B-20-0741

Geotechnical Engineering Report

P/N 0420203068

2401 West Stewart
Puyallup, Washington
Short Plat No. P-15-0024

April 21, 2016

prepared for:

Farris Vet Clinic
Attention: Richard Farris
2401 West Stewart
Puyallup, Washington 98371

prepared by:

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MGI Project P475-T15

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April 21, 2016

Farris Vet Clinic
2401 West Stewart
Puyallup, WA 98371

Attention: Richard Farris

Subject: **Geotechnical Engineering Report**
Residential Development
2401 West Stewart
Puyallup, WA 98371
P/N 0420203068
Short Plat No. P-15-0024

MGI Project P475-T15

Dear Mr. Farris:

Migizi Group, Inc. (MGI) is pleased to submit this report describing the results of our geotechnical engineering evaluation of the proposed residential development in Puyallup, Washington.

This report has been prepared for the exclusive use of Farris Vet Clinic, and their consultants, for specific application to this project, in accordance with generally accepted geotechnical engineering practice.

1.0 SITE AND PROJECT DESCRIPTION

The project site consists of an irregularly shaped, 2.84 acre parcel located on the north side of West Stewart Street in Puyallup, Washington, as shown on the enclosed Topographic and Location Map (Figure 1). The parcel is orientated lengthwise from north to south, spanning approximately 692 feet along this orientation, and contains a maximum width of ± 185 feet. A short-plat of the property has recently taken place, dividing the parcel into two lots. Lot 1 is roughly rectangular shaped, and encompasses a 67 by 322 foot area towards the southwest corner of the project site. Farris Vet Clinic, associated parking facilities, and the large shed building directly to the north are all contained within Lot 1. The remaining 2.37 acres of the project area, including the long gravel driveway, are incorporated into Lot 2. Outside of the aforementioned gravel driveway, and an existing greenhouse, Lot 2 is largely undeveloped and occupied by an open, grassy field.

Development plans involve the construction of a new single family residence towards the center of the south end of Lot 2, directly north of the west end of the existing greenhouse. The existing gravel driveway will also be improved and expanded to access the proposed residence. Site produced stormwater will be retained on site if feasible, and the improved driveway will be constructed using pervious pavement.

2.0 EXPLORATORY METHODS

We explored surface and subsurface conditions at the project site on March 8, 2016. Our exploration and evaluation program comprised the following elements:

- Surface reconnaissance of the site;
- Four test pit explorations (designated TP-1 through TP-4), advanced on March 8, 2016;
- Two grain-size analyses performed on samples collected from our test pit explorations; and
- A review of published geologic and seismologic maps and literature.

Table 1 summarizes the approximate functional locations and termination depths of our subsurface exploration, and Figure 2 depicts their approximate relative location. The following sections describe the procedures used for excavation of the test pit.

TABLE 1
APPROXIMATE LOCATION AND DEPTH OF EXPLORATION

Exploration	Functional Location	Termination Depth (feet)
TP-1	South of proposed residential site, immediately northwest of existing greenhouse	5
TP-2	West side of proposed residential site	6
TP-3	East side of proposed residential site	6
TP-4	Southwest of existing greenhouse, northeast of existing shed building	6

The specific number and location of our exploration was selected in relation to the existing site features, under the constraints of surface access, underground utility conflicts, and budget considerations.

It should be realized that the exploration performed and utilized for this evaluation reveals subsurface conditions only at discrete locations across the project site and that actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations would not become evident until additional explorations are performed or until construction activities have begun. If significant variations are observed at that time, we may need to modify our conclusions and recommendations contained in this report to reflect the actual site conditions.

2.1 Test Pit Procedures

Our exploratory test pit was excavated with a Deer 310E backhoe operated by the property owner. An engineering geologist from our firm observed the test pit excavation, collected soil samples, and logged the subsurface conditions.

The enclosed test pit logs indicate the vertical sequence of soils and materials encountered in our test pits, based on our field classifications. Where a soil contact was observed to be gradational or undulating, our logs indicate the average contact depth. We estimated the relative density and consistency of the in-situ soils by means of the excavation characteristics and the stability of the test pit sidewalls. Our logs also indicate the approximate depths of any sidewall caving or groundwater seepage observed in the test pits. The soils were classified visually in general accordance with the system described in Figure A-1, which includes a key to the exploration logs. Summary logs of the explorations are included as Figures A-2 through A-5.

3.0 SITE CONDITIONS

The following sections present our observations, measurements, findings, and interpretations regarding, surface, soil, groundwater, and infiltration conditions.

3.1 Surface Conditions

The subject property is located towards the west end of the city limits of Puyallup, Washington. Immediately to the east is more densely populated residential areas, whereas to the west are more sparsely populated agricultural sites. The project area is located between the Puyallup River (to the north) and Clarks Creek (to the south). As previously indicated, the project site consists of a 2.84 acre tax parcel which has recently been short-platted. Lot 1, located towards the southwest corner of the project area, is occupied by the Farris Vet Clinic, associated parking facilities, and a large shed building north of the clinic. Access to the clinic is gained through a gravel driveway which hugs the eastern site boundary, extending north from West Stewart Ave. Lot 2 contains the gravel driveway and portions of the property east and north of the large shed building. The southeast corner of Lot 2 contains an existing greenhouse, and is littered with miscellaneous debris. The remainder of Lot 2 is undeveloped and occupied by an open, grass field. Vegetation on site is largely comprised of tall grasses in the vicinity of Lot 2, and younger cedar along the western, eastern, and northern margins of the site. Scattered brush is encountered throughout the property, and within designated landscaping areas within Lot 1. The subject property is relatively level, with minimal grade change observed over its extent.

No hydrologic features were observed on site, such as seeps, springs, ponds and streams, though scattered ponding was observed within tire ruts along the south side of the Lot 2.

3.2 Soil Conditions

We observed subsurface conditions through the advancement of 4 test pit explorations adjacent to proposed improvements. Test pit explorations TP-1 through TP-3 were performed adjacent to the proposed residential site; south, west, and east of the proposed footprint, respectively. Test pit exploration TP-4 was advanced north of the existing parking facilities, along the proposed alignment of the expanded driveway. In general, our test pit explorations encountered relatively similar subsurface conditions; typically consisting of alluvial deposits associated with the flood plains of the nearby Puyallup River. Underlying a surface mantle of sod and topsoil, we encountered a thin horizon of silty fine sand to sandy silt, typically less than 1 foot in overall thickness. Beneath this stratum, we observed mottled, saturated silt with intermittent lenses or layers of fine sand or silty sand. This stratum was continuous through the termination of all of our subsurface explorations, a maximum depth of 6 feet. Deeper subsurface explorations were not feasible for this project given shallow groundwater and severe caving conditions. An exception to the above described soil sequence was observed in test pit exploration TP-4, with a small fill proponent being encountered towards the top of the exploration, and the upper stratum, free of mottling, was slightly thicker. All soils encountered in our subsurface explorations were in a loose/soft to very loose/soft in situ condition.

The National Cooperative Soil Survey (NCSS) for Pierce County, Washington, classifies soils within the northern half of the property as 42A-Sultan silt loam, and soils within the southern half of the property as 6A-Briscot loam. Each soil group reportedly formed in alluvial flood plain deposits, and is texturally comprised of sand, loam, silt loam and clay loam. Our subsurface explorations generally correspond with the site classification developed by the NCSS.

The enclosed exploration logs (Appendix A) provide a detailed description of the soil strata encountered in our subsurface explorations.

3.3 Groundwater Conditions

We encountered shallow groundwater seepage in all of our test pit explorations, typically observed at a depth of 2½ to 3½ feet below existing grade. Given the fact that our test pit explorations were performed towards the latter end of one of the wettest winters in the recent history of Western Washington, it is our opinion that the observed seepage is representative of seasonally high levels. Given the fact that groundwater was encountered a foot deeper in test pit exploration TP-4, which was the southernmost of our test pit explorations, we anticipate that there will be a general trend of increasing depth to groundwater towards the north to south across the project area. Actual groundwater levels will fluctuate with localized precipitation and geology.

3.4 Infiltration Conditions and Infiltration Rate

Based on our field observations and grain size analyses (presented in Table 2, below), it's evident that native soils consist of slowly permeable silty sand to sandy silt at or near surface elevations, grading to mottled silt with depth, which extended through the termination of our subsurface explorations. Given the relatively shallow depth to groundwater, the only feasible stratum to utilize for infiltration would be the lower of the two soil groups described above, which was found to have a relative fines content (percent silt/clay) that ranges from 79 to 90 percent.

The results of our soil grain size analyses are presented below, and the attached Soil Gradation Graphs (Appendix B) display the grain-size distribution of the samples tested.

TABLE 2
LABORATORY TEST RESULTS FOR NON-ORGANIC ONSITE SOILS

Soil Sample, Depth	% Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines	D_{10}
TP-2, S-2, 1.5 feet	0	0	0.2	4.1	5.4	90.2	--
TP-4, S-2, 4 feet	0	0	0	1.7	19.0	79.2	--

Drainage Design Considerations

Given the fine-grained nature of site soils, and the presence of extremely shallow groundwater, it is our opinion that standard retention facilities associated with the full or limited infiltration of stormwater produced by residential construction (i.e. trenches, drywells…) are not feasible for this project. Given such, it is our opinion that roof-runoff produced by the proposed residence should be managed through the introduction of raingardens, a dispersion system, or a combination of the two.

As indicated earlier, the improved driveway will be constructed utilizing pervious pavement. In our opinion, adequate separation from groundwater is present to make this system feasible within the project area.

0.3in/hr is required for bioretention and permeable pavement

We determined an infiltration rate for the pervious subgrade by comparing the results of our sieve analyses from test pit explorations TP-2 and TP-4 with Table 3.7, in Volume III of the *2005 DOE Stormwater Management Manual for Western Washington*, located on page 3-76. The alluvial silt stratum, with its intermittent lens and/or layers of silty sand, generally corresponds with a loam U.S.D.A. soil classification. As such, our recommended long-term infiltration rate for the pervious subgrade, using the native fine-grained soils as the infiltrative unit, is 0.13 inches per hour.

Treatment Considerations

As part of our evaluation, we also submitted a sample of native soils for testing to determine the organic content, and cation exchange capacity (CEC) of soils that will underlie proposed pervious pavements. The following table illustrates the results of the laboratory analyses:

TABLE 3
LABORATORY TEST RESULTS FOR TREATMENT CAPACITY OF ONSITE SOILS

Soil Sample, Depth	Organic Content (%)	Cation Exchange Capacity (CEC)(meq/100g)
TP-4, S-1, 18 inches	5.4	10.1

18" min required Min 1% required CEC > 5

The civil engineer in charge should evaluate the above results to determine if native soils are adequate for treatment. Laboratory results prepared by Krazan & Associates, Inc. and AgSource Laboratories are attached as Appendix C.

3.5 Seismic Conditions

Based on our analysis of subsurface exploration logs and our review of published geologic maps, we interpret the onsite soil conditions to generally correspond with site class E, as defined by Table 30.2-1 in *ASCE 7*, per the 2012 *International Building Code (IBC)*.

Using 2012 IBC information on the USGS Design Summary Report website, Risk Category I/II/III seismic parameters for the site are as follows:

S_s = 1.261 g	S_{MS} = 1.135 g	S_{DS} = 0.757 g
S_1 = 0.487 g	S_{M1} = 1.168 g	S_{D1} = 0.778 g

Using the 2012 IBC information, MCE_R Response Spectrum Graph on the USGS Design Summary Report website, Risk Category I/II/III, S_a at a period of 0.2 seconds is 1.135 g and S_a at a period of 1.0 seconds is 1.168 g.

The Design Response Spectrum Graph from the same website, using the same IBC information and Risk Category, S_a at a period of 0.2 seconds is 0.757 g and S_a at a period of 1.0 seconds is 0.778 g.

3.6 Liquefaction Potential

Liquefaction is a sudden increase in pore water pressure and a sudden loss of soil shear strength caused by shear strains, as could result from an earthquake. Research has shown that saturated, loose, fine to medium sands with a fines (silt and clay) content less than about 20 percent are most susceptible to liquefaction. As described in the Soil Conditions section of this report, native soils are comprised of poorly consolidated alluvial deposits. Given the high relative fines content observed in much of the native soils, some measure of resistance to liquefaction is present, but the potential for liquefaction during a large-scale seismic event should still be considered high in the project area. Recommended subgrade preparation techniques highlighted in Section 4.2 of this report will help mitigate some, but not all of the risk for seismically induced post-construction settlement.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Development plans involve the construction of a new single family residence towards the center of the south end of Lot 2, directly north of the west end of the existing greenhouse. The existing gravel driveway will also be improved and expanded to access the proposed residence. Site produced stormwater will be retained on site if feasible, and the improved driveway will be constructed using pervious pavement. We offer these recommendations:

- Feasibility: Based on our field explorations, research and analyses, the proposed structure appears feasible from a geotechnical standpoint.
- Foundation Options: Due to the soft soils underlying the site, over-excavation of spread footing subgrades, to a depth of 3 feet, and the construction of structural fill bearing pads will be necessary for foundation support of the new structure. Given the fact that the over-excavation will likely extend below the water table, we recommend that the bottom 12 inches of the bearing pads consist of 2-4 inch quarry spalls driven into the subgrade using a hoe pack. Recommendations for Spread Footings are provided in Section 4.2.
- Floor Options: Floor sections should bear on medium dense or denser native soils or on properly compacted structural fill that extends down to medium dense or denser native soil. We recommend over-excavation of slab-on-grade floor subgrades to a

minimum depth of 2 feet, then placement of properly compacted structural fill as a floor subbase. If floor construction occurs during wet conditions, it is likely that a geotextile fabric, placed between the structural fill floor subbase and native soils, will be necessary. Recommendations for slab-on-grade floors are included in Section 4.3. Fill underlying floor slabs should be compacted to 95 percent (ASTM:D-1557).

- Infiltration Conditions: Given the fine-grained nature of site soils, and the shallow depth to groundwater, we do not interpret standard full or limited infiltration as being feasible to manage roof-runoff from the proposed residence. Given such, it is our opinion that roof-runoff produced by the proposed residence should be managed through the introduction of raingardens, a dispersion system, or a combination of the two. Pervious pavements utilized in the improved driveway system should be designed utilizing an infiltration rate of **0.13 inches/hour** for native subgrade materials.

The following sections of this report present our specific geotechnical conclusions and recommendations concerning site preparation, spread footings, slab-on-grade floors, asphalt pavement, and structural fill. The Washington State Department of Transportation (WSDOT) Standard Specifications and Standard Plans cited herein refer to WSDOT publications M41-10, *Standard Specifications for Road, Bridge, and Municipal Construction*, and M21-01, *Standard Plans for Road, Bridge, and Municipal Construction*, respectively.

4.1 Site Preparation

Preparation of the project site should involve erosion control, temporary drainage, clearing, stripping, excavations, cutting, subgrade compaction, and filling.

Erosion Control: Before new construction begins, an appropriate erosion control system should be installed. This system should collect and filter all surface water runoff through silt fencing. We anticipate a system of berms and drainage ditches around construction areas will provide an adequate collection system. Silt fencing fabric should meet the requirements of WSDOT Standard Specification 9-33.2 Table 3. In addition, silt fencing should embed a minimum of 6 inches below existing grade. An erosion control system requires occasional observation and maintenance. Specifically, holes in the filter and areas where the filter has shifted above ground surface should be replaced or repaired as soon as they are identified.

Temporary Drainage: We recommend intercepting and diverting any potential sources of surface or near-surface water within the construction zones before stripping begins. Because the selection of an appropriate drainage system will depend on the water quantity, season, weather conditions, construction sequence, and contractor's methods, final decisions regarding drainage systems are best made in the field at the time of construction. Based on our current understanding of the construction plans, surface and subsurface conditions, we anticipate that curbs, berms, or ditches placed around the work areas will adequately intercept surface water runoff.

Clearing and Stripping: After surface and near-surface water sources have been controlled, sod, topsoil, and root-rich soil should be stripped from the site. Our subsurface exploration indicates that the organic horizon can reach thicknesses of up to 8 inches. Stripping is best performed during a period of dry weather.

Site Excavations: Based on our exploration, we expect that site excavations to encountered loose/soft silty alluvial soils, which can be readily excavated using standard excavation equipment.

Dewatering: Our explorations encountered groundwater seepage at a depth of 2½ to 3½ feet below existing grade. For shallow excavations, we anticipate that an internal system of ditches, sump holes, and pumps will be adequate to temporarily dewater excavations. For deeper excavations, those performed well below the water table, we anticipate that well points, or other expensive dewatering techniques will need to be employed to adequately dewater excavations.

Temporary Cut Slopes: All temporary soil slopes associated with site cutting or excavations should be adequately inclined to prevent sloughing and collapse. Temporary cut slopes in site soils should be no steeper than 1½H:1V, and should conform to Washington Industrial Safety and Health Act (WISHA) regulations.

Subgrade Compaction: Exposed subgrades for the foundation of the proposed residence should be compacted to a firm, unyielding state before new concrete or fill soils are placed. Any localized zones of looser granular soils observed within a subgrade should be compacted to a density commensurate with the surrounding soils. In contrast, any organic, soft, or pumping soils observed within a subgrade should be overexcavated and replaced with a suitable structural fill material.

Site Filling: Our conclusions regarding the reuse of onsite soils and our comments regarding wet-weather filling are presented subsequently. Regardless of soil type, all fill should be placed and compacted according to our recommendations presented in the Structural Fill section of this report. Specifically, building pad fill soil should be compacted to a uniform density of at least 95 percent (based on ASTM:D-1557).

Onsite Soils: We offer the following evaluation of these onsite soils in relation to potential use as structural fill:

- *Surficial Organic Soil and Organic-Rich Fill Soils*: Where encountered, surficial organic soils, like duff, topsoil, root-rich soil, and organic-rich fill soils are *not* suitable for use as structural fill under any circumstances, due to high organic content. Consequently, this material can be used only for non-structural purposes, such as in landscaping areas.
- *Alluvial Silt*: Underlying a surface mantle of sod and topsoil, we encountered mottled, silty soils to a depth of 7 feet below existing grade. These soils are extremely moisture sensitive and will be difficult, if not impossible to reuse during wet weather conditions. If reuse is planned, care should be taken while stockpiling in order to avoid saturation/over-saturation of the material, and moisture conditioning should be expected.

- *Alluvial Silty Sand*: Underlying the silt stratum discussed in the above section, we encountered fine silty sand, which was continuous to the termination depth of our subsurface exploration; 12 feet below existing grade. This material type contains a relative fines content (percent silt/clay) of upwards of 38 percent, and is moderately to severely moisture sensitive. This material type will be difficult to reuse in wet weather conditions, particularly given the fact that it was encountered in a saturated in-situ condition.

Permanent Slopes: All permanent cut slopes and fill slopes should be adequately inclined to reduce long-term raveling, sloughing, and erosion. We generally recommend that no permanent slopes be steeper than 2H:1V. For all soil types, the use of flatter slopes (such as 2½H:1V) would further reduce long-term erosion and facilitate revegetation.

Slope Protection: We recommend that a permanent berm, swale, or curb be constructed along the top edge of all permanent slopes to intercept surface flow. Also, a hardy vegetative groundcover should be established as soon as feasible, to further protect the slopes from runoff water erosion. Alternatively, permanent slopes could be armored with quarry spalls or a geosynthetic erosion mat.

4.2 Spread Footings

In our opinion, conventional spread footings will provide adequate support for the residences if the subgrades are properly prepared. Due to the soft soils underlying the site, over-excavation of spread footing subgrades, to a depth of 3 feet, and the construction of structural fill bearing pads will be necessary for foundation support of the new structure.

Footing Depths and Widths: For frost and erosion protection, the bases of all exterior footings should bear at least 18 inches below adjacent outside grades, whereas the bases of interior footings need bear only 12 inches below the surrounding slab surface level. To reduce post-construction settlements, continuous (wall) and isolated (column) footings should be at least 16 and 24 inches wide, respectively.

Bearing Subgrades: Structural fill bearing pads, 3 feet thick and compacted to a density of at least 95 percent (based on ASTM:D-1557), should underlie spread footings on this site. Given the fact that the over-excavation will likely extend below the water table, we recommend that the bottom 12 inches of the bearing pads consist of 2-4 inch quarry spalls driven into the subgrade using a hoe pack.

In general, before footing concrete is placed, any localized zones of loose soils exposed across the footing subgrades should be compacted to a firm, unyielding condition, and any localized zones of soft, organic, or debris-laden soils should be overexcavated and replaced with suitable structural fill.

Lateral Overexcavations: Because foundation stresses are transferred outward as well as downward into the bearing soils, all structural fill placed under footings, should extend horizontally outward from the edge of each footing. This horizontal distance should be equal to the depth of placed fill. Therefore, placed fill that extends 3 feet below the footing base should also extend 3 feet outward from the footing edges.

Subgrade Observation: All footing subgrades should consist of firm, unyielding, native soils, or structural fill materials that have been compacted to a density of at least 95 percent (based on ASTM:D-1557). Footings should never be cast atop loose, soft, or frozen soil, slough, debris, existing uncontrolled fill, or surfaces covered by standing water.

Bearing Pressures: In our opinion, for static loading, footings that bear on properly prepared, structural fill bearing pads 3 feet thick can be designed for a preliminary allowable soil bearing pressure of 1,500 psf. A one-third increase in allowable soil bearing capacity may be used for short-term loads created by seismic or wind related activities.

Footing Settlements: Assuming that structural fill soils are compacted to a medium dense or denser state, we estimate that total post-construction settlements of properly designed footings bearing on properly prepared subgrades will not exceed 1 inch. Differential settlements for comparably loaded elements may approach one-half of the actual total settlement over horizontal distances of approximately 50 feet.

Footing Backfill: To provide erosion protection and lateral load resistance, we recommend that all footing excavations be backfilled on both sides of the footings and stemwalls after the concrete has cured. Either imported structural fill or non-organic onsite soils can be used for this purpose, contingent on suitable moisture content at the time of placement. Regardless of soil type, all footing backfill soil should be compacted to a density of at least 90 percent (based on ASTM:D-1557).

Lateral Resistance: Footings that have been properly backfilled as recommended above will resist lateral movements by means of passive earth pressure and base friction. We recommend using an allowable passive earth pressure of 225 psf and an allowable base friction coefficient of 0.35 for site soils.

4.3 Slab-On-Grade Floors

In our opinion, soil-supported slab-on-grade floors can be used if the subgrades are properly prepared. We offer the following comments and recommendations concerning slab-on-grade floors.

Floor Subbase: We recommend over-excavation of slab-on-grade floor subgrades to a minimum depth of 2 feet, then placement of properly compacted structural fill as a floor subbase. If floor construction occurs during wet conditions, it is likely that a geotextile fabric, placed between the structural fill floor subbase and native soils, will be necessary.

All subbase fill should be compacted to a density of at least 95 percent (based on ASTM:D-1557).

Capillary Break and Vapor Barrier: To retard the upward wicking of moisture beneath the floor slab, we recommend that a capillary break be placed over the subgrade. Ideally, this capillary break would consist of a 4-inch-thick layer of pea gravel or other clean, uniform, well-rounded gravel, such as "Gravel Backfill for Drains" per WSDOT Standard Specification 9-03.12(4), but clean angular gravel can be used if it adequately prevents capillary wicking. In addition, a layer of plastic sheeting (such as Crosstuff, Visqueen, or Moistop) should be placed over the capillary break to serve as a vapor barrier. During subsequent casting of the concrete slab, the contractor should exercise care to avoid puncturing this vapor barrier.

Vertical Deflections: Due to elastic compression of subgrades, soil-supported slab-on-grade floors can deflect downwards when vertical loads are applied. In our opinion, a subgrade reaction modulus of 250 pounds per cubic inch can be used to estimate such deflections.

4.4 Drainage Systems

In our opinion, structures should be provided with permanent drainage systems to reduce the risk of future moisture problems. We offer the following recommendations and comments for drainage design and construction purposes.

Perimeter Drains: We recommend that buildings be encircled with a perimeter drain system to collect seepage water. This drain should consist of a 4-inch-diameter perforated pipe within an envelope of pea gravel or washed rock, extending at least 6 inches on all sides of the pipe, and the gravel envelope should be wrapped with filter fabric to reduce the migration of fines from the surrounding soils. Ideally, the drain invert would be installed no more than 8 inches above the base of the perimeter footings.

Subfloor Drains: We recommend that subfloor drains be included beneath the new building. These subfloor drains should consist of 4-inch-diameter perforated pipes surrounded by at least 6 inches of pea gravel and enveloped with filter fabric. A pattern of parallel pipes spaced no more than 20 feet apart and having inverts located about 12 inches below the capillary break layer would be appropriate, in our opinion.

Discharge Considerations: If possible, all perimeter drains should discharge to a sewer system or other suitable location by gravity flow. Check valves should be installed along any drainpipes that discharge to a sewer system, to prevent sewage backflow into the drain system. If gravity flow is not feasible, a pump system is recommended to discharge any water that enters the drainage system.

Runoff Water: Roof-runoff and surface-runoff water should *not* discharge into the perimeter drain system. Instead, these sources should discharge into separate tightline pipes and be routed away from the building to a storm drain or other appropriate location.

Grading and Capping: Final site grades should slope downward away from the buildings so that runoff water will flow by gravity to suitable collection points, rather than ponding near the building. Ideally, the area surrounding the building would be capped with concrete, asphalt, or low-permeability (silty) soils to minimize or preclude surface-water infiltration.

4.5 Pervious Pavement

We understand that pervious pavement will be utilized in the construction of the improved driveway system. Site grading will consist of removal of sufficient sod and underlying soil to install a thick coarse gravel reservoir along with a slightly finer gravel pavement base course under the area to receive porous paving. The actual thickness of these elements will be determined by the design engineer; however, a minimum of one foot of separation needs to be maintained between from the bottom of the gravel reservoir and seasonally high groundwater levels. We offer the following comments and recommendations for pavement construction.

Subgrade Preparation: The existing subgrade under all pervious pavements must remain in an uncompacted condition to facilitate water infiltration. Traffic from construction equipment and vehicles should be limited to the extent practical prior to placement of the pavement section. Control erosion and avoid introducing sediment from surrounding land uses onto permeable pavements. Do not allow muddy construction equipment on the base material or pavement. Any concentrated areas of fines accumulation due to ponding may be removed to a maximum depth of 6 inches. If desired, these areas may be re-leveled using clean sand. Materials meeting the requirements for "Sand Drainage Blanket" in section 9-03.13(1) of the WSDOT Standard Specifications may be used for this purpose.

We recommend placement of a nonwoven filter fabric such as Mirafi 160N or equal over the prepared subgrade prior to construction of the pervious pavement section.

Maintenance Considerations: Do not allow sediment laden runoff onto permeable pavements. Pavements fouled with sediments or no longer passing an initial infiltration test must be cleaned using procedures from the local stormwater manual or the manufacturer's procedures.

Construction Observation: We recommend that an MGI representative be retained to observe and document the placement of each course before any overlying layer is placed.

4.6 Structural Fill

The term "structural fill" refers to any material placed under foundations, retaining walls, slab-on-grade floors, sidewalks, pavements, and other structures. Our comments, conclusions, and recommendations concerning structural fill are presented in the following paragraphs.

Materials: Typical structural fill materials include clean sand, gravel, pea gravel, washed rock, crushed rock, well-graded mixtures of sand and gravel (commonly called "gravel borrow" or "pit-run"), and miscellaneous mixtures of silt, sand, and gravel. Recycled asphalt, concrete, and glass, which are derived from pulverizing the parent materials, are also potentially useful as structural fill in certain applications. Soils used for structural fill should not contain any organic matter or debris, nor any individual particles greater than about 6 inches in diameter.

Fill Placement: Clean sand, gravel, crushed rock, soil mixtures, and recycled materials should be placed in horizontal lifts not exceeding 8 inches in loose thickness, and each lift should be thoroughly compacted with a mechanical compactor.

Compaction Criteria: Using the Modified Proctor test (ASTM:D-1557) as a standard, we recommend that structural fill used for various onsite applications be compacted to the following minimum densities:

Fill Application	Minimum Compaction
Footing subgrade and bearing pad	95 percent
Foundation and subgrade wall backfill	90 percent
Slab-on-grade floor subgrade and subbase	95 percent

Subgrade Observation and Compaction Testing: Regardless of material or location, all structural fill should be placed over firm, unyielding subgrades prepared in accordance with the Site Preparation section of this report. The condition of all subgrades should be observed by geotechnical personnel before filling or construction begins. Also, fill soil compaction should be verified by means of in-place density tests performed during fill placement so that adequacy of soil compaction efforts may be evaluated as earthwork progresses.

Soil Moisture Considerations: The suitability of soils used for structural fill depends primarily on their grain-size distribution and moisture content when they are placed. As the "fines" content (that soil fraction passing the U.S. No. 200 Sieve) increases, soils become more sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (by weight) cannot be consistently compacted to a firm, unyielding condition when the moisture content is more than 2 percentage points above or below optimum. For fill placement during wet-weather site work, we recommend using "clean" fill, which refers to soils that have a fines content of 5 percent or less (by weight) based on the soil fraction passing the U.S. No. 4 Sieve.

5.0 RECOMMENDED ADDITIONAL SERVICES

Because the future performance and integrity of the structural elements will depend largely on proper site preparation, drainage, fill placement, and construction procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process. Subsequently, we recommend that MGI be retained to provide the following post-report services:

- Review all construction plans and specifications to verify that our design criteria presented in this report have been properly integrated into the design;
- Prepare a letter summarizing all review comments (if required);
- Check all completed subgrades for footings and slab-on-grade floors before concrete is poured, in order to verify their bearing capacity; and
- Prepare a post-construction letter summarizing all field observations, inspections, and test results (if required).

6.0 CLOSURE

The conclusions and recommendations presented in this report are based, in part, on the explorations that we observed for this study; therefore, if variations in the subgrade conditions are observed at a later time, we may need to modify this report to reflect those changes. Also, because the future performance and integrity of the project elements depend largely on proper initial site preparation, drainage, and construction procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process. MGI is available to provide geotechnical monitoring of soils throughout construction.

We appreciate the opportunity to be of service on this project. If you have any questions regarding this report or any aspects of the project, please feel free to contact our office.

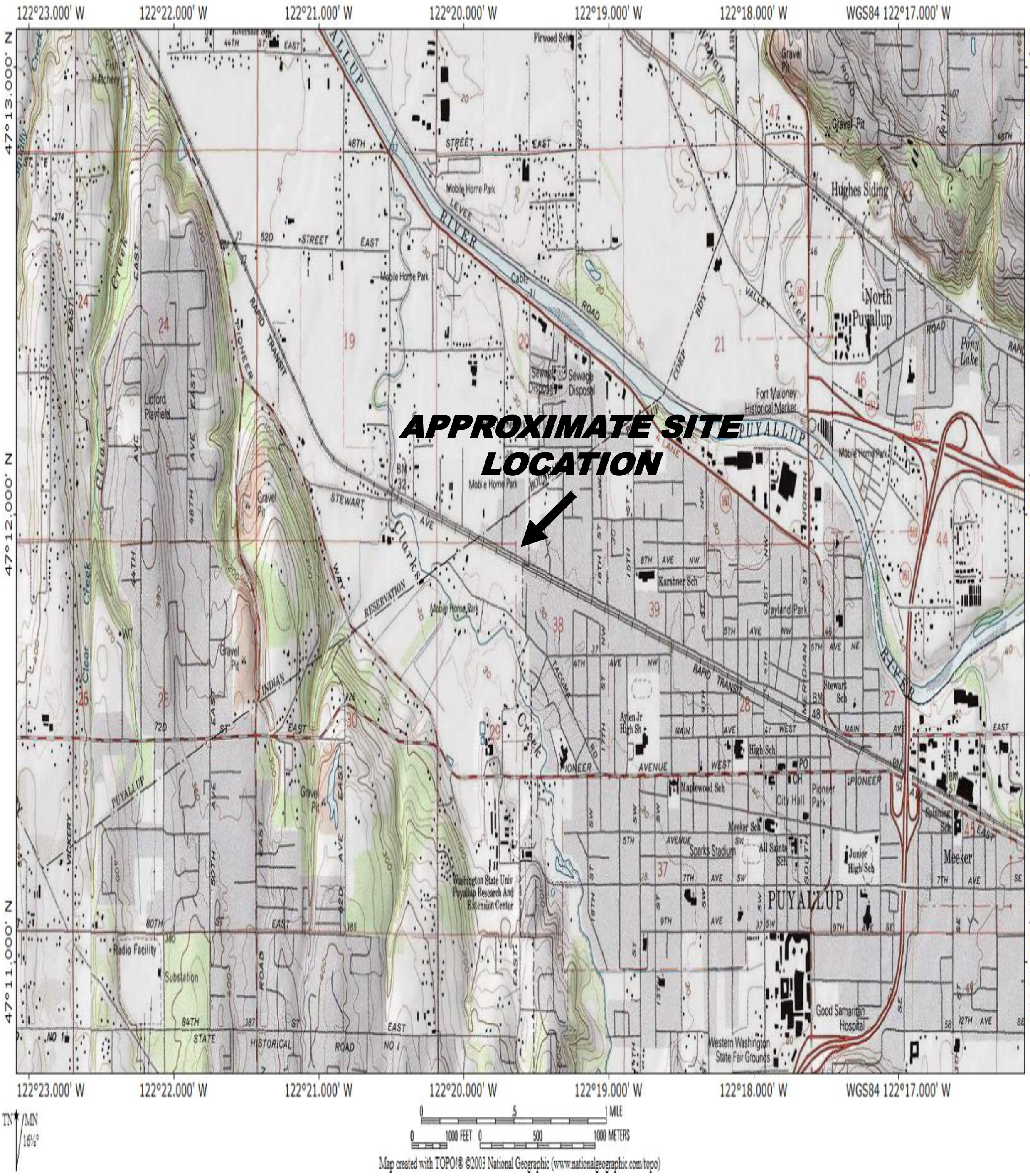
Respectfully submitted,

MIGIZI GROUP, INC.

Zach L. Logan
Staff Geologist

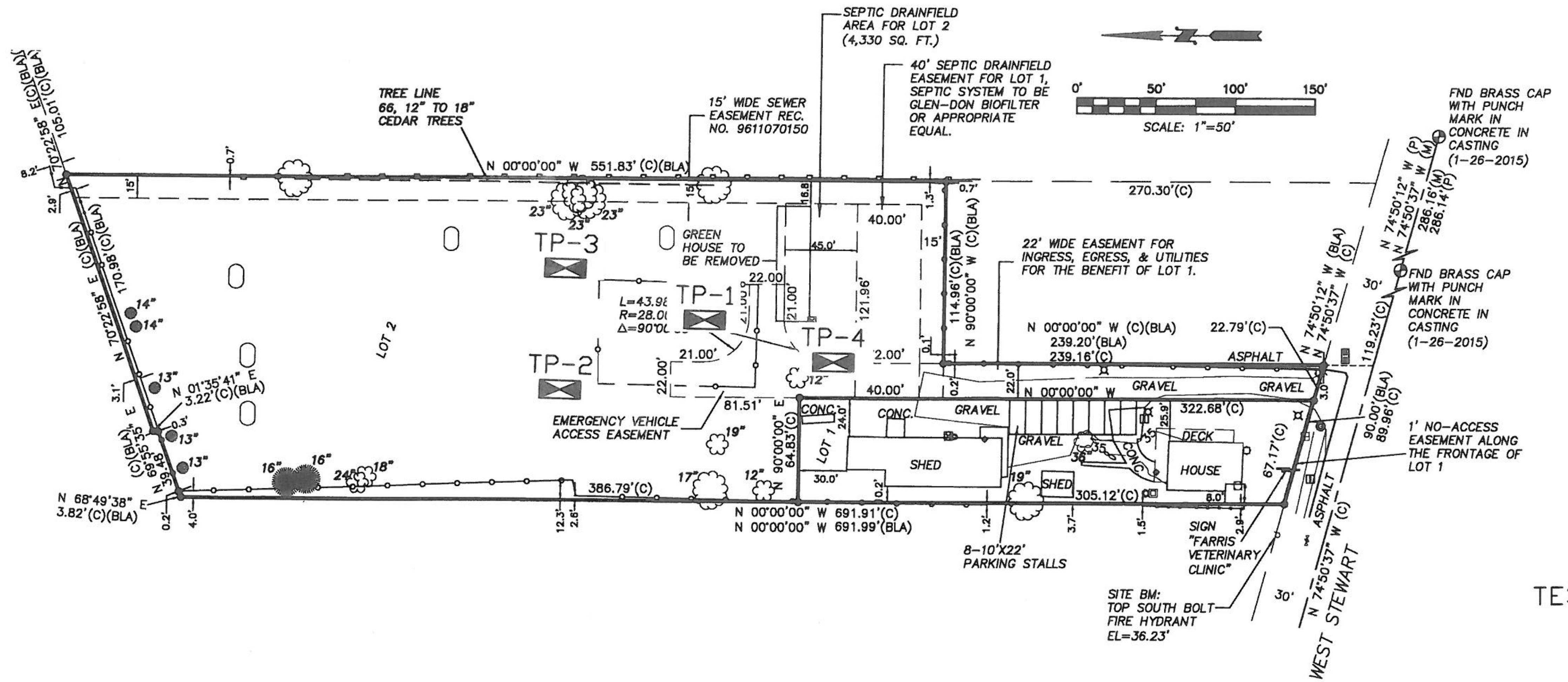
James E. Brigham, P.E.
Principal Engineer

TOPO! map printed on 03/09/16 from "Untitled.tpo"



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Migizi Group, Inc. **P.O. Box 44840** **Tacoma, WA 98448**	2401 West Stewart Avenue Puyallup, Washington 98371 Topographic and Location Map	**FIGURE 1** **P475-T15**



TEST PIT LOCATION

TP-1

NOTE:
BOUNDARY AND TOPOGRAPHY ARE BASED ON MAPPING PROVIDED TO MIGIZI OBSERVATIONS MADE IN THE FIELD. THE INFORMATION SHOWN DOES NOT CONSTITUTE A FIELD SURVEY BY MIGIZI.

Migizi Group, Inc. PO Box 44840 Tacoma, WA 98448 253-537-9400 253-537-9401 fax www.migizigroup.com	PROJECT: 2401 W Stewart St Puyallup, Washington	
	SHEET TITLE: Site and Exploration Plan	
	DESIGNER: CRL	JOB NO. P475-T15
	DRAWN BY: CRL	SCALE: As Shown
	CHECKED BY: JEB	FIGURE: 2
	DATE: Mar. 29, 2016	FILE: Fig2.dwg

APPENDIX A
SOIL CLASSIFICATION CHART AND KEY TO TEST DATA

LOG OF TEST PIT

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS More than Half > #200 sieve	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES
		GRAVELS WITH OVER 15% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 15% FINES	SM	SILTY SANDS, POOORLY GRADED SAND-SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAINED SOILS More than Half < #200 sieve	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

⧗	Modified California	RV	R-Value
⊠	Split Spoon	SA	Sieve Analysis
■	Pushed Shelby Tube	SW	Swell Test
◧	Auger Cuttings	TC	Cyclic Triaxial
✋	Grab Sample	TX	Unconsolidated Undrained Triaxial
■	Sample Attempt with No Recovery	TV	Torvane Shear
CA	Chemical Analysis	UC	Unconfined Compression
CN	Consolidation	(1.2)	(Shear Strength, ksf)
CP	Compaction	WA	Wash Analysis
DS	Direct Shear	(20)	(with % Passing No. 200 Sieve)
PM	Permeability	▽	Water Level at Time of Drilling
PP	Pocket Penetrometer	▼	Water Level after Drilling(with date measured)

SOIL CLASSIFICATION CHART AND KEY TO TEST DATA

Figure A-1

MIGIZI GROUP

Migizi Group, Inc.
PO Box 44840
Tacoma, WA 98448
Telephone: 253-537-9400
Fax: 253-537-9401

TEST PIT NUMBER TP-1

Figure A-2

CLIENT Farris Vet Clinic
PROJECT NAME 2401 W Stewart Geotech Report
PROJECT NUMBER P475-T15
PROJECT LOCATION Puyallup, Washington
DATE STARTED 3/8/16 **COMPLETED** 3/8/16
GROUND ELEVATION **TEST PIT SIZE**
EXCAVATION CONTRACTOR Owner-Operator
GROUND WATER LEVELS:
EXCAVATION METHOD Rubber Tracked Excavator
∇ **AT TIME OF EXCAVATION** 3.00 ft Moderate seepage
LOGGED BY ZLL **CHECKED BY** JEB
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION
0.0				0.5	Sod and Topsoil
	GB S-1	SM		1.0	(SM) Brown silty fine sand (very loose, moist) (Alluvial Deposits)
2.5	GB S-2	ML		4.0	(ML) Gray mottled silt (very soft, moist) (Alluvial Deposits) Grades to wet at 2 feet ∇
5.0	GB S-3	SM		5.0	(SM) Gray/brown mottled silty fine sand (very loose, wet) (Alluvial Deposits)

Severe caving observed from 0 to 5 feet
Moderate groundwater seepage observed at 3 feet

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

Bottom of test pit at 5.0 feet.

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TEST PIT NUMBER TP-2

Figure A-3

CLIENT Farris Vet Clinic
PROJECT NAME 2401 W Stewart Geotech Report
PROJECT NUMBER P475-T15
PROJECT LOCATION Puyallup, Washington
DATE STARTED 3/8/16 **COMPLETED** 3/8/16
GROUND ELEVATION **TEST PIT SIZE**
EXCAVATION CONTRACTOR Owner-Operator
GROUND WATER LEVELS:
EXCAVATION METHOD Rubber Tracked Excavator
▽ **AT TIME OF EXCAVATION** 2.50 ft Moderate seepage
LOGGED BY ZLL **CHECKED BY** JEB
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION
0.0					Sod and Topsoil
	GB S-1 GB S-2	ML		0.6	(ML) Brown sandy silt (very soft, moist) (Alluvial Deposits)
2.5		ML		1.3	(ML) Gray mottled silt (very soft, wet) (Alluvial Deposits) ▽
5.0		SM		4.0	(SM) Gray/brown mottled silty fine sand (very loose, wet) (Alluvial Deposits) Buried logs encountered at 4 to 5.5 feet
				6.0	

Severe caving observed from 1.5 to 6 feet
Moderate groundwater seepage observed at 2.5 feet

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

Bottom of test pit at 6.0 feet.

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TEST PIT NUMBER TP-3

CLIENT Farris Vet Clinic
PROJECT NAME 2401 W Stewart Geotech Report
PROJECT NUMBER P475-T15
PROJECT LOCATION Puyallup, Washington
DATE STARTED 3/8/16 **COMPLETED** 3/8/16
GROUND ELEVATION **TEST PIT SIZE**
EXCAVATION CONTRACTOR Owner-Operator
GROUND WATER LEVELS:
EXCAVATION METHOD Rubber Tracked Excavator
AT TIME OF EXCAVATION 2.50 ft Moderate seepage
LOGGED BY ZLL **CHECKED BY** JEB
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0	GB S-1			Sod and Topsoil
0.7		SM		(SM) Brown fine silty sand (very loose, moist) (Alluvial Deposits)
1.2		ML		(ML) Gray/brown mottled silt (very soft, wet) (Alluvial Deposits)
2.5				▽
5.0				
6.0				

Severe caving observed from 3 to 6 feet
Moderate groundwater seepage observed at 2.5 feet

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

Bottom of test pit at 6.0 feet.

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Fax: 253-537-9401

TEST PIT NUMBER TP-4

Figure A-5

CLIENT Farris Vet Clinic
PROJECT NAME 2401 W Stewart Geotech Report
PROJECT NUMBER P475-T15
PROJECT LOCATION Puyallup, Washington
DATE STARTED 3/8/16 **COMPLETED** 3/8/16
GROUND ELEVATION **TEST PIT SIZE**
EXCAVATION CONTRACTOR Owner-Operator
GROUND WATER LEVELS:
EXCAVATION METHOD Rubber Tracked Excavator
▽ **AT TIME OF EXCAVATION** 3.50 ft Slow seepage
LOGGED BY ZLL **CHECKED BY** JEB
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0	GB S-1	SM	1.0	(SM) Brown silty sand with gravel, crushed rock, and brick debris (medium dense, moist) (Fill)
2.5		SM	3.0	(SM) Brown fine silty sand (loose, moist) (Alluvial Deposits)
5.0	GB S-2	ML	6.0	(ML) Gray/brown mottled silt (soft, wet) (Alluvial Deposits) ▽

No caving observed
Slow groundwater seepage observed at 3.5 feet

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

Bottom of test pit at 6.0 feet.

APPENDIX B
LABORATORY TESTING RESULTS

Particle Size Analysis Summary Data

Job Name: 2401 W Stewart Ave Puyallup
Job Number: P475-T15
Tested By: ZLL
Date: 3/8/16
Boring #: TP-2
Sample #: 2
Depth: 1.5 feet

Moisture Content (%)	37.8%

Sieve Size	Percent Passing (%)
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.8
No. 20 (.850-mm)	98.0
No. 40 (.425-mm)	95.6
No. 60 (.250-mm)	93.9
No. 100 (.150-mm)	92.4
No. 200 (.075-mm)	90.2

Size Fraction	Percent By Weight
Coarse Gravel	
Fine Gravel	
Coarse Sand	0.2
Medium Sand	4.1
Fine Sand	5.4
Fines	90.2
Total	100.0

LL ________
PI ________

D10 ________
D30 ________
D60 ________

Cc ________
Cu ________

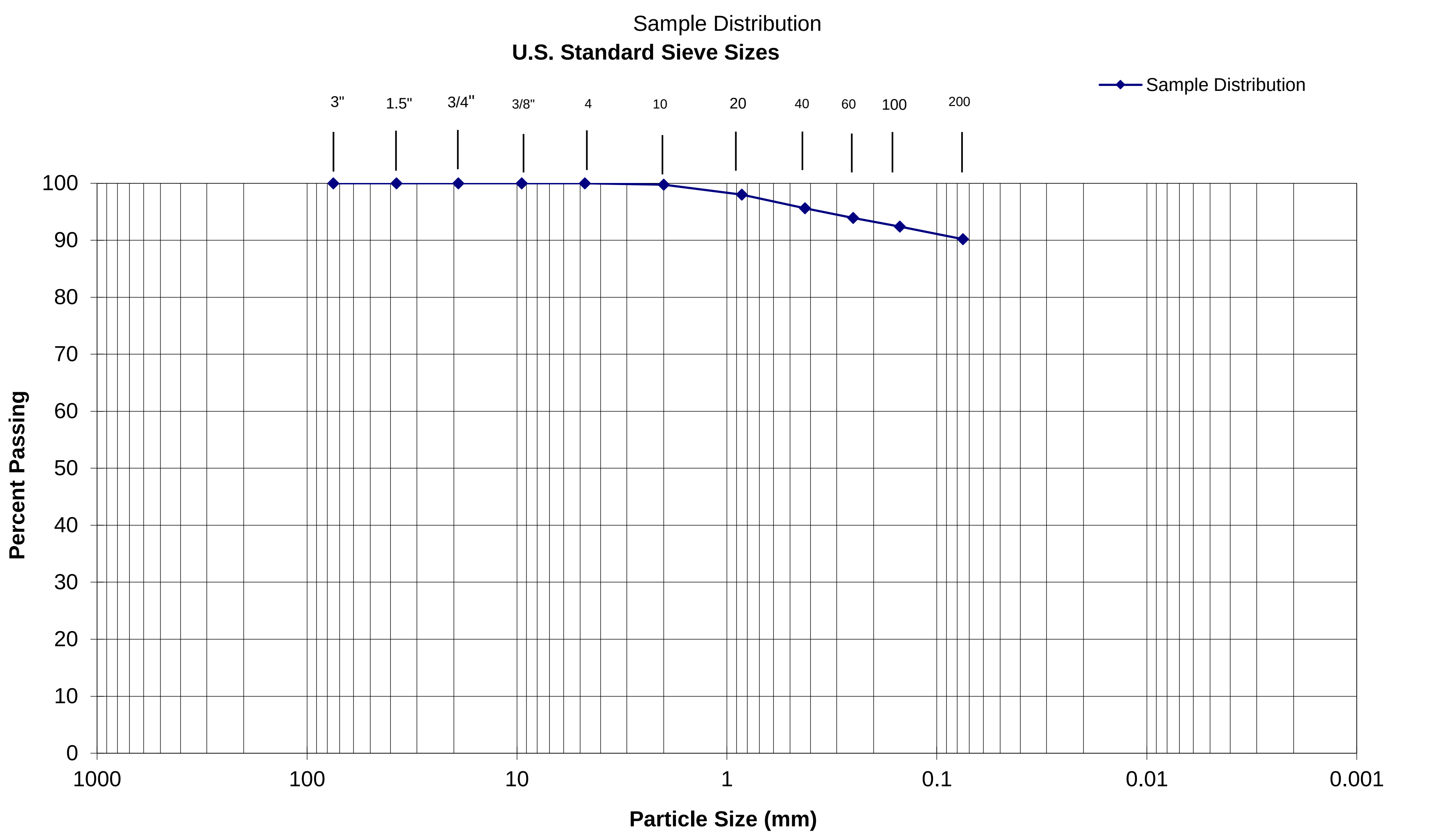
ASTM Classification

Group Name Grayish-brown silt
Symbol (ML) (very soft, wet)

MIGIZI GROUP

Figure B-1

Soil Classification Data Sheet



MIGIZI GROUP	**Sample Distribution**	Job Name: 2401 W Stewart Ave Puyallup	Sample #: 2	
		Job Number: P475-T15	Date: 3/8/16	
	Figure: B-2	Tested By: ZLL	Depth: 1.5 feet	
		Exploration #: TP-2		

Particle Size Analysis Summary Data

Job Name: 2401 W Stewart Ave Puyallup
Job Number: P475-T15
Tested By: ZLL
Date: 3/8/16
Boring #: TP-4
Sample #: 2
Depth: 4 feet

Moisture Content (%)	37.2%

Sieve Size	Percent Passing (%)
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	100.0
No. 20 (.850-mm)	99.3
No. 40 (.425-mm)	98.2
No. 60 (.250-mm)	97.5
No. 100 (.150-mm)	95.7
No. 200 (.075-mm)	79.2

Size Fraction	Percent By Weight
Coarse Gravel	
Fine Gravel	
Coarse Sand	0.0
Medium Sand	1.7
Fine Sand	19.0
Fines	79.2
Total	100.0

LL ______
PI ______

D10 ______
D30 ______
D60 ______

Cc ______
Cu ______

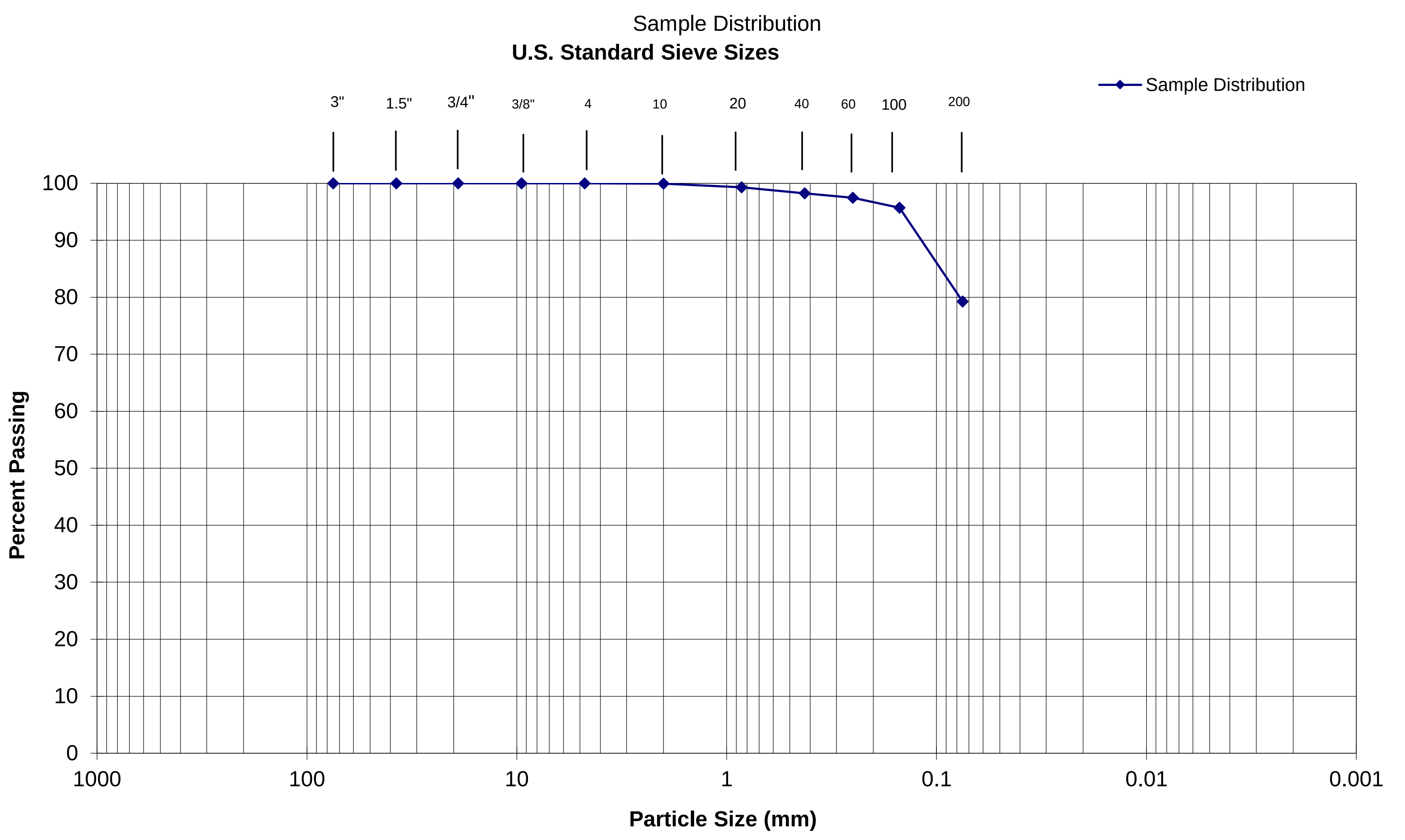
ASTM Classification

Group Name Grayish-brown silt with sand
Symbol (ML) (med. stiff, wet)

MIGIZI GROUP

Figure B-3

Soil Classification Data Sheet



MIGIZI GROUP	**Sample Distribution**	Job Name: 2401 W Stewart Ave Puyallup		Sample #: 2
		Job Number: P475-T15		Date: 3/8/16
	Figure: B-4	Tested By: ZLL		Depth: 4 feet
		Exploration #: TP-4		

APPENDIX C
KRAZAN & ASSOCIATES, INC. AND AGSOURCE LABORATORIES RESULTS

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION

April 1, 2016

KA Project No: 066-16081

Zach Logan
Migizi Group,Inc.
201 160th St. S.
Spanaway WA 98387

RE: Organic Content & Cat-Ion Exchange
Ferris Vet Clinic P475-T15

Dear Mr. Logan,

In accordance with your request and authorization, we have performed laboratory testing and analysis of a silty sand per A.S.T.M. standard D2974. Please the table below for a summary of our test results.

Sample ID	Material Description	Organic Content (ASTM D2974	Cat-Ion Exchance Capacity
16L150	Silty sand	5.4%	10.1 ~~ppm~~ meq/100g

If you have any questions or need any additional information, please do not hesitate to contact our office at (253) 939-2500.

Respectfully submitted,
KRAZAN & ASSOCIATES, INC

Michael Thomas
Laboratory Manager
Krazan and Associates, Inc.
Phone: (253) 939-2500
Email: Mikethomas@krazan.com

Attached:
Agsource Laboratories Soil Analysis of Cat-Ion Exchange Capacity

AgSource Laboratories
A Subsidiary of Cooperative Resources International
323 Sixth Street
Umatilla, OR 97882
Tel:541-922-4894
umatilla@agsource.com

Soil Analysis

Submitted By: **UMK23345**
KRAZAN & ASSOCIATES, INC. - PUYALLUP
922 VALLEY AVENUE NW, SUITE 101
PUYALLUP, WA 98391

Submitted For:
FERRIS VET CLINIC P475-T15

Laboratory Sample #
AU48434

Date Received
24-Mar-2016

Date Reported
25-Mar-2016

Information Sheet #
S9830

REPORT OF ANALYTICAL RESULTS

Client Sample Identification	Analysis	Result
TP-4 SAMPLE 1		
	Actual CEC	10.1 ~~ppm~~ meq/100g