearing pressure for design of footing foundations, including dead and live loads, should be no greater than 2,500 psf. The footing bearing soils should be verified by a geotechnical engineer after the footing trenches are excavated and before the footings poured.
- The minimum depth to bottom of perimeter footings below adjacent final exterior grade should be no less than 18 inches. The minimum depth to bottom of the interior footings below top of floor slab should be no less than 12 inches.
- The minimum width should be no less than 16 inches for continuous footings, and no less than 24 inches for individual footings, except those footings supporting light-weight decks or porches.

A one-third increase in the above recommended allowable soil bearing pressure may be used when considering short-term, transitory, wind or seismic loads. For footing foundations designed and constructed per recommendations above, we estimate that the maximum total post-construction settlement of the buildings should be 3/4 inch or less and the differential settlement across building width should be 1/2 inch or less.

Lateral loads on the proposed residences may be resisted by the friction force between the foundations and the subgrade soils or the passive earth pressure acting on the below-grade portion of the foundations. For the latter, the foundations must be poured "neat" against undisturbed soils or backfilled with a clean, free-draining, compacted structural fill. We recommend that an equivalent fluid density (EFD) of 275 pcf (pounds per cubic foot) for the passive earth pressure be used for lateral resistance. The above passive pressure assumes that the backfill is level or inclines upward away from the foundations for a horizontal distance at least twice the depth of the foundations below the final grade. A coefficient of friction of 0.55 between the foundations and the subgrade soils may be used. The above soil parameters are unfactored values, and a proper factor of safety should be used in calculating the resisting forces against lateral loads on the buildings.

SLAB-ON-GRADE FLOORS

Slab-on-grade floors, if used for the proposed residences, should be placed on firm subgrade soil prepared as outlined in the SITE PREPARATION AND GENERAL EARTHWORK and the STRUCTURAL FILL sections of this report. Where moisture control is critical, the slab-on-grade floors should be placed on a capillary break which is in turn placed on the compacted subgrade. The capillary break should consist of a minimum four-inch-thick layer of clean, free-draining, 7/8-inch crushed rock, containing no more than 5 percent by weight passing the No. 4 sieve. A vapor barrier, such as a 6-

mil plastic membrane, may be placed over the capillary break, as required, to keep moisture from migrating upwards.

PAVED ROADWAY/DRIVEWAYS AND PARKING AREAS

Performance of roadway, driveways, and parking area pavement is critically related to the conditions of the underlying subgrade soils. We recommend that the subgrade soils under the roadways, driveways and parking areas be treated and prepared as described in the SITE PREPARATION AND GENERAL EARTHWORK section of this report. Prior to placing base material, the subgrade soils should be compacted to a non-yielding state with a vibratory roller compactor and proof-rolled with a piece of heavy construction equipment, such as a fully-loaded dump truck. Any areas with excessive flexing or pumping should be over-excavated and re-compacted or replaced with a structural fill or crushed rock placed and compacted in accordance with the recommendations provided in the STRUCTURAL FILL section of this report.

We recommend that a layer of compacted, 7/8-inch crushed rock base (CRB), be placed for the roadways, driveways, and parking areas. This crushed rock base should be at least 6 inches for the public roadways and 4 inches for the private driveways and parking areas. This crushed rock base should be overlain with a 3-inch asphalt treated base (ATB) topped by a 2-inch-thick Class B asphalt concrete (AC) surficial course for the public roads and overlain by a 3-inch-thick Class B asphalt concrete (AC) surficial course for private driveways and parking areas.

DRAINAGE CONTROL

Building Footprint Excavation

Footprint excavation for the proposed residences, if encountering groundwater seepage, should have bottom of excavation sloped slightly and ditches excavated along bases of the cut banks to direct collected groundwater into sump pits from which water can be pumped out. A layer of 2-inch crushed rock should be placed over footing bearing subgrade soils, as required, to protect the soils from disturbance by construction traffic. This crushed rock base should be built to a few inches above groundwater level, but not less than 6 inches thick. The crush rock base should be compacted in 12-inch lifts to a non-yielding state with a vibratory mechanical compactor.

Runoff over Impervious Surfaces

Storm runoff over impervious surfaces, such as roofs, paved roadway, driveways and parking areas, should be collected by underground drain line systems connected to downspouts and by catch basins installed in paved roadways, driveways and parking areas. Stormwater thus collected should be tightlined to discharge into a storm sewer or suitable stormwater disposal facilities.

Building Footing Drains

A subdrain should be installed around the perimeter footings of each residence. The subdrains should consist of a 4-inch-minimum-diameter, perforated, rigid, drain pipe, laid a few inches below bottom of the perimeter footings of the residences. The trenches and the drain lines should have a sufficient gradient (0.5% minimum) to generate flow by gravity. The drain lines should be wrapped in a non-woven filter fabric sock and completely enclosed in clean washed gravel. The remaining trenches may be backfilled with clean onsite soils. Water collected by the perimeter footing subdrain systems should be tightlined, separately from the roof and surface stormwater drain lines, to discharge into a storm sewer or suitable stormwater disposal facilities.

Surface Drainage

Water should not be allowed to stand in any areas where footings, on-grade slabs, or pavement is to be constructed. Finish ground surface should be graded to direct surface runoff away from the residences. We recommend the finish ground be sloped at a gradient of 3 percent minimum for a distance of at least 10 feet away from buildings, except in the areas to be paved.

Cleanouts

Sufficient number of cleanouts at strategic locations should be provided for underground drain lines. The underground drain lines should be cleaned and maintained periodically to prevent clogging.

RISK EVALUATION STATEMENT

The subject site is underlain at shallow depth by an alluvium deposit of medium-dense to dense, gravelly sand. This deposit is of moderately-high shear strength and the site is nearly level. Therefore, the site should be quite stable. It is our opinion that if the recommendations in this report are fully implemented and observed during and following completion of construction, the areas disturbed by construction will be stabilized and will remain stable, and will not increase potential for soil movement. In our opinion, the risk for damages to the proposed development and from the development to adjacent properties due to soil movement should be minimal.

LIMITATIONS

This report has been prepared for the specific application to this project for the exclusive use by Hanson Homes and its associates, representatives, consultants and contractors. We recommend that this report, in its entirety, be included in the project contract documents for the information of prospective contractors for their estimating and bidding purposes and for compliance with the recommendations in this report during construction. The conclusions and interpretations in this report, however, should not be construed as a warranty of the subsurface conditions. The scope of this study does not include services related to construction safety precautions and our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in this report for design considerations. All geotechnical construction work should be monitored and inspected by a geotechnical engineer during construction.

Our recommendations and conclusions are based on the geologic and soil conditions encountered in the test pits excavated on the site, and our experience and engineering judgment. The conclusions and recommendations are professional opinions derived in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty, expressed or implied, is made.

The actual subsurface conditions of the site may vary from those encountered by the test pits excavated on the site. The nature and extent of such variations may not become evident until construction starts. If variations appear then, we should be retained to re-evaluate the recommendations of this report, and to verify or modify them in writing prior to proceeding further with the construction of the proposed development of the site.

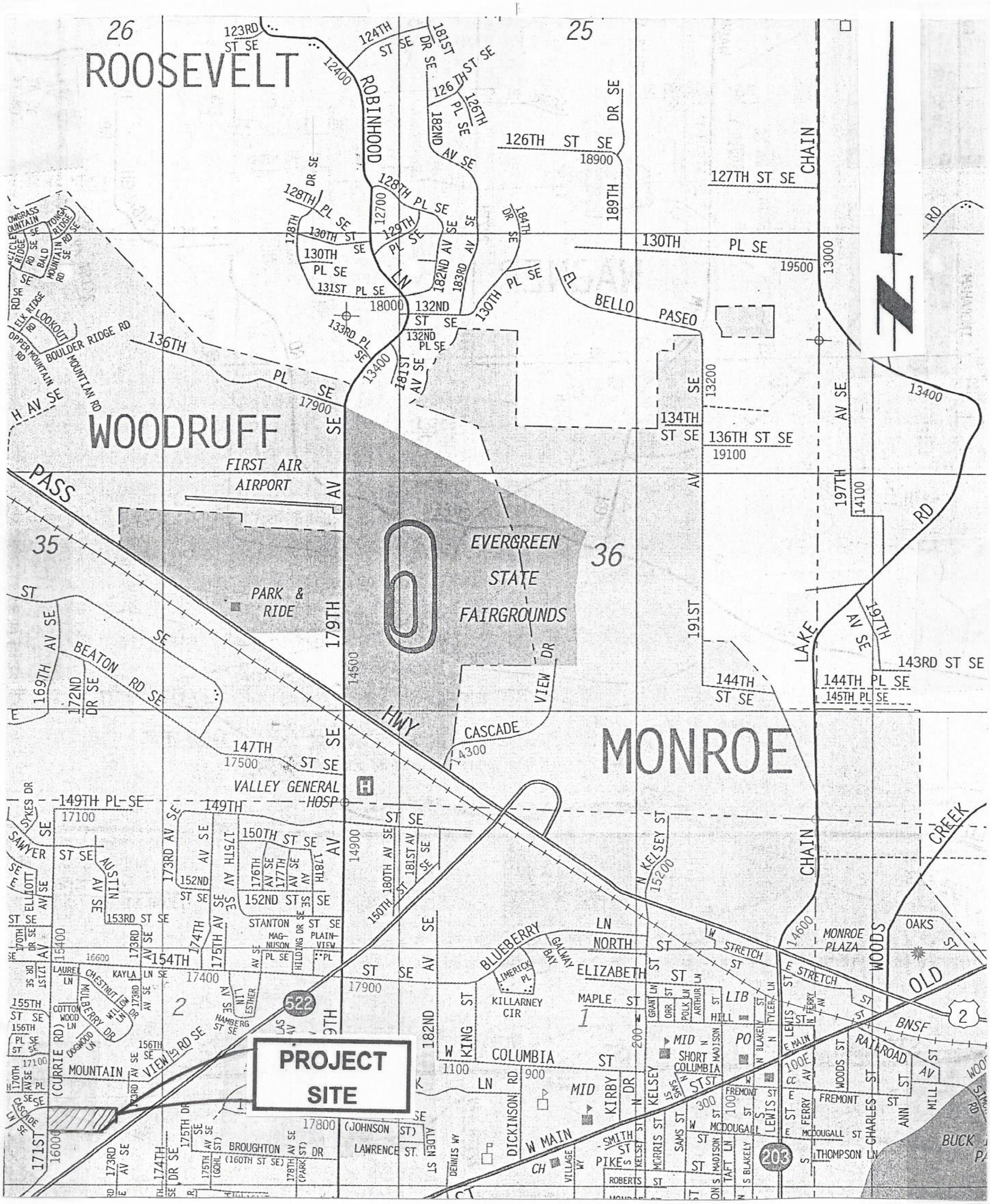
CLOSURE

We are pleased to be of service to you on this project. Please feel free to contact us if you have questions regarding this report or need further consultation.

Yours very truly,
LIU & ASSOCIATES, INC.

J. S. (Julian) Liu, Ph.D., P.E.
Principal

Attached: Five Plates and Appendix



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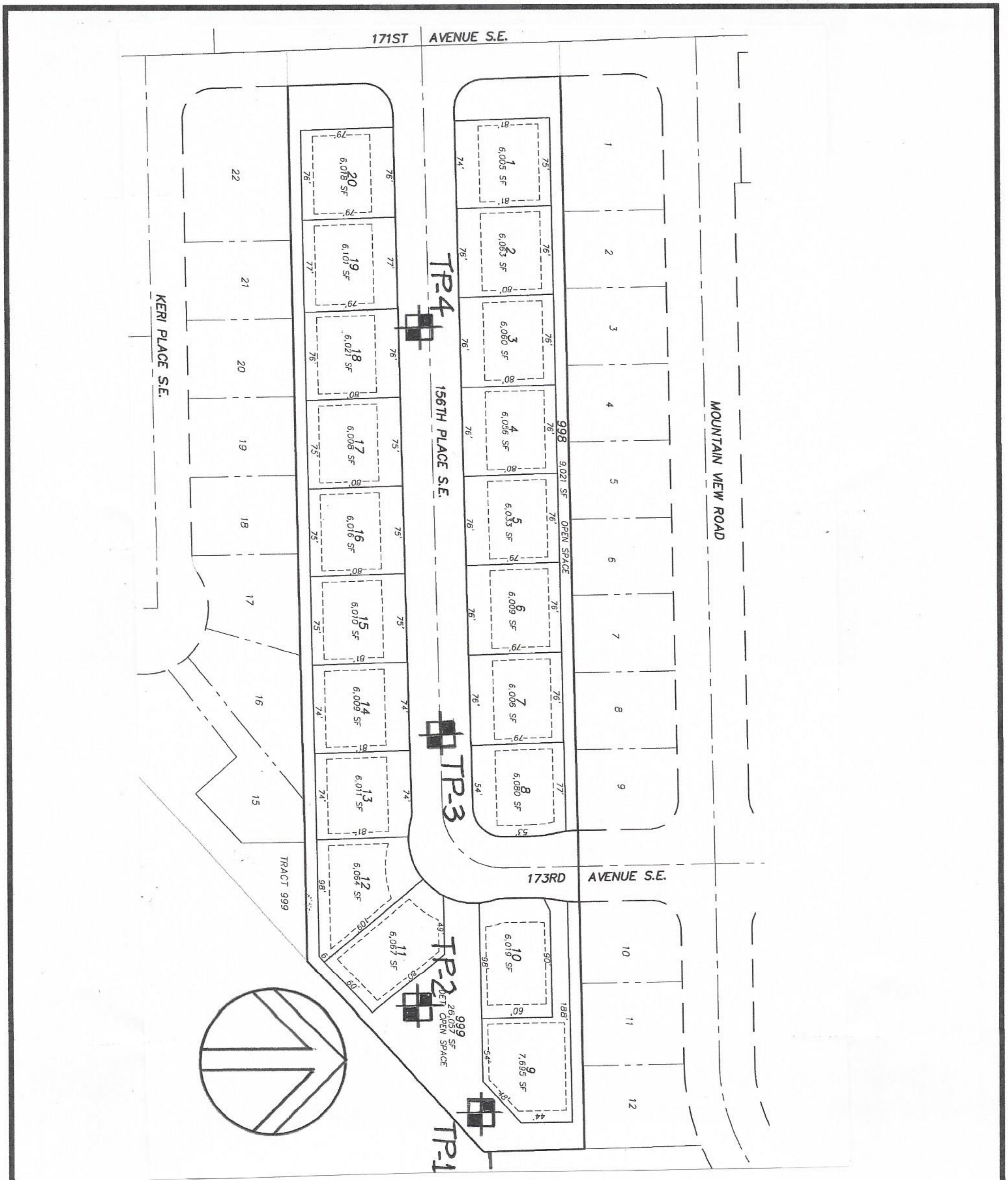
Geotechnical Engineering · Engineering Geology · Earth Science

VICINITY MAP
CURRIE FARM
15831 - 171ST AVENUE SE
MONROE, WASHINGTON

JOB NO. 16-085 | DATE 6/24/2016 | PLATE 1



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SITE AND EXPLORATION LOCATION PLAN
CURRIE FARM
15831 - 171ST AVENUE SE
MONROE, WASHINGTON

JOB NO. 16-085	DATE 6/24/2016	PLATE 2

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS MORE THAN 50% RETAINED ON THE NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE-GRAINED SOILS MORE THAN 50% PASSING ON THE NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50%	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILTY AND CLAY LIQUID LIMIT 50% OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC SILT, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

NOTES:

1. FIELD CLASSIFICATION IS BASED ON VISUAL EXAMINATION OF SOIL IN GENERAL ACCORDANCE WITH ASTM D2488-83.
2. SOIL CLASSIFICATION USING LABORATORY TESTS IS BASED ON ASTM D2487-83.
3. DESCRIPTIONS OF SOIL DENSITY OR CONSISTENCY ARE BASED ON INTERPRETATION OF BLOW-COUNT DATA, VISUAL APPEARANCE OF SOILS, AND/OR TEST DATA.

SOIL MOISTURE MODIFIERS:

DRY - ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH

SLIGHTLY MOIST - TRACE MOISTURE, NOT DUSTY

MOIST - DAMP, BUT NO VISIBLE WATER

VERY MOIST - VERY DAMP, MOISTURE FELT TO THE TOUCH

WET - VISIBLE FREE WATER OR SATURATED, USUALLY SOIL IS OBTAINED FROM BELOW WATER TABLE

TEST PIT NO. 1

Logged By: JSL   Date: 6/15/2016   Ground El. ±

Depth ft.	USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1	OL	Dark-brown, loose, organic, silty fine SAND, very-moist (TOPSOIL)			
2, 3, 4	SM	Brown, loose, silty fine SAND, moist			
5	ML/SM	Light-gray, stiff, silty fine SAND to fine-sandy SILT, slightly-moist			
6, 7, 8, 9, 10	SW	Light-gray, medium-dense to dense, gravelly, fine to medium SAND, slightly-moist (ALLUVIUM)			
11, 12		Test pit terminated at 10.0 ft; groundwater not encountered,			

TEST PIT NO. 2

Logged By: JSL   Date: 6/15/2016   Ground El. ±

Depth ft.	USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1	OL	Dark-brown, loose, organic, silty fine SAND, very-moist (TOPSOIL)			
2, 3	SM	Brown, loose, silty fine SAND, moist			
4	ML/SM	Light-gray, stiff, silty fine SAND to fine-sandy SILT, slightly-moist			
5, 6, 7, 8, 9	SW	Light-gray, medium-dense to dense, gravelly, fine to medium SAND, slightly-moist (ALLUVIUM)			
10		Test pit terminated at 10.5 ft; groundwater not encountered.			

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TEST PIT LOGS
CURRIE FARM
15831 - 171ST AVENUE SE
MONROE, WASHINGTON

JOB NO. 16-085 DATE 6/15/2016 PLATE 4

TEST PIT NO. 3

Logged By: JSL   Date: 6/15/2016   Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1		OL	Dark-brown, loose, organic, silty fine SAND, very-moist (TOPSOIL)			
2, 3, 4		SM	Yellowish-brown, loose, silty fine SAND, moist			
5		ML/SM	Light-brown to light-gray, very-stiff, silty fine SAND to fine-sandy SILT, slightly-moist			
6, 7, 8, 9		SW	Light-gray, medium-dense to dense, gravelly, fine to medium SAND, slightly-moist (ALLUVIUM)			
10			Test pit terminated at 9.0 ft; groundwater not encountered,			

TEST PIT NO. 4

Logged By: JSL   Date: 6/15/2016   Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1		OL	Dark-brown, loose, organic, silty fine SAND, very-moist (TOPSOIL)			
2, 3		SM	Yellowish-brown, loose, silty fine SAND, moist			
4, 5, 6, 7, 8		ML/SM	Light-gray, stiff to very-stiff, silty fine SAND to fine-sandy SILT, slightly-moist			
9, 10, 11		SW	Light-gray, medium-dense to dense, gravelly, fine to medium SAND, slightly-moist (ALLUVIUM)			
12			Test pit terminated at 11.0 ft; groundwater not encountered.			

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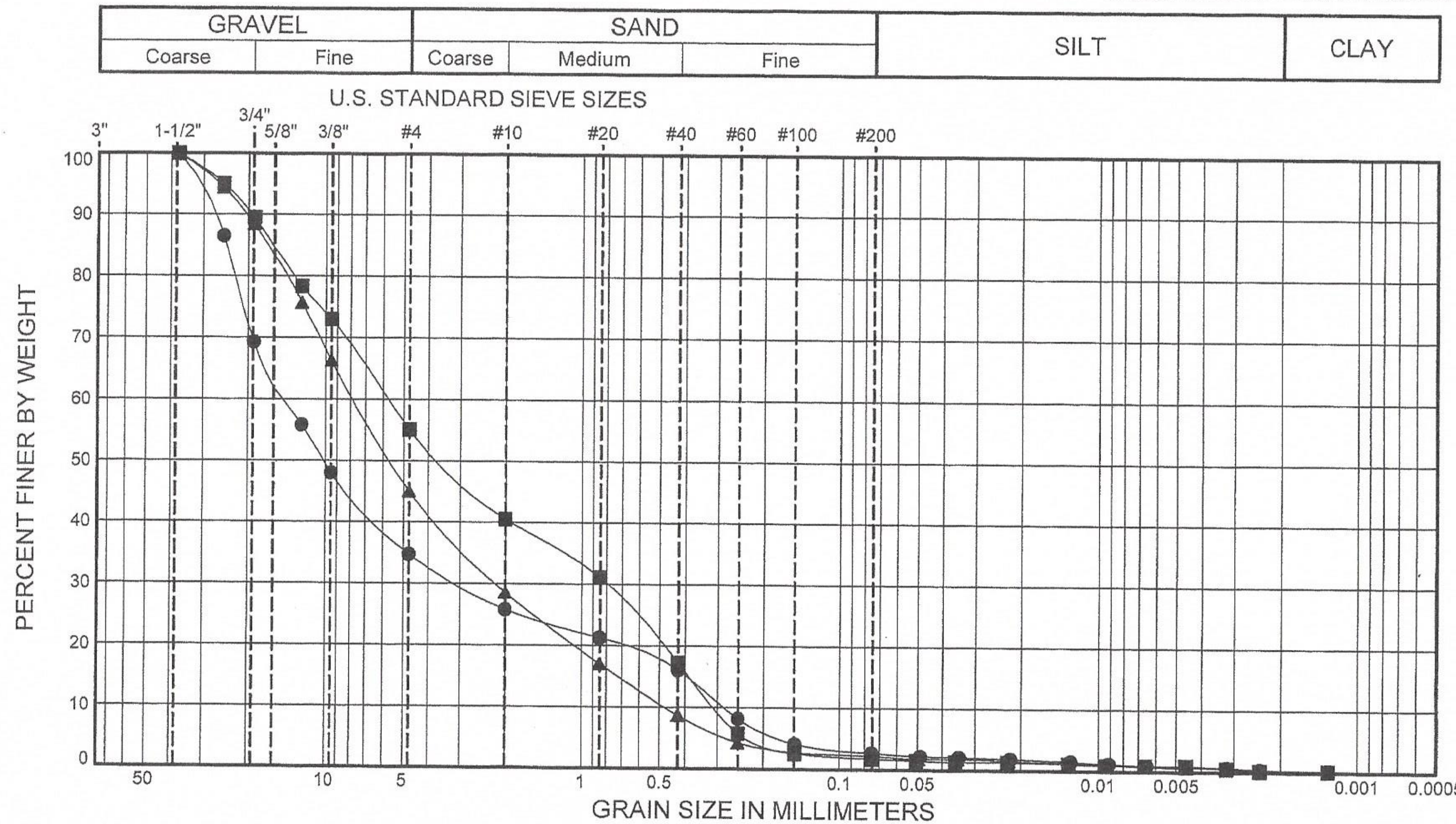
TEST PIT LOGS
CURRIE FARM
15831 - 171ST AVENUE SE
MONROE, WASHINGTON

JOB NO. 16-085   DATE 6/15/2016   PLATE 5

APPENDIX

Soil Particle Size Distribution Test Report
Currie Farm
15831 – 171st Avenue SE
Monroe, Washington
L&A Job No. 16-085

LIU & ASSOCIATES, INC.



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	D90	D60	D10	Gravel %	Sand %	Silt %	Clay %
●	TP-1	S-1	6.0 - 7.0	(GW) Dark yellowish brown, well graded GRAVEL with sand	2	27.79	14.24	0.2831	65.3	32.1	2.3	0.3
■	TP-2	S-2	5.0 - 6.0	(SP) Dark yellowish brown, poorly graded SAND with gravel	3	19.50	5.74	0.3043	44.9	53.4	1.6	0.2
▲	TP-3	S-3	6.0 - 7.0	(GW) Dark yellowish brown, well graded GRAVEL with sand	4	20.50	7.75	0.4759	55.0	42.8	1.8	0.3

HWA GEOSCIENCES INC.

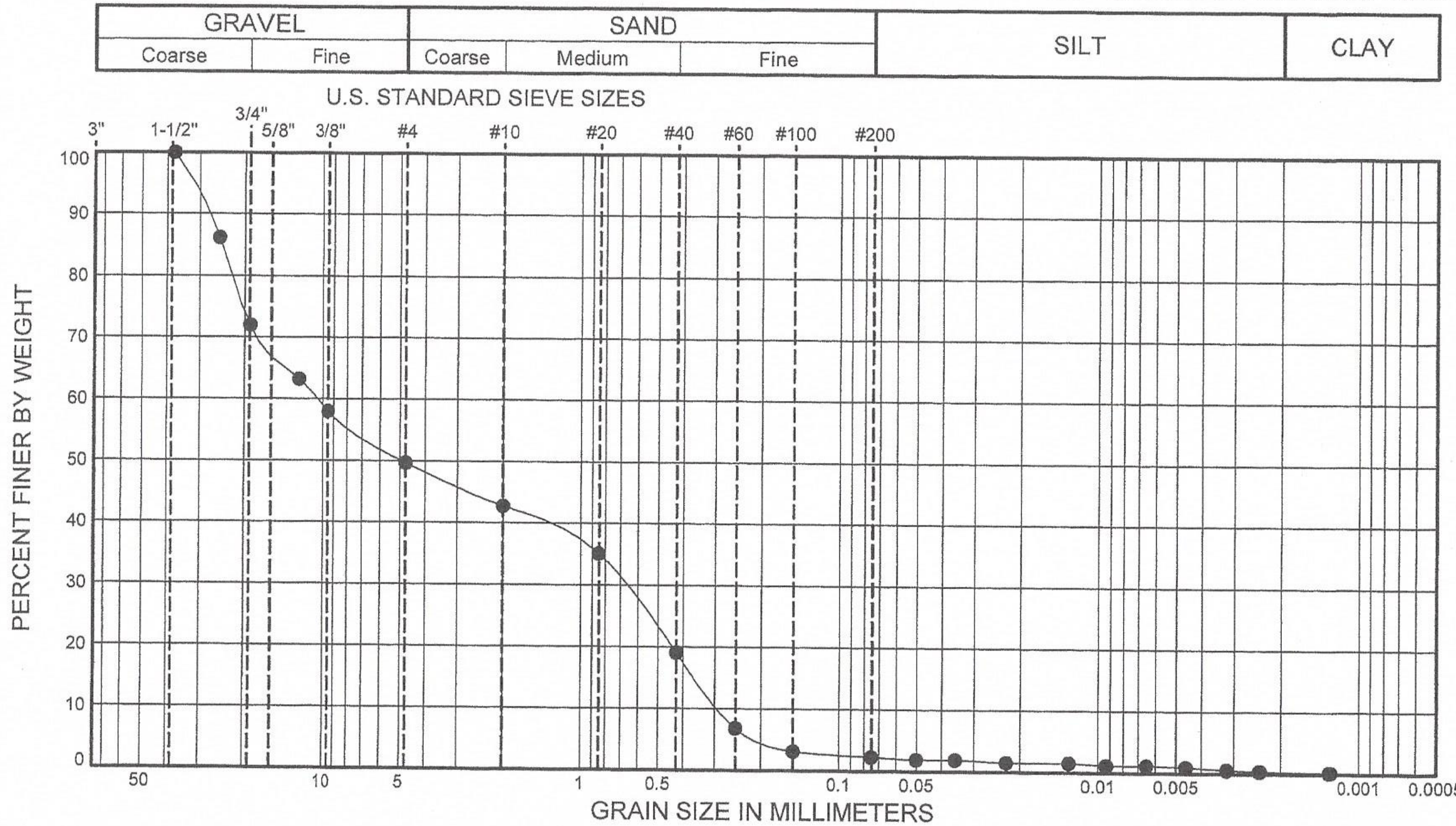
Testing for Liu & Associates Inc.
Hanson Plat
Liu Project No. 16-085

PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D422

PROJECT NO.: 2012-025 T8200 FIGURE: 1

PLATE A1-1

HWA GRSZ D90-D60-D10 2012-025 T8200.GPJ 6/24/16



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	D90	D60	D10	Gravel %	Sand %	Silt %	Clay %
●	TP-4	S-4	9.0 - 10.0	(GP) Dark yellowish brown, poorly graded GRAVEL with sand	5	28.00	10.58	0.2870	50.4	47.4	1.9	0.3

HWA GEOSCIENCES INC.

Testing for Liu & Associates Inc.
Hanson Plat
Liu Project No. 16-085

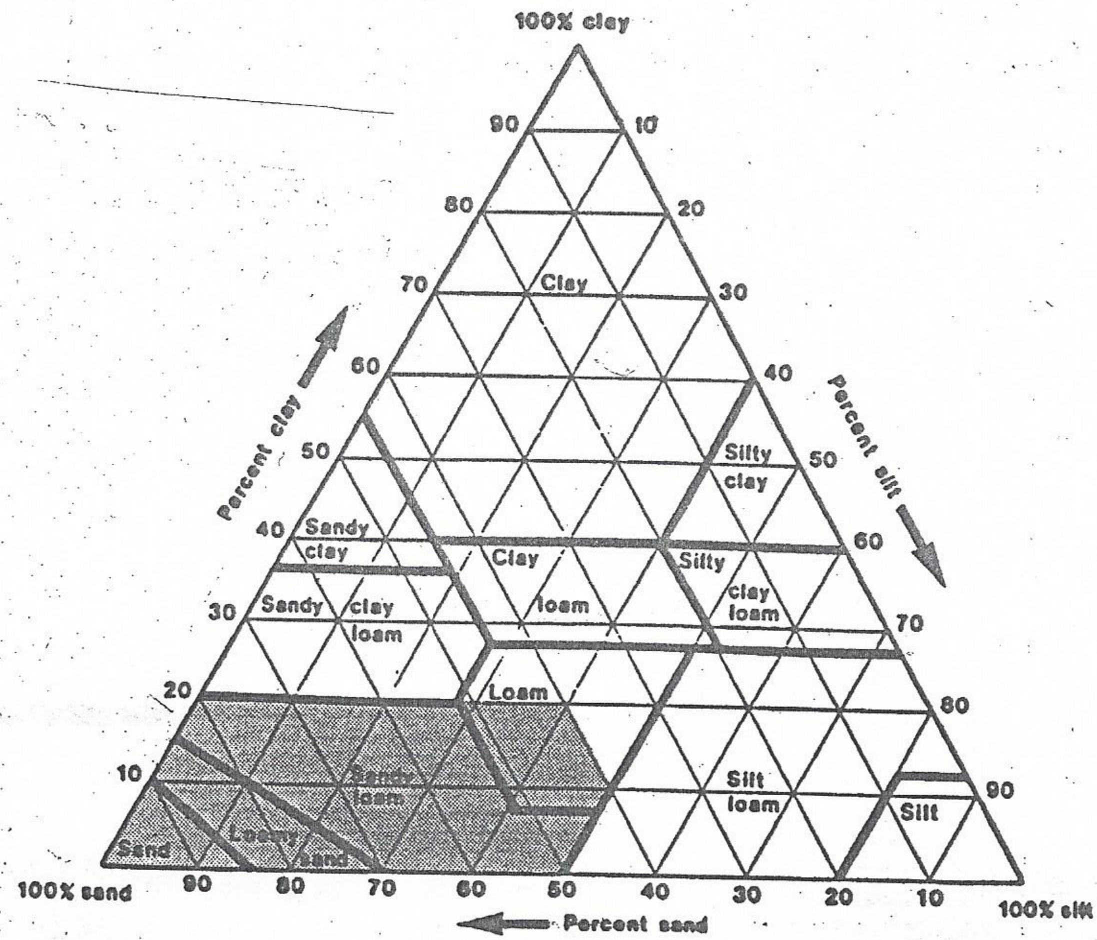
PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D422

PROJECT NO.: 2012-025 T8200 FIGURE: 2

HWA GRSZ D90-D60-D10 2012-025 T8200.GPJ 6/24/16

PLATE A1-2

Textural Triangle U.S.D.A.



Shaded area is applicable for design of infiltration BMPs

Figure 3.27 USDA Textural Triangle

Source: U.S. Department of Agriculture

PLATE A2