ROBINSON
NOBLE

January 23, 2015

Mr. Prakash Modi
14317 Northeast 187th Place
Woodinville, Washington

3rd Revision Geotechnical Engineering Report
Modi Short Plat
Woodinville, Washington
RN File No. 2869-001A

Dear Mr. Modi:

This letter serves as a transmittal for our report for the Modi Short Plat project, located at 19400 – 136th Avenue Northeast in Woodinville, Washington. Preliminary development plans call for three, two-story duplex residences with daylight basements and with stormwater dispersion trenches on the east side of the lots. The subsurface soils are capable of providing support for the residences using deep foundation walls, prisms of structural fill or stone columns.

We appreciate the opportunity of working with you on this project. If you have any questions regarding this report, please contact us.

Sincerely,

Rick B. Powell, PE
Principal Engineer

BAG:RBP:am

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cc: Beyler Consulting, LLC

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INTRODUCTION

This report presents the results of our geotechnical engineering investigation at your proposed single-family residential project, Modi Short Plat, in the Woodinville area of King County, Washington. The site is located at 19400 – 136th Avenue Northeast, Woodinville, Washington, as shown on the Vicinity Map in Figure 1.

You have requested that we complete this report to evaluate subsurface conditions and provide recommendations for site development. For our use in preparing this report, we have been provided with a preliminary site plan by Beyler Consulting dated March 19, 2014, that shows the lot layout and the locations of the stormwater dispersion trenches.

PROJECT DESCRIPTION

Preliminary development plans call for three, two-story duplex residences with daylight basements and with stormwater dispersion trenches on the east side of the lots. We have not been provided with a detailed grading plan, but based on the planned daylight basement it is likely that site grading will include cuts and fills of up to about 6 feet.

SCOPE

The purpose of this study is to explore and characterize the subsurface conditions and present recommendations for site development. Specifically, our scope of services as outlined in our Services Agreement, dated July 15, 2014, includes the following:

- Review available geologic maps for the site.
- Explore the subsurface soil and groundwater conditions in the area of the planned residential lots with borings in the planned infiltration and building areas.
- Evaluate pertinent physical and engineering characteristics of the soils encountered in the explorations.
- Complete up to six grain size analyses on soil samples collected in the planned infiltration areas and up to ten moisture content tests on other soil samples.
- Prepare a geotechnical report containing the results of our subsurface explorations, and our conclusions and recommendations for geotechnical design elements of the project.

SITE CONDITIONS

Surface Conditions

The roughly rectangular shaped project site is about 1.54 acres in size and has maximum dimensions of approximately 359 feet in the east-west direction and 202 feet in the north-south direction. Access to the site is provided by 136th Avenue Northeast to the west. The site is also bordered by existing residential acreage to the north and south, and State Route 522 to the east. Bear Creek bisects the site in an approximate north-south direction in the eastern third of the site. A designated wetland is located in the north-central portion of the site. A layout of the site is shown on the Site Plan in Figure 2.

The ground surface within the site is steeply to moderately sloping down to the east. The site is currently undeveloped, and vegetated mostly with medium to large sized trees, horsetails and brush.

Geology

Most of the Puget Sound Region was affected by past intrusion of continental glaciation. The last period of glaciation, the Vashon Stade of the Fraser Glaciation, ended approximately 14,000 years ago. Many of the geomorphic features seen today are a result of scouring and overriding by glacial ice. During the Vashon Stade, areas of the Puget Sound region were overridden by over 3,000 feet of ice. As the glaciers retreated low areas carved out from the glaciers became large river valleys. Over time collected soil from the flowing water was deposited and size of soil particles deposited was dependent on the flow rates of the river. These deposits are referred to as Alluvium. Large sand and gravel was deposited within faster moving water and fine grained soils were deposited in slow to stagnant water. As more deposits were placed the river channels became more confined to the paths they currently exist in. Alluvial deposits were not compacted by the weight of the glaciers and may exhibit less strength and density compared to soils that were.

The geologic units for this area are mapped on the Geologic Map of the Bothell Quadrangle, Snohomish and King Counties, Washington, by James P. Minard (U.S. Geological Survey, 1985). The site is mapped as being underlain by a deposit of Alluvium. The soils observed in our explorations are in general agreement with this classification.

Explorations

We explored subsurface conditions within the site on July 3, 2014 by excavating one test pit with a track-hoe, on July 24, 2014 by drilling three borings with a portable hollow stem auger drill rig and advancing one hand auger with hand held equipment, and on July 31, 2014 by advancing a second hand auger. The test pit was excavated to a depth of 2.0 feet below the ground surface. The borings and hand augers were drilled to depths of 3.0 to 26.5 feet below the ground surface. Grab samples were obtained from the test pit and the hand augers at various depths. Samples were obtained from the borings at 2.5 to 5-foot intervals by driving a split spoon sampler with a 140-pound hammer dropping 30 inches. The number of blows required for penetration of three 6-inch intervals was recorded. To determine the standard penetration number at that depth the number of blows required for the lower two intervals are summed. If the number of blows reached 50 before the sampler was driven through any 6-inch interval, the sampler was not driven further and the blow count is recorded as 50 for the actual penetration distance.

The explorations were located in the field by an engineer from this firm who also examined the soils and geologic conditions encountered, and maintained logs of the borings. The approximate locations of the borings are shown on the Site Plan in Figure 2. The soils were visually classified in general accordance with the Unified Soil Classification System, a copy of which is presented as Figure 3. The log of the test pit is presented in Figure 4. The logs of the hand augers are presented in Figure 5. The logs of the borings are presented in Figures 6 through 9.

Subsurface Conditions

A brief description of the conditions encountered in our explorations is included below. For a more detailed description of the soils encountered, review the test pit, hand auger and boring logs in Figures 4 through 9.

Our explorations at the top of the slope generally encountered a surficial layer of topsoil that was less than 0.5 feet in thickness. The topsoil consisted of loose, brown silty very fine sand with roots and organics. Underlying the topsoil we encountered loose to medium dense fine sand with trace silt and varying amounts of gravel that was interpreted as probable roadway fill. This material extended to the depth explored in Hand Auger 2 and to about 13.5 feet below ground surface in Boring 1. Below the fill in Boring 1, we encountered loose to medium dense silty fine sand interpreted as alluvium that extended to about 24.5 feet. This was underlain by very stiff silt with sand interpreted as alluvium that extended to the depth explored.

Our explorations at the bottom of the slope generally encountered a surficial layer of loose and soft black silty fine sand and peat that was less than 2.0 feet in thickness. This was underlain by loose to medium dense silty sand with varying amounts of gravel and loose sand with gravel interpreted as alluvium. In Test Pit 1 and Hand Auger 1 this material extended to the depths explored. Borings 2 and 3 disclosed loose to medium dense fine to coarse sand with gravel and trace silt interpreted as alluvium below the silty sand that extended to the depths explored.

Hydrologic Conditions

Shallow groundwater seepage was encountered in four of the explorations and mottling indicating seasonal fluctuations in groundwater was observed in a fifth exploration at varying depths. Groundwater elevations are based on the provided topographical site plan and our observations during the explorations. In Boring 1 and 3 we encountered groundwater at approximate elevations 107 and 104, respectively. In Hand Auger 1 and Test Pit 1, we encountered groundwater at about elevations 96 and 99, respectively. Mottling was observed in Boring 2 at approximate elevation 99. We consider this water to be perched within gravel layers of the silty sand underlying the site. Bear Creek bisects the eastern third of the site in an approximate north-south direction. The Ordinary High Water Mark is at about elevation 82 and represents the regional groundwater table.

CONCLUSIONS AND RECOMMENDATIONS

General

Preliminary development plans call for three, two-story duplex residences with daylight basements and with stormwater dispersion trenches on the east side of the lots. Section 21.24.310(1)(h)(i) of the Woodinville Municipal Code (WMC) states "Land that is located wholly within an erosion or landslide hazard area or its buffer may not be subdivided. Land that is located partially within an erosion or landslide hazard area or its buffer may be divided; provided, that each resulting lot has sufficient buildable area outside of, and will not affect, the erosion or landslide hazard or its buffer." Our conclusions and recommendations regarding geologic hazards are presented below in the **Geologic Hazards** section of this report. Our recommendations for stormwater dispersion are discussed in the **Drainage** section of this report.

The underlying medium dense alluvium deposits are capable of supporting residential structures and pavements. We recommend that the foundations for the structure extend through any fill, topsoil, loose, or disturbed soils, and bear on the underlying medium dense or firmer, native alluvium, on structural fill extending to these soils or on stone columns. Based on our site explorations, we anticipate these soils will generally be encountered at depths ranging from 6 to 10 feet below ground surface east of the toe of the slope. These options are discussed further in the **Foundations** section of this report.

Geologic Hazards

Landslide Hazards: Section 21.24.290(2)(b)(6) of the WMC defines a landslide hazard area as "Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of consolidated rock." The 40 percent and greater slope inclinations with a vertical relief of 10 feet or more on a large portion of the central and south lots designate these areas as landslide hazard areas per WMC section 21.24.290(2)(b)(6). Some of these slopes appear to have been created through past grading activities. It is our opinion that retaining walls could be used to create a more stable condition. Retaining walls should provide a suitable factor of safety against adverse impacts to meet the standards of subsection (1)(b) of WMC 21.24.310 to allow alterations of designated landslide hazard areas. WMC 21.24.310(1)(b) states:

> (i) The development will not increase surface water discharge or sedimentation to adjacent properties beyond predevelopment conditions;
>
> (ii) The development will not decrease slope stability on adjacent properties; and
>
> (iii) Such alterations will not adversely impact other critical areas.

We observed indications of surficial seepage and two evergreen trees with curved trunks on the southern lot. We did not observe indications of surficial seepage or shallow or deep-seated slope failures on the north and central lots. Several second and third-growth evergreen trees are growing on the steep slope adjacent to 136th Avenue; the trunks of these trees on the north and central lots were straight and did not exhibit curving that would indicate past slope movement.

There is a potential that the surficial soils on the steeper sections of the slope could slough over time. Any slough events are expected to be surficial, and are affected by surface water and man-made impacts. The risk of slough events can be minimized if proper drainage is installed, vegetation on the slope is maintained, and yard waste and other debris are kept off the slopes. We would expect if a slough event were to occur, it would be small in scale and relatively shallow. We did not observe any indication of recent sloughing on site.

Our recommendations, outlined below, should provide a suitable factor of safety against adverse impacts to meet the standards of WMC section 21.24.310(1)(b)(ii) to allow a landslide hazard area buffer reduction. It is our opinion that the landslide hazard areas should have a reduced buffer from 50 feet down to 10 feet provided the recommendations in this report are followed. The buffer should be left in its natural and undisturbed state. To protect the planned residences from shallow sloughing failures over the lifetime of the structure, we recommend the structure foundations be constructed as recommended in the **Foundations** section of this report. We also recommend not placing any fill, debris or yard clippings, etc. on the steep slope or within the buffer. Best Management Practices should also be used to reduce the chance of shallow slough or slide events.

The Site Plan in Figure 2 shows the existing Landslide Hazard Areas and the corresponding 10-foot buffer. It is our opinion that modification of the Landslide Hazard Areas with engineered retaining walls is feasible. These engineered walls must by designed or, at a minimum, reviewed by the geotechnical engineer of record. It must be determined that the recommendations in this report have been followed in the wall design and that these walls will provide a stable slope for the Landslide Hazard Areas and a catchment for any surficial sloughing. This will enable a residence to be built adjacent to the walls and will justify construction within the 10-foot buffer zone provided the recommendations in this report are followed.

WMC section 21.24.310(c) presents design standards for development within an erosion or landslide hazard area. Development plans are in the preliminary stages and detailed plans are not available at this time. Project plans will require a geotechnical review to determine that the intent of the code is met and that factors of safety for landslide occurrences are above 1.5 for static conditions and 1.2 for dynamic conditions. It is our opinion that provided the recommendations in this report are followed, development within the Landslide Hazard Areas will meet the requirements presented in this section.

Erosion Hazard: The erosion hazard criteria used for determination of affected areas includes soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types (group classification), which are related to the underlying geologic soil units. We reviewed the Web Soil Survey by the Natural Resources Conservation Service (NRCS) to determine the erosion hazard of the on-site soils. The site surface soils were classified using the SCS classification system as Everett gravelly sandy loam (EvC) and Norma sandy loam (No). The corresponding geologic unit for these soils is glacial outwash and alluvium, which is in partial agreement with the alluvium soils encountered in our site explorations. The erosion hazards for the soils are listed as being slight to moderate for the sloping conditions at the site.

Seismic Hazard: The site is mapped on the City of Woodinville's Identified Critical Areas Figure A13-1 as a Seismic Critical Area. In our opinion, provided the recommendations in this report are followed, development of residential structures will meet the standards of WMC section 21.24.300.

It is our opinion based on our subsurface explorations that the Soil Profile in accordance with 2012 International Building Code (IBC) is Site Class E with Seismic Design Category D. We used the US Geological Survey program "U.S. Seismic Design Maps Web Application." The design map summary report for 2012 IBC is included in this report as Appendix A.

Additional seismic considerations include liquefaction potential and amplification of ground motions by soft soil deposits. The liquefaction potential is highest for loose sand with a high groundwater table. The underlying loose to medium dense alluvial soils are considered to have a moderate to high potential for liquefaction and amplification of ground motion. However, the recommended ground improvements for foundation construction are expected to reduce the potential for liquefaction and amplification of ground motion.

Site Preparation and Grading

The first step of site preparation should be to strip the vegetation, topsoil, or loose soils to expose medium dense or firmer native soils in pavement and building areas. The excavated material should be removed from the site, or stockpiled for later use as landscaping fill. The resulting subgrade should be compacted to a firm, non-yielding condition. Areas observed to pump or yield should be repaired prior to placing hard surfaces.

The on-site alluvium soil likely to be exposed during construction is considered moisture sensitive, and the surface will disturb easily when wet. We expect these soils would be difficult to compact to structural fill specifications in wet weather. We recommend that earthwork be conducted during the drier months. Additional expenses of wet weather or winter construction could include extra excavation and use of imported fill or rock spalls. During wet weather, alternative site preparation methods may be necessary. These methods may include utilizing a smooth-bucket trackhoe to complete site stripping and diverting construction traffic around prepared subgrades. Disturbance to the prepared subgrade may be minimized by placing a blanket of rock spalls or imported sand and gravel in traffic and roadway areas. Cutoff drains or ditches can also be helpful in reducing grading costs during the wet season. These methods can be evaluated at the time of construction.

Structural Fill

General: All fill placed beneath buildings, pavements or other settlement sensitive features should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards, and is observed by an experienced geotechnical professional or soils technician. Field observation procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction.

Materials: Imported structural fill should consist of a good quality, free-draining granular soil, free of organics and other deleterious material, and be well graded to a maximum size of about

3 inches. Imported, all-weather structural fill should contain no more than 5 percent fines (soil finer than a Standard U.S. No. 200 sieve), based on that fraction passing the U.S. 3/4-inch sieve. The use of on-site soil as structural fill will be dependent on moisture content control. Some drying of the native soils may be necessary in order to achieve compaction. During warm, sunny days this could be accomplished by spreading the material in thin lifts and compacting. Some aeration and/or addition of moisture may also be necessary. We expect that compaction of the native soils to structural fill specifications would be difficult, if not impossible, during wet weather.

Fill Placement: Following subgrade preparation, placement of the structural fill may proceed. Fill should be placed in 8- to 10-inch-thick uniform lifts, and each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas, and within a depth of 2 feet below pavement and sidewalk subgrade, should be compacted to at least 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D1557 compaction test procedure. Fill more than 2 feet beneath sidewalks and pavement subgrades should be compacted to at least 90 percent of the maximum dry density. The moisture content of the soil to be compacted should be within about 2 percent of optimum so that a readily compactable condition exists. It may be necessary to overexcavate and remove wet surficial soils in cases where drying to a compactable condition is not feasible. All compaction should be accomplished by equipment of a type and size sufficient to attain the desired degree of compaction.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, such as the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open, and the presence of surface or groundwater. It is exceedingly difficult under these variable conditions to estimate a stable temporary cut slope geometry. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations, since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered.

For planning purposes, we recommend that temporary cuts in the alluvial soils be no steeper than 1.5 Horizontal to 1 Vertical (1.5H:1V). If groundwater seepage is encountered, we expect that flatter inclinations may be necessary. Groundwater seepage is anticipated to be encountered at depths ranging from 2.0 to 5.0 feet below ground surface.

We recommend that cut slopes be protected from erosion. Measures taken may include covering cut slopes with plastic sheeting and diverting surface runoff away from the top of cut slopes. We do not recommend vertical slopes for cuts deeper than 4 feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to local and WISHA/OSHA standards.

Final slope inclinations for granular structural fill and the native soils should be no steeper than 2H:1V. Lightly compacted fills, common fills, or structural fill predominately consisting of fine grained soils should be no steeper than 3H:1V. Common fills are defined as fill material with some organics that are "trackrolled" into place. They would not meet the compaction specification of structural fill. Final slopes should be vegetated and covered with straw or jute netting. The vegetation should be maintained until it is established.

Foundations

Conventional shallow spread foundations should be founded on undisturbed, medium dense or firmer soil. If the soil at the planned bottom of footing elevation is not suitable, it should be overexcavated to expose suitable bearing soil. Footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection. Minimum foundation widths should conform to IBC requirements. Standing water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete. Loose silty sand was encountered in our explorations to depths ranging from about 6 to 10 feet below ground surface. The excavation for the foundations must extend through the loose soil to bear on medium dense or better native material.

The second option is to place the footings on prisms of structural fill that extend down to native bearing material. The excavation for the footings would extend laterally ½ the width of the footing on each side of the footing. Temporary excavation support such as trench boxes or aluminum hydraulic shoring should be considered in order to reduce the amount of excavation required.

The third option is to support the buildings on stone columns. The stone columns would extend through the native bearing material. In order to design the stone columns more geotechnical information would be required, so we would need to drill additional borings on the site in order to obtain Standard Penetration Test (SPT) information for the underlying soils at depth. The borings would extend approximately 10 feet into native bearing soils for total depths ranging from about 20 to 30 feet. The caveat with this option is that the depositional nature of these soils can result in loose soils below medium dense layers. The number and location of the borings will be dependent upon the footprint of the planned residence. We anticipate that three to four borings would be sufficient.

Any options that do not include complete removal of the soft or loose soils beneath the slabs will place the slabs at risk. If settlement of the subgrade occurs, either by normal stress loading or by liquefaction, the slabs will settle with it.

For foundations constructed as outlined above, we recommend an allowable design bearing pressure of 1,500 pounds per square foot (psf) be used for the footing design. IBC guidelines should be followed when considering short-term transitory wind or seismic loads. Potential foundation settlement using the recommended allowable bearing pressure is estimated to be less than 1-inch total and ½-inch differential between footings or across a distance of about 30 feet. Higher soil bearing values may be appropriate with wider footings. These higher values can be determined after a review of a specific design.

Lateral Loads

The lateral earth pressure acting on retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement, which can occur as backfill is placed, and the inclination of the backfill. Walls that are free to yield at least one-thousandth of the height of the wall are in an "active" condition. Walls restrained from movement by stiffness or bracing are in an "at-rest" condition. Active earth pressure and at-rest earth pressure can be calculated based on equivalent fluid density. Equivalent fluid densities for active and at-rest earth pressure of 35 pounds per cubic foot (pcf) and 55 pcf, respectively, may be used for design for a level backslope. Equivalent fluid densities for active and at-rest earth pressure of 50 pounds per cubic foot (pcf) and 80 pcf, respectively, may be used for design for a 2H:1V backslope. These values assume that imported granular fill is used for backfill, and that the wall backfill is drained. The preceding values do not include the effects of surcharges, such as due to foundation loads or other surface loads. Surcharge effects should be considered where appropriate. The above drained values should be increased by a uniform pressure of 5.6H psf when considering seismic conditions. H represents the wall height.

The above lateral pressures may be resisted by friction at the base of the wall and passive resistance against the foundation. A coefficient of friction of 0.4 may be used to determine the base friction in the native alluvial soils. An equivalent fluid density of 200 pcf may be used for passive resistance design. To achieve this value of passive pressure, the foundations should be poured "neat" against the native dense soils, or compacted fill should be used as backfill against the front of the footing, and the soil in front of the wall should extend a horizontal distance at least equal to three times the foundation depth. A resistance factor of 0.67 has been applied to the passive pressure to account for required movements to generate these pressures.

All wall backfill should be well compacted. Care should be taken to prevent the buildup of excess lateral soil pressures due to overcompaction of the wall backfill.

Slabs-On-Grade

Slab-on-grade areas should be prepared as recommended in the **Site Preparation and Grading** subsection. Slabs should be supported on medium dense or firmer native soils, or on structural fill extending to these soils. Where moisture control is a concern, we recommend that slabs be underlain by 6 inches of pea gravel for use as a capillary break. A suitable vapor barrier, such as heavy plastic sheeting, should be placed over the capillary break. An additional 2-inch-thick damp sand blanket can be used to cover the vapor barrier to protect the membrane and to aid in curing the concrete. This will also help prevent cement paste bleeding down into the capillary break through joints or tears in the vapor barrier. The capillary break material should be connected to the footing drains to provide positive drainage.

Drainage

General: We recommend that runoff from impervious surfaces, such as roofs, driveway and access roadways, be collected and routed to an appropriate storm water discharge system. The finished ground surface should be sloped at a gradient of 5 percent minimum for a distance of at least 10 feet away from the buildings, or to an approved method of diverting water from the foundation, per IBC Section 1803.3. Surface water should be collected by permanent catch basins and drain lines, and be discharged into a storm drain system.

We recommend that footing drains be used around all of the structures where moisture control is important. The underlying silty sand may pond water that could accumulate in crawlspaces. It is good practice to use footing drains installed at least 1 foot below the planned finished floor slab or crawlspace elevation to provide drainage for the crawlspace. At a minimum, crawlspaces should be sloped to drain to an outlet tied to the drainage system. If drains are omitted around slab-on-grade floors where moisture control is important, the slab should be a minimum of 1 foot above surrounding grades. It should be noted that groundwater was encountered east of the toe of the slope at depths ranging from 2 to 4 feet below ground surface.

Where used, footing drains should consist of 4-inch-diameter, perforated PVC pipe that is surrounded by free-draining material, such as pea gravel. Footing drains should discharge into tightlines leading to an appropriate collection and discharge point. Crawlspaces should be sloped to drain, and a positive connection should be made into the foundation drainage system. For slabs-on-grade, a drainage path should be provided from the capillary break material to the footing drain system. Roof drains should not be connected to wall or footing drains.

Infiltration: The City of Woodinville has adopted the 2009 King County Stormwater Management Manual (KCSMM). For infiltration to be considered, a 5 foot separation between the bottom of an infiltration trench and an impermeable layer or groundwater is required. The separation may be reduced to three feet if a groundwater mounding analysis is performed. Groundwater was encountered in the explorations east of the toe of the slope at depths ranging from 2 to 4 feet below ground surface in the north lot and 3 feet below ground surface in the south lot. Mottling indicating seasonal groundwater fluctuations was observed in the exploration in the central lot at about 5 feet below ground surface. However, the silty sand observed in the explorations is not suitable for infiltration.

Dispersion: Appendix C.2.1.1.5 of the KCSMM states: "Dispersion devices are not allowed in critical area **buffers** or on **slopes** steeper than 20%. Dispersion devices proposed on slopes steeper than 15% or within 50 feet of a ***steep slope hazard area*** or ***landslide hazard area*** must be approved by a ***geotechnical engineer*** or ***engineering geologist*** unless otherwise approved by the DDES staff geologist." The slopes east of the planned dispersion trenches on the north and central lots are greater than 20 percent, and as such, are ineligible for dispersion. The slope east of the planned dispersion trench on the south lot is 15 percent and within 50 feet of a landslide hazard area. Hand Auger 1 advanced at this location encountered fine to coarse sand with gravel from 2 to 3 feet below ground surface that should provide a suitable flow path for dispersed stormwater. In our opinion, dispersion of stormwater from the single family residences onto this slope would not create flooding or erosion impacts per KCSMM C.2.1.1.6.

Pavement Subgrade

The performance of roadway pavement is critically related to the conditions of the underlying subgrade. We recommend that the subgrade soils within the roadways be prepared as described in the **Site Preparation and Grading** subsection 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 then proof-rolled with a piece of heavy construction equipment, such as a fully-loaded dump truck. Any areas with excessive weaving or flexing should be overexcavated and recompacted or replaced with a structural fill or crushed rock placed and compacted in accordance with recommendations provided in the **Structural Fill** subsection of this report.

CONSTRUCTION OBSERVATION

We should be retained to provide observation and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, and to provide recommendations for design changes, should the conditions revealed during the work differ from those anticipated. As part of our services, we would also evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

USE OF THIS REPORT

We have prepared this report for Mr. Prakash Modi and his agents, for use in planning and design of this project. The data and report should be provided to prospective contractors for their bidding and estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of subsurface conditions.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report, for consideration in design. There are possible variations in subsurface conditions. We recommend that project planning include contingencies in budget and schedule, should areas be found with conditions that vary from those described in this report.

Within the limitations of scope, schedule and budget for our services, we have strived to take care that our services have been completed in accordance with generally accepted practices followed in this area at the time this report was prepared. No other conditions, expressed or implied, should be understood.

We appreciate the opportunity to be of service to you. If there are any questions concerning this report or if we can provide additional services, please call.

Sincerely,

Robinson Noble, Inc.

BARBARA ANN GALLAGHER
STATE OF WASHINGTON
48050
REGISTERED PROFESSIONAL ENGINEER

1/23/2015

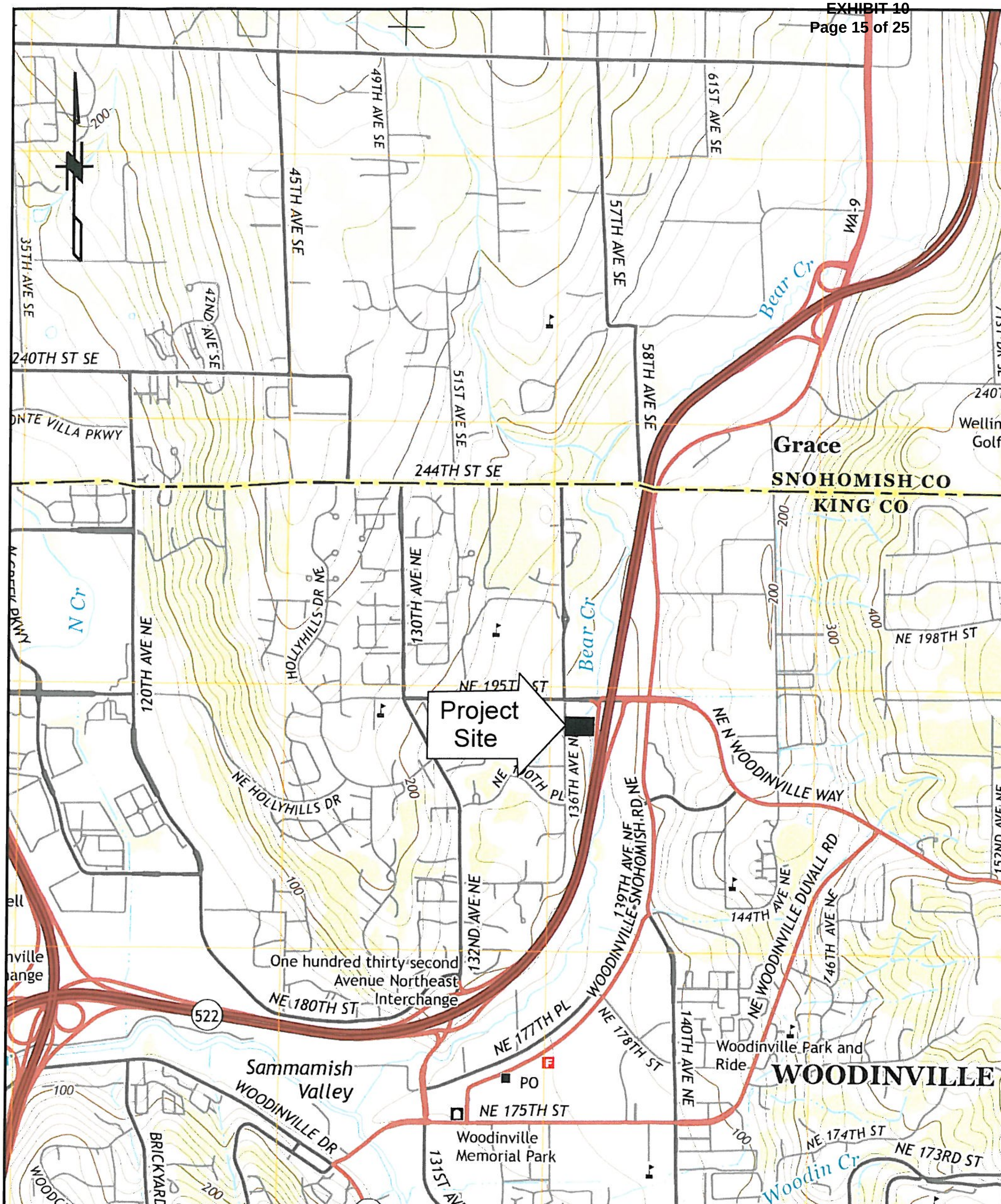
Barbara A. Gallagher, PE
Senior Project Engineer

Rick B. Powell, PE
Principal Engineer

BAG:RBP:am

Nine Figures
Appendix A

cc: Beyler Consulting, LLC



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Note: Basemap taken from Bothell Quadrangle 7.5-Minutre Series. USGS 2014.

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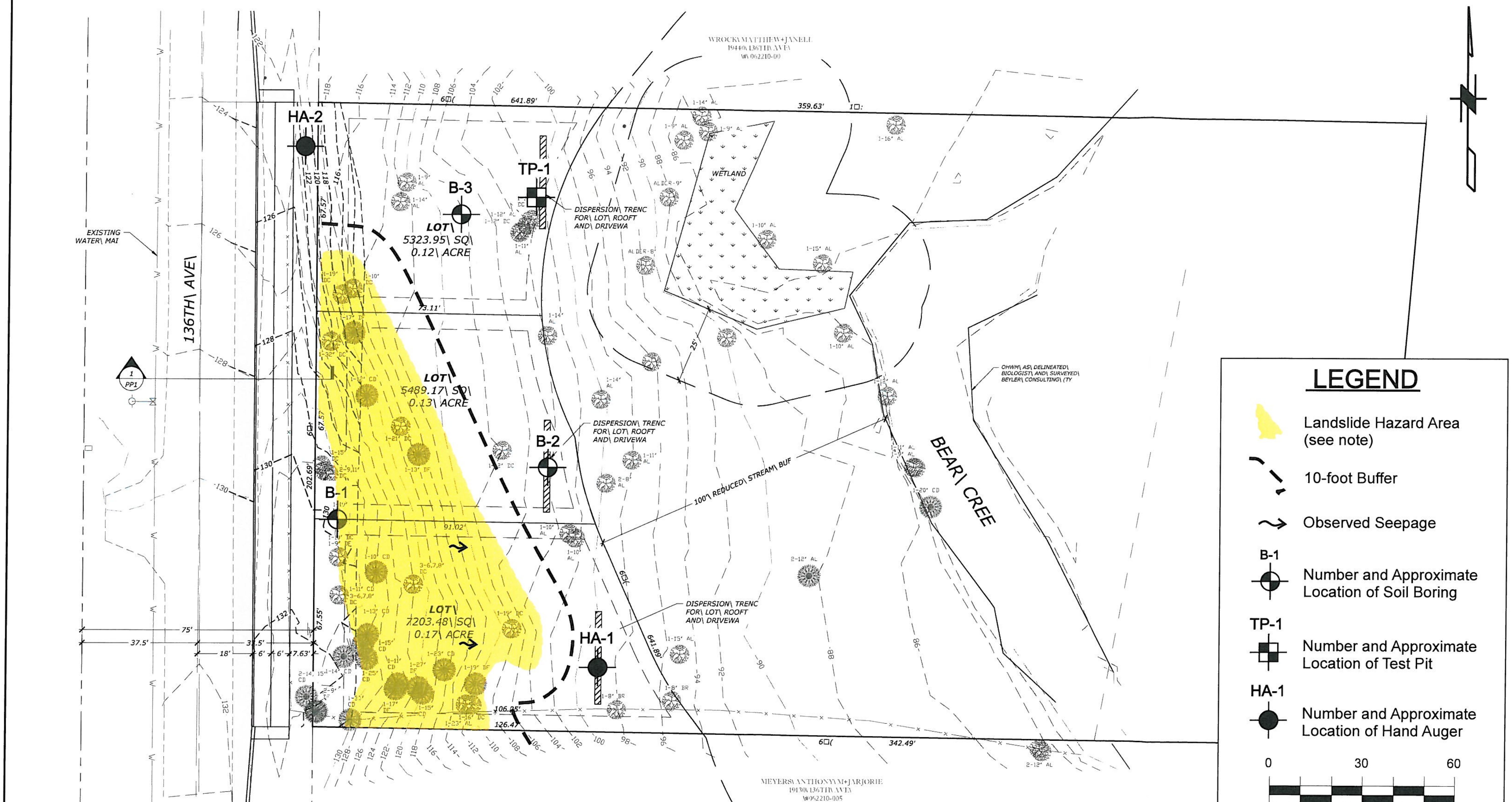
Figure 1
Vicinity Map
Modi Short Plat



Note: The Landslide Hazard Areas shown on this plan represent landslide hazard areas meeting the slope criteria of WMC 21.24.290(2)(vi), based on analysis of the topographic surface provided by the project surveyor.

ROBINSON NOBLE	Note: Basemap taken from Site Plan prepared by Beyler Consulting dated 03/19/2014.	PM: BAG January 2015 2869-001A	Figure 2 Site Plan Modi Short Plat

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50% RETAINED ON 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 PASSES 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% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50%	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT 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 CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

* 1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.

* 2) Soil classification using laboratory tests is based on ASTM D 2487-93.

3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance, of soils, and/or test data.

* Modifications have been applied to ASTM methods to describe sit and clay content.

$N_{60} = N_M * C_E * C_B * C_R * C_S$

N_M = blows/foot, measured in field

C_E = $ER_m/60$, convert measured hammer energy to 60% for comparison with design charts.

C_B = adjusts borehole diameter

C_R = rod length, adjusts for energy loss in rods

C_S = Sample liner = 1.0

SOIL MOISTURE MODIFIERS

Dry- Absence of moisture, dusty, dry to the touch

Moist- Damp, but no visible water

Wet- Visible free water or saturated, usually soil is obtained from below water table

KEY TO BORING LOG SYMBOLS

∇ Ground water level

● Blows required to drive sample 12 in. using SPT (converted to N_{60})

MC (■) = % Moisture = $\frac{\text{(Weight of water)}}{\text{(Weight of dry soil)}}$

DD = Dry Density

SM — Letter symbol for soil type

— Contact between soil strata (Dashed line indicates approximate contact between soils)

ML — Letter symbol for soil type

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual

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PM: BAG
January 2015
2869-001A

Figure 3

Modi Short Plat

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT ONE		
0.0 – 1.5	PT	Dark brown hemic slightly acidic peat with sand (very soft, wet)
1.5 – 2.0	SM	Gray silty fine to coarse sand with gravel (very loose, wet) **(Alluvium)**

Approximate Elevation 101 feet
Samples were collected at 1.0 and 1.5 feet
Groundwater was encountered at 2.0 feet
Test pit caving was not encountered
Test pit was completed at 2.0 feet on 7/3/2014

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
HAND AUGER ONE		
0.0 – 2.0	SM/PT	Dark brown silty fine sand with abundant organics/peat and gravel (loose, moist)
2.0 – 3.0	SP	Gray fine to coarse sand with gravel (loose, wet) **(Alluvium)**
		Approximate Elevation 99 feet Samples were collected at 1.0 and 3.0 feet Groundwater was encountered at 3.0 feet Hand auger caving was not encountered Hand auger was completed at 3.0 feet on 7/24/2014
HAND AUGER TWO		
0.0 – 0.5	SM	Brown silty sand with gravel trace roots (loose, moist) (Topsoil)
0.5 – 3.0	SM	Brown silty sand with gravel (loose, moist) **(Probable Fill)**
3.0 – 6.0	SP	Tannish-brown fine sand trace silt and roots (loose to medium dense, moist) **(Probable Fill)**
		Approximate Elevation 99 feet Samples were collected at 1.5, 3.0 and 6.0 feet Groundwater was not encountered Hand auger caving was not encountered Hand auger was completed at 6.0 feet on 7/31/2014

B-1 Page 1 of 2	Date 7/24/2014; Logged by BAG; Driller CN; Elevation (ft) 129.0; Sample Liner No	Hole dia. (in) 6; Hole depth ft 26.5; Well dia. (in) N/A; Well depth N/A; Hammer Eff. 60%

LITHOLOGY / DESCRIPTION	U.S.C.	Sample Recovery/ Driven Interval (in)	N- Blow Counts (blows/6")	Static Water Level	Depth (feet)
Light brown silty fine sand with gravel and organics (Loose, moist) **(Topsoil)**	SM	8/18	2 4 4		1
Gray fine to medium sand with gravel trace silt (loose, mosit) **(Probable Fill)**	SP	8/18	2 2 3		3
Tannish-gray fine to medium sand trace silt (loose, moist) **(Probable Fill)**	SP	6/18	2 3 4		6
Gray fine sand trace silt (medium dense, moist) **(Probable Fill)**	SP	12/18	4 5 6		11
Gray silty fine sand (loose to medium dense, moist) **(Alluvium)**	SM	16/18	4 5 5		16
Gray silty fine sand (medium dense, moist to wet) **(Alluvium)**	SM	12/18	8 11 7	▽	21

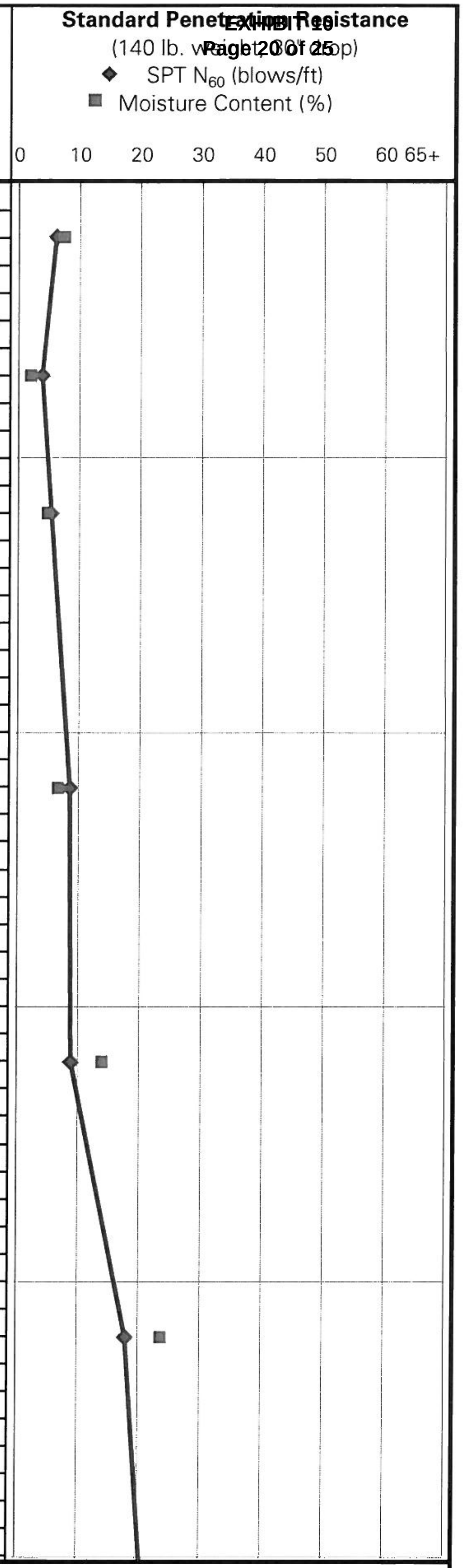

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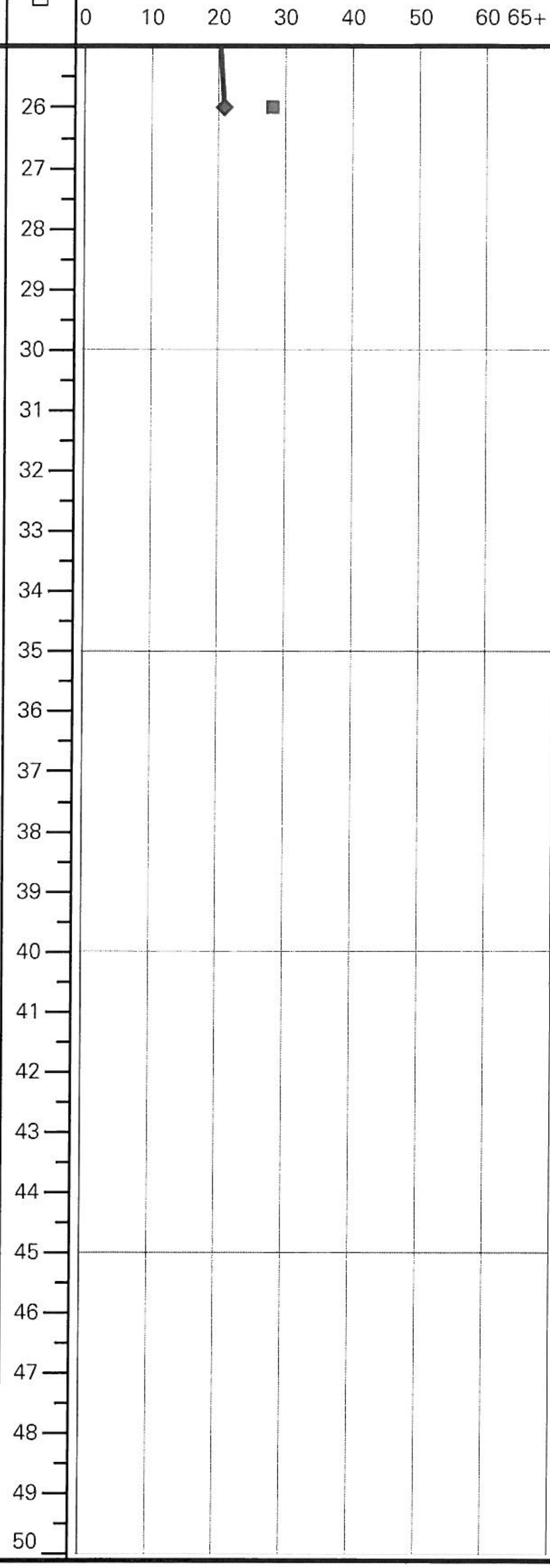
Figure 6

B-1	Date	7/24/2014	Hole diameter	6
	Logged by	BAG	Hole depth	26.5
	Driller	CN	Well diameter	N/A
Page 2 of 2	Elevation (ft)	129.0	Well depth	N/A
	Sample Liner	No	Hammer Eff.	60%

LITHOLOGY / DESCRIPTION	U.S.C.	Sample Recovery/ Driven Interval (in)	N- Blow Counts (blows/6")	Static Water Level	Depth (feet)
Gray silt with sand (very stiff, moist to wet) **(Alluvium)**	ML	7/18	2 10 11		26
Boring was completed at 26.5 feet on 7/24/2014 Groundwater observed at 22.0 feet on 7/24/2014					

Standard Penetration Resistance
(140 lb. weight, 30" drop)
◆ SPT N_{60} (blows/ft)
■ Moisture Content (%)



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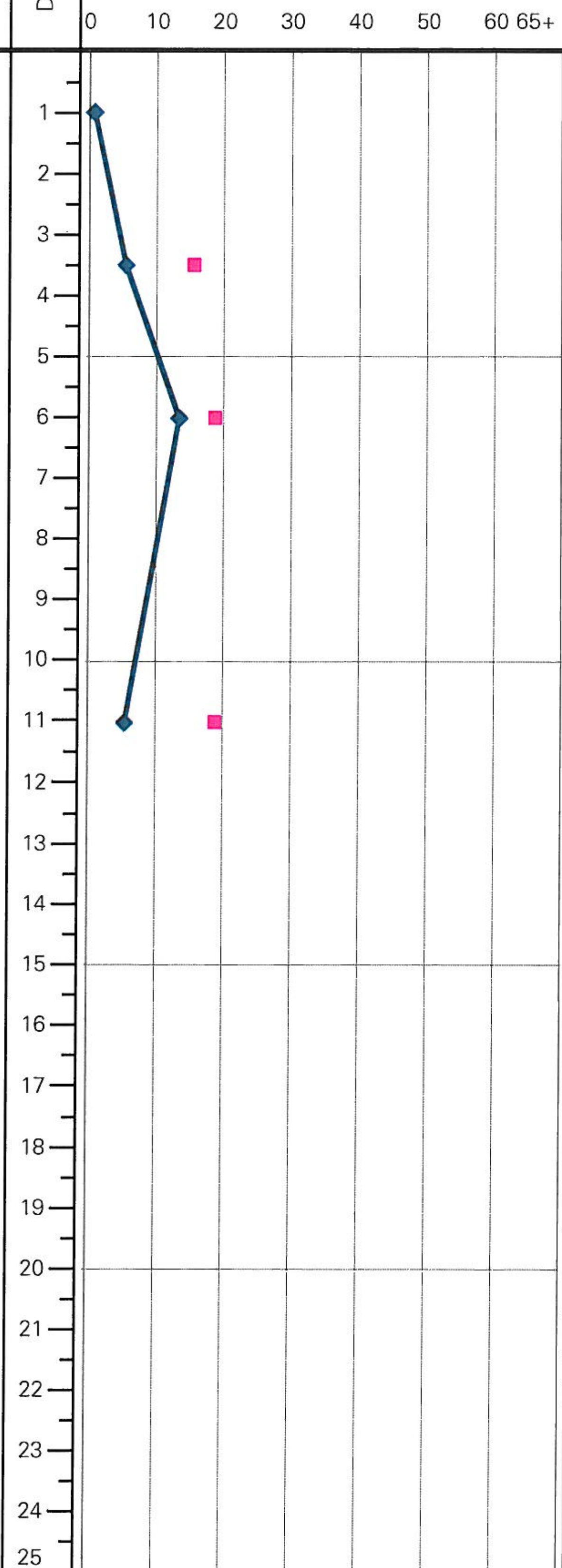
2869-001A | Figure 7

B-2				
	Date	7/24/2014	Hole dia. (in)	6
	Logged by	BAG	Hole depth ft	11.5
	Driller	CN	Well dia. (in)	N/A
Page 1 of 1	Elevation (ft)	104.0	Well depth	N/A
	Sample Liner	No	Hammer Eff.	60%

LITHOLOGY / DESCRIPTION	U.S.C.	Sample Recovery/ Driven Interval (in)	N- Blow Counts (blows/6")	Static Water Level
Black silty fine sand abundant organics with peat (very loose, moist)	SM/PT	12/18	0 0 0	
Dark gray silty fine to medium sand with gravel and organics (loose, moist) **(Alluvium)**	SM	7/18	2 4 3	
Gray silty fine sand with rust staining trace gravel (medium dense, moist) **(Alluvium)**	SM	12/18	8 9 8	
Gray fine to coarse sand with gravel (loose, moist) **(Alluvium)**	SP	4/18	1 3 4	
Boring was completed at 11.5 feet on 7/24/2014 Groundwater was not observed				

Standard Penetration Resistance
(140 lb. weight, 30" drop)
◆ SPT N_{60} (blows/ft)
■ Moisture Content (%)



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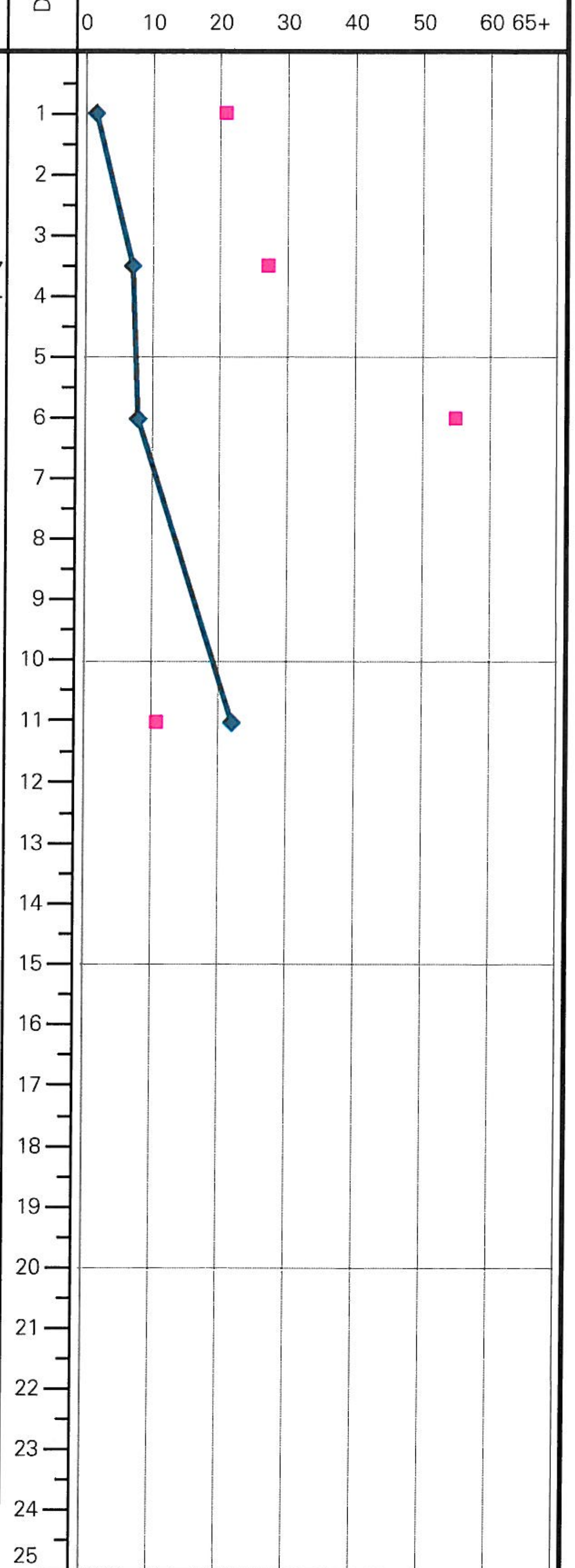
Modi Short Plat	
2869-001A	Figure 8

B-3	Date	7/24/2014	Hole dia. (in)	6
	Logged by	BAG	Hole depth ft	11.5
	Driller	CN	Well dia. (in)	N/A
Page 1 of 1	Elevation (ft)	108.0	Well depth	N/A
	Sample Liner	No	Hammer Eff.	60%

LITHOLOGY / DESCRIPTION	U.S.C.	Sample Recovery/ Driven Interval (in)	N- Blow Counts (blows/6")	Static Water Level	Depth (feet)
Black silty fine sand with peat (loose/soft, moist)	SM/PT	9/18	1 1 1		
Gray silty fine sand with rust staining (loose, moist) **(Alluvium)**	SM	10/18	3 4 5	▽	
Gray silty fine sand with rust staining trace gravel (loose to medium dense, moist) **(Alluvium)**	SM	12/18	3 5 5		
Gray fine to coarse sand with rust staining and gravel trace silt (medium dense, moist) **(Alluvium)**	SP	18/18	14 15 13		
Boring was completed at 11.5 feet on 7/24/2014 Groundwater observed at 4.0 feet on 2/24/2014					

Standard Penetration Resistance
(140 lb. weight, 30" drop)
◆ SPT N_{60} (blows/ft)
■ Moisture Content (%)



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Modi Short Plat	
2869-001A	Figure 9

Appendix A

USGS Design Maps Summary Report

User–Specified Input

Report Title Modi Short Plat
Wed August 27, 2014 21:44:11 UTC

Building Code Reference Document 2012 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 47.76802°N, 122.15798°W

Site Soil Classification Site Class E – "Soft Clay Soil"

Risk Category I/II/III

USGS–Provided Output

$S_S =$	1.284 g	$S_{MS} =$	1.156 g	$S_{DS} =$	0.770 g
$S_1 =$	0.498 g	$S_{M1} =$	1.196 g	$S_{D1} =$	0.797 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.