- REVISION 2 -
GEOTECHNICAL ENGINEERING REPORT
BETROZOFF-JONES PLAT
REDMOND, WASHINGTON
FOR
SHERMAN BUILDING COMPANY, LLC

MAY 2013

ATTACHMENT 24

ROBINSON
NOBLE

May 15, 2013

Mr. Todd Sherman
Sherman Building Company, LLC
2100 124th Avenue NE, Suite 100
Bellevue, WA 98005

Revision 2 - Geotechnical Engineering Report
Betrozoff-Jones Property
Redmond, Washington
RN File No. 2777-001A

Dear Mr. Sherman:

This letter serves as a transmittal for six copies of our report for the Betrozoff-Jones Property residential project. The site is located on King County Parcels 9428500065 and 9428500070 in Redmond, Washington. The project will consist of the development of 32 residential lots, two stormwater detention facilities, and two associated access roads. The site soils are compatible with the planned development.

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

Six Copies Submitted
Seven Figures
Appendix A

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INTRODUCTION

This report presents the results of our geotechnical engineering investigation for the 32-lot subdivision in Redmond, Washington. The site consists of King County Parcels 9428500065 and 9428500070 and is located between Woodinville-Redmond Road and 154^{th} Place NE, 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 residential construction. For our use in preparing this report, we have been provided with a Cover Sheet and Site Plan dated May 3, 2013, prepared by ESM Consulting Engineers, which shows the planned lot layout, site topography, and the locations of existing structures on-site.

We understand from conversations with you that if infiltration is not feasible for stormwater detention ponds, precast stormwater detention vaults are planned in the northwest and northeast corners of the site at depths of approximately 12 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 December 27, 2012, includes the following:

- Explore the subsurface soil and groundwater conditions with an excavator provided by you. You have requested that we complete 8 test pits.
- Evaluate pertinent physical and engineering characteristics of the soils encountered in our explorations based on field test results, laboratory results and our experience.
- Prepare a geotechnical report containing the results of our subsurface explorations, and our conclusions and recommendations for geotechnical design elements of the project. Our report will include:
    - Description of the geologic materials encountered.
    - Depth to groundwater, if encountered.
    - Discussion of seismicity at the site along with seismic design parameters including Site Class and site coefficients based on current IBC criteria.
    - Recommendations for earthwork and site preparation.
    - Recommendations for temporary and permanent excavation cuts.
    - Recommendations for shallow foundations including allowable soil bearing values, minimum footing sizes and soil parameters for lateral load resistance.
    - Estimate the total and differential settlements of conventional footings within the building.
    - Recommendations for roadway subgrade preparation.
    - Detention pond recommendations including preliminary infiltration estimates based on grain-size distribution.

SITE CONDITIONS

Surface Conditions

The roughly rectangular-shaped project site is about 9.06 acres in size and has maximum dimensions of approximately 600 feet in the east-west direction and 875 feet in the north-south direction. Access to the site is provided by Woodinville-Redmond Road, bordering the east side of the site. The site is also bordered by existing residential acreage to the north and south. 154th Place Northeast borders the site to the west. A layout of the site is shown on the Site Plan in Figure 2.

The ground surface within the site slopes gently down to the north and gently to steeply down to the west. The site is vegetated with a grass lawn, landscaping bushes, several stands of small- to- medium sized trees and several larger trees. Two single family residences with associated outbuildings and asphalt drives currently within the site are to be removed.

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. Soil layers overridden by the ice sheet were compacted to a much greater extent than those that were not. Part of a typical glacial sequence within the area of the site includes the following soil deposits from newest to oldest:

Artificial Fill (af) – Fill material is often locally placed by human activities, consistency will depend on the source of the fill. The thickness and expanse of this material will be dependent of extent of fill required to grade land to the desired elevations. Density of the fill will depend on earthwork activities and compaction efforts made during the placement of the material.

Recessional Outwash (Qvr) – These deposits were derived from the stagnating and receding Vashon glacier and consist of mostly of stratified sand and gravel, but include unstratified ablation and melt-out deposits. Recessional deposits were not compacted by the glacier and are typically not as dense as those that were.

Vashon Till (Qvt) – The till is a non-sorted mixture of clay, sand, pebbles, cobbles and boulders, all in variable amounts. The till was deposited directly by the ice as it advanced over and eroded irregular surfaces of previously deposited formations and sediments. The till was well compacted by the advancing glacier and exhibits high strength and stability. Drainage is considered very poor in the till.

Older Alluvium (Qoal) – Older alluvium consists of sand, silt, gravel and cobbles that may include landslide debris and colluvium at margins. These deposits form terraces along the valley sides.

The geologic units for this area are mapped on the Geologic Map of Kirkland Quadrangle, Washington, by James P. Minard (U.S. Geological Survey, 1983). The site is mapped as being underlain by deposits of older alluvium and glacial till. Our site explorations encountered older alluvium and glacial till.

Explorations

We explored subsurface conditions within the site on January 11, 2013 by excavating eight test pits with an excavator provided by you. The test pits were excavated to depths of 9.0 to 17.0 feet below the ground surface. The test pits were located in the field by you and an engineer from this firm. Our engineer also examined the soils and geologic conditions encountered, and maintained logs of the explorations. The approximate locations of the test pits 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 logs of the test pits are presented in Figures 4 through 6.

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 logs in Figures 4 through 6.

Our explorations generally encountered a surficial layer of topsoil that ranged in thickness from ½ to 1½ feet. The topsoil was underlain in Test Pits 1 through 3 and Test Pit 8 by medium stiff to stiff silt with trace sand, which we interpreted as weathered older alluvium and which extended to depths ranging from 7 to 13 feet below ground surface (bgs). Below the weathered alluvium, we encountered very stiff to hard older alluvium, which extended to the depths explored of 15 to 17 feet bgs. Test Pit 7 disclosed about 3 feet of loose silty sandy gravel, interpreted as fill, that was underlain by a weathered zone of loose to medium dense silty sand. Below the weathered zone we encountered medium dense silty sand that was interpreted as weathered or ablated till. The topsoil was underlain in Test Pits 4 through 6 by silty sand with varying amounts of gravel that was interpreted to be weathered glacial till. Below the weathered till we encountered dense to very dense glacial till, which extended to the depths explored of 9 to 13 feet bgs.

Overall, the glacial till was encountered in the test pits excavated in the upland portions of the site. These test pits were generally located east of the planned north-south access road. The older alluvium was revealed in the test pits excavated at the lower elevations. These test pits were generally located in the western and northern portions of the site.

Hydrologic Conditions

Minor to moderate perched groundwater seepage was encountered in Test Pits 1, 2, 4, 5 and 8 at depths ranging from 3 to 5½ feet bgs. Groundwater seepage was not observed in the other test pits. The medium dense to very dense glacial till deposits and the very stiff to hard older alluvium deposits interpreted to underlie the site are considered poorly draining. During the wetter times of the year, we expect perched water conditions will occur as pockets of water on top of these layers. Perched water does not represent a regional groundwater "table" within the upper soil horizons. Volumes of perched groundwater vary depending upon the time of year and the upslope recharge conditions.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion that the site is compatible with the planned residential structures. The underlying medium dense to very dense glacial till deposits and stiff older alluvium deposits are capable of supporting the proposed structures. We recommend that the foundations for the structures extend through any fill, topsoil, loose, or disturbed soils, and bear on the underlying medium dense or firmer native glacial till deposits, the underlying stiff or firmer older alluvial soils, or on structural fill extending to these soils. These soils were generally encountered at depths ranging from 3 to 5 feet bgs. We have not been provided with a grading plan. However, based on our site explorations, we anticipate that these soils will generally be encountered at or within a few feet of typical footing depths on the upland portion of the site; this depth increases to the north and west in the lower portions of the site. We recommend that test pits be excavated at the time of construction or that a representative from our firm observe the grading operations to evaluate the need to overexcavate foundation soils. We expect that some type of overexcavation and replacement scheme will be needed, at least in the lower northern and western portions of the site.

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 glacial till deposits and stiff older alluvium deposits likely to be exposed during construction are considered highly moisture sensitive, and the surface will disturb easily when wet. We expect these soils would be difficult, if not impossible, 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.

Geologic Hazards

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 (WSS) on the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) website for the King County Area, Washington to determine the erosion hazard of the on-site soils. The site surface soils were classified using the NRCS classification system as Kitsap silt loam with 2 to 8 percent slopes and 15 to 30 percent slopes (KpB and KpD). The corresponding description for parent material for these soils is listed as lacustrine which is similar to the low energy alluvial soils encountered in half of our site explorations. The soils east of Woodinville-Redmond Road were classified as Alderwood gravelly sandy loam (AgC). The corresponding description for parent material for these soils is listed as basal till which is in agreement with the soils encountered in half of our site explorations. The erosion hazard for the soil is listed as being slight for the gently sloping conditions at the site and moderate for the moderately sloping conditions at the site.

Seismic Hazard

It is our opinion based on our subsurface explorations that the Soil Profile in accordance with the 2009 and 2012 International Building Code (IBC) is Site Class C with Seismic Design Category D. We used the US Geological Survey program "U.S. Seismic Design Maps Web Application." The design maps summary reports for the 2009 and 2012 IBC are included in this report as Appendix A.

Additional seismic considerations include liquefaction potential and amplification of ground motions by loose and soft soil deposits. The liquefaction potential is highest for loose sand with a high groundwater table. The underlying dense and hard soils are considered to have a very low potential for liquefaction and amplification of ground motion.

Steep Slope Hazard

General: We observed fine-grained soils with a blocky structure in Test Pit 8. Based on our observations, in our opinion the steep slope area on the property west of the site may not be stable with respect to deep-seated slope failures. In addition, some surficial sloughing could occur on the steeper portions of the slope. We, therefore, are recommending setbacks from the top of the steepest portions of the slopes. Those setbacks are described in the **Slope Setback** portion of the report.

Slope Setback: To protect the planned residences from shallow sloughing failures over the lifetime of the structures, we recommend a 35-foot horizontal distance, as presented in Figure 7, from the slope face to the footings for the planned residences on lots 20 through 26. It is possible that further testing of the slope soils could justify a reduced distance.

Slope Protection: Protection of the setback and steep slope areas should be performed as required. It should be understood that the closer the site disturbance and development are to the slope, the more risk there is of affecting slope stability. Care should be taken to minimize disturbance to the slope face.

From a geotechnical standpoint, selective pruning and thinning of vegetation should be acceptable. Cutting and pruning of trees located on the slope can be performed, if allowed by the City, but certain precautions should be taken. We recommend that the root bundle/stump of fallen trees be left in place. Pruned materials and debris should be removed from the area and not allowed to remain on the slope. Any disturbed areas should be immediately re-stabilized through vegetation planting or other approved means. Soil, sod, clippings or other matter should not be placed on the slope.

Of great importance to the long-term stability of the slope is the control of surface and near-surface water, and erosion protection. We recommend that all drains, including foundation, roof and yard drains, be directed away from the top of slope and outfall at an approved area. Surface drainage over the slope should not be permitted.

Structural Fill

General: All fill placed beneath buildings 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 sidewalk and access road subgrade, should be compacted to at least 95 percent of its maximum dry density (MDD). 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 near-surface fill and alluvial soils be no steeper than 1.5 Horizontal to 1 Vertical (1.5H:1V). Cuts in the medium dense to very dense till may stand at a 0.5H:1V inclination or possibly steeper. If groundwater seepage is encountered, we would expect that flatter inclinations would be necessary.

If possible, the detention vaults in the northwest and northeast portions of the site should be planned to allow for safe excavation cuts. If the vaults need to be excavated closer to the property line, shoring may be required.

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 glacial soils should be no steeper than 2H:1V. Lightly compacted fills, common fills, native alluvial soils 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 or undisturbed stiff 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 or compacted to at least 95% MDD. 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.

For foundations constructed on stiff alluvium soil, we recommend an allowable design bearing pressure of 1,500 pounds per square foot (psf) be used for the footing design. For foundations constructed on medium dense or firmer till soil, or on structural fill compacted to at least 95% MDD, we recommend an allowable design bearing pressure of 2,500 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. 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 active and at-rest values should be increased by a uniform pressure of 7.1H and 17.8H psf, respectively, when considering seismic conditions using the 2009 IBC seismic parameters. The above drained active and at-rest values should be increased by a uniform pressure of 7.6H and 18.8H psf, respectively, when considering seismic conditions using the 2012 IBC seismic parameters. 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 0.5 may be used to determine the base friction in the native glacial soils. An equivalent fluid density of 360 pcf may be used for passive resistance design in the native glacial soils. A coefficient of friction of 0.34 may be used to determine the base friction in the native alluvial soils. An equivalent fluid density of 220 pcf may be used for passive resistance design in the native alluvial soils. 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 factor of safety of 1.5 has been applied to the passive pressure to account for required movements to generate these pressures. The friction coefficient also includes a factor of safety of 1.5.

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.

Infiltration

We understand that project plans include the use of either stormwater detention ponds or detention vaults. We obtained soil samples from the test pits located in the planned stormwater detention areas. We have used the United States Department of Agriculture (U.S.D.A.) soil group classification (Figure 3.27) as presented in the "Storm Water Management Manual for Western Washington", (Ecology 2005) to classify the soil samples analyzed. Based on the sieve results, this material is classified as silt. Based on this manual, infiltration is not considered feasible, as indicated on Table 3.7 for silt soils.

Drainage

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. Surface water should be collected by permanent catch basins and drain lines, and be discharged into the existing storm drain system.

We recommend that footing drains be used around all of the structures where moisture control is important. The underlying till and fine-grained alluvial soils 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.

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.

Due to the impermeable nature of the underlying silt in the northern and western portions of the site, we recommend a perforated pipe below–slab collection system that can flow by gravity to a suitable discharge location. On a preliminary basis, we recommend these drains on 25-foot horizontal spacing. The drains, with cleanouts, should consist of a minimum 4-inch diameter perforated pipe that is surrounded by free-draining material, such as pea gravel. The drain invert should be at least 1 foot below the base of the slab, with the pipe sloped to drain. The need for below-slab drainage should be more fully evaluated during construction.

Detention Vault

Because the soils in the planned stormwater facility areas are not conducive to infiltration, we understand that stormwater detention vaults are planned. The stormwater detention vaults may be supported on footing foundations bearing on the underlying hard alluvial soils. We recommend a soil bearing pressure of 4,000 pounds per square foot (psf) for the design of vault footings poured on undisturbed very stiff to hard alluvial and a footing width of at least 3 feet.

We recommend that footing drains be installed on the outside of perimeter footings. The footing drains should be at least 4 inches in diameter and should consist of perforated or slotted, rigid, smooth-walled PVC pipe, laid at the bottom of the footings. The drain line should be surrounded with free-draining pea gravel or coarse sand and wrapped with a layer of non-woven filter fabric. A vertical drainage blanket at least 12 inches thick, consisting of compacted pea gravel or other free-draining granular soils, should be placed against the walls. A vertical drain mat, such as Miradrain 6000 by Mirafi Inc., may be placed against the walls in lieu of the vertical drainage blanket. Structural fill is then placed behind the vertical drainage blanket or drain mat to backfill the walls. The vertical drainage blanket or drain mat should be hydraulically connected to the drain line at the base of the walls. Sufficient number of cleanouts at strategic locations should be installed for periodical cleaning of the wall drain line to prevent clogging.

The perimeter walls of the concrete vault with a lid would be restrained at their top from horizontal movement and should be designed for at-rest lateral soil pressure, while the perimeter walls of a vault without a lid would be unrestrained at the top and may be designed for active lateral soil pressure. 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 pcf and 55 pcf, respectively, may be used for design for a level backslope. These values assume that granular soils are used for backfill, and that the wall backfill is drained. The preceding values do not include the effects of surcharges due to foundation loads, traffic or other surface loads. Surcharge effects should be considered where appropriate. Recommended seismic lateral loading is provided in the **Lateral Load** section of this report. For <u>undrained</u> soil conditions, the active and at-rest pressures should be increased to 78 pcf and 88 pcf, respectively. Undrained conditions may occur in the lower portion of the vault if there is not suitable fall to place a wall drain at the footing elevation.

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.

Utilities

Our explorations indicate that deep dewatering will not be needed to install standard depth utilities. Anticipated groundwater is expected to be handled with pumps in the trenches. We also expect that some groundwater seepage may develop during and following the wetter times of the year. We expect this seepage to mostly occur in pockets. We do not expect significant volumes of water in these excavations.

The soils likely to be exposed in utility trenches after site stripping are considered highly moisture sensitive. We recommend that they be considered for trench backfill during the drier portions of the year. Provided these soils are within 2 percent of their optimum moisture content, they should be suitable to meet compaction specifications. During the wet season, it may be difficult to achieve compaction specifications; therefore, soil amendment with kiln dust or cement may be needed to achieve proper compaction with the on-site materials.

Pavement Subgrade

The performance of access road 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 foundation excavation 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 Sherman Building Company, LLC and its 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.

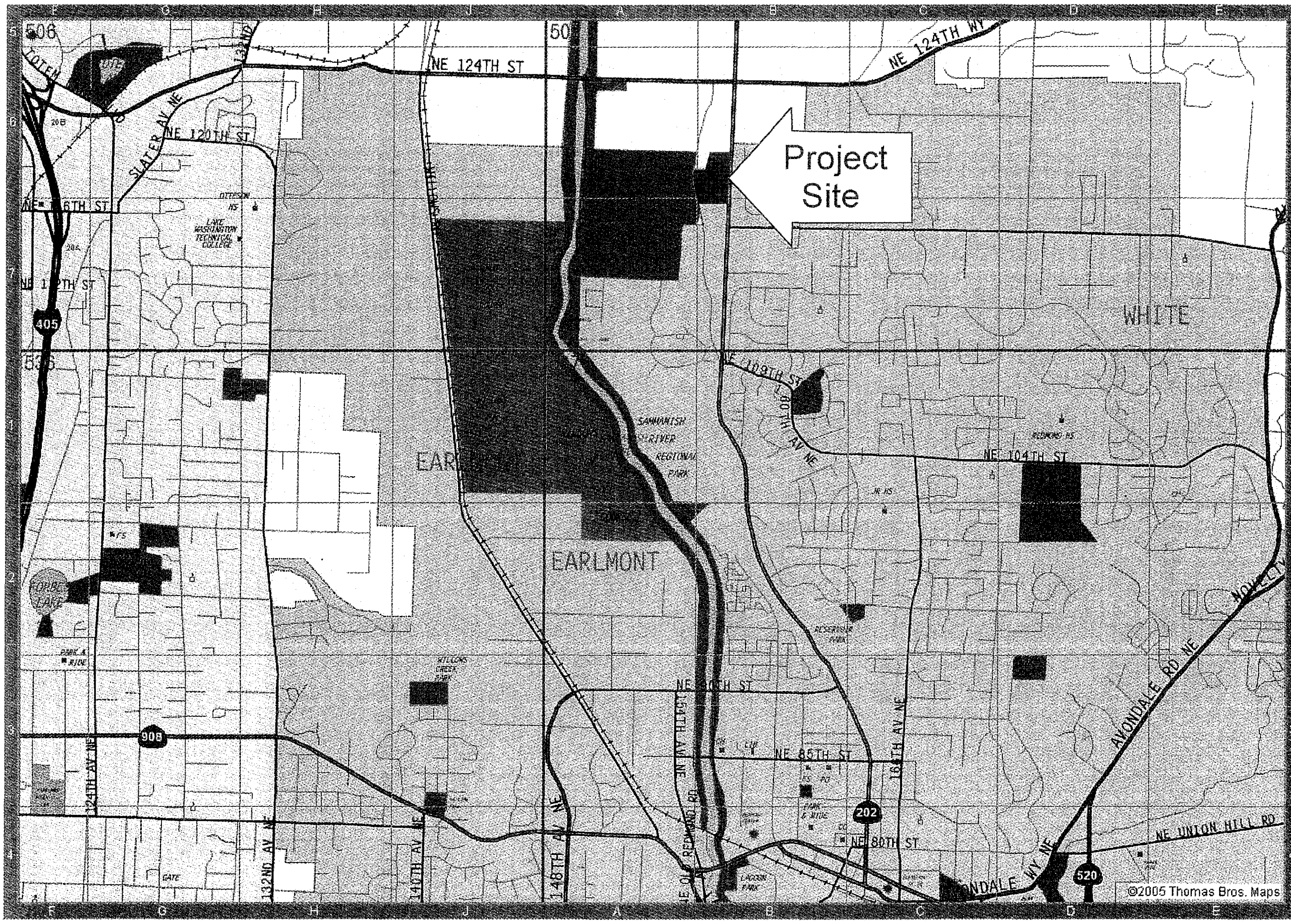
5/15/2013

Barbara A. Gallagher, PE
Senior Project Engineer

Rick B. Powell, PE
Principal Engineer

BAG:RBP:am

Six Copies Submitted
Seven Figures
Appendix A



ROBINSON NOBLE		PM: RBP May 2013 2777-001A	Figure 1 Vicinity Map Sherman Building Company, LLC: Betrozoff-Jones Plat

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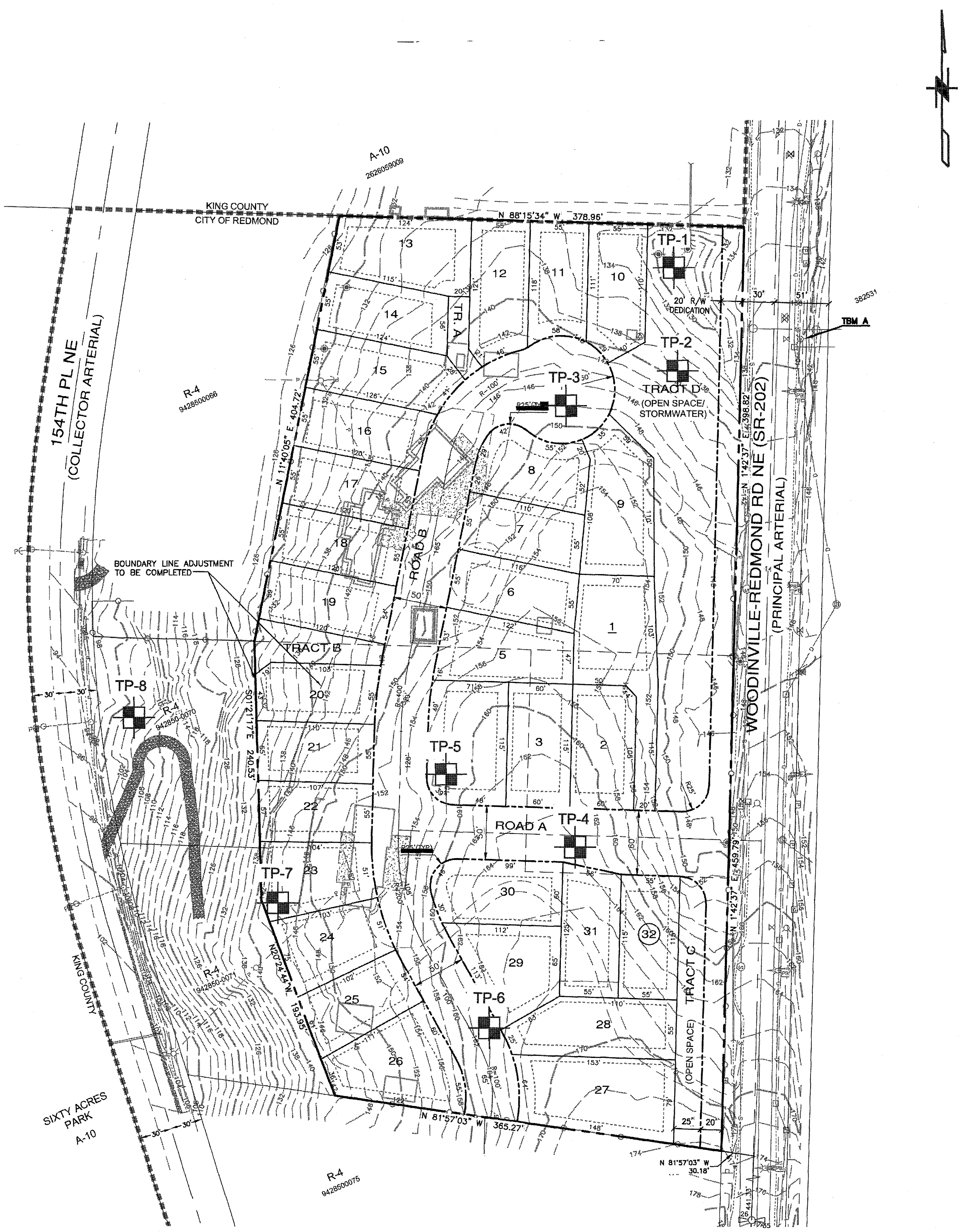

LEGEND

TP-1

Number and Approximate Location of Test Pit

0' 100'

Approximate Scale

ROBINSON NOBLE	Note: Basemap taken from "Betrozoff Jones Cover Sheet & Site Plan" prepared by ESM Consulting Engineers dated 05/03/2013.	PM: RBP May 2013 2777-001A	Figure 2 Site Plan Sherman Building Company - Betrozoff Jones Plat

ATTACHMENT 24

Unified Soil Classification System

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50% RETAINED ON number 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 2488-83.
2) Soil classification using laboratory tests is based on ASTM D 2487-83.
3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

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

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May 2013
2777-001A

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Figure 3

Unified Soil Classification System

ATTACHMENT 24

Sherman Building Compnay, LLC: Betrozoff-Jones Plat

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT ONE		
0.0 – 1.0	ML	Dark brown silt with roots (soft, moist) **(Topsoil)**
1.0 - 4.5	ML	Brown silt with trace sand (soft, moist)
4.5 – 7.0	ML	Grayish brown mottled silt with trace fine sand (medium stiff to stiff, moist to wet) MC = 26.7% at 5.0 feet
7.0 – 13.0	ML	Gray silt with trace fine sand (very stiff, moist) MC = 25.8% at 8.0 feet
13.0 – 15.5	ML	Gray silt with trace fine sand (hard, moist) (PP=3.5 tsf) **(Older Alluvium)** MC = 22.2% at 15.5 feet
		Samples were collected at 5.0, 8.0 and 15.5 feet Moderate groundwater seepage was encountered at 4.0 feet Test pit caving was not encountered Test pit was completed at 15.5 feet on 1/11/2013
TEST PIT TWO		
0.0 – 0.5	ML	Dark brown silt with roots (soft, moist) **(Topsoil)**
0.5 – 5.0	ML	Brown silt with trace sand (soft to medium stiff, moist) MC = 27.6% at 5.0 feet
5.0 – 5.5	SP	Brown fine to coarse sand with trace silt (medium dense, moist)
5.5 – 8.0	ML	Brown silt with trace fine sand (stiff to very stiff, moist)
8.0 – 15.5	ML	Gray silt with trace fine sand (very stiff to hard, moist) (PP=2.5 tsf) **(Older Alluvium)** MC = 26.4% at 15.5 feet
		Samples were collected at 5.0 and 15.5 feet Minor groundwater seepage was encountered at 3.0 feet Test pit caving was not encountered Test pit was completed at 15.5 feet on 1/11/2013
TEST PIT THREE		
0.0 – 0.5	ML	Dark brown sandy silt (soft, moist) **(Topsoil)**
0.5 – 1.5	ML	Reddish-brown silt with fine to medium sand (soft, moist)
1.5 – 3.0	ML	Brown slightly mottled silt with trace fine sand (soft to medium stiff, moist)
3.0 – 13.0	ML	Brown slightly mottled silt with trace fine sand (stiff to very stiff, moist) MC = 24.7% at 12.0 feet
13.0 – 15.0	ML	Gray silt with trace fine sand (very stiff to hard, moist) (PP=2.5 tsf) **(Older Alluvium)** MC = 22.6% at 15.0 feet
		Sample was collected at 12.0 and 15.0 feet Groundwater seepage was not encountered Test pit caving was not encountered Test pit was completed at 15.0 feet on 1/11/2013

MC = Moisture Content

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT FOUR		
0.0 – 0.5	ML	Dark brown sandy silt with roots (soft, moist) **(Topsoil)**
0.5 – 5.5	SM	Brown silty fine sand with tree roots to 3 feet (medium dense, moist)
5.5 – 11.0	SM	Grayish-brown silty gravelly fine sand with cobbles (dense to very dense, moist) **(Weathered Till)**
11.0 – 13.0	SM	Gray silty fine gravelly sand with cobbles (very dense, moist) **(Glacial Till)** MC = 9.4% at 13.0 feet
		Sample was collected at 13.0 feet Groundwater seepage was encountered at 5.5 feet Test pit caving was not encountered Test pit was completed at 13.0 feet on 1/11/2013
TEST PIT FIVE		
0.0 – 1.5	ML	Brown sandy silt with roots (soft, moist) **(Topsoil)**
1.5 – 4.0	SM	Reddish-brown silty sand with trace cobbles and boulders (loose to medium dense, moist)
4.0 – 10.5	SM	Grayish-brown silty gravelly fine sand with trace cobbles (dense to very dense, moist) **(Weathered Till)** MC = 8.6% at 5.0 feet
10.5 – 11.5	SM	Gray silty fine gravelly fine sand with trace cobbles (very dense, moist) **(Glacial Till)** MC = 8.8% at 11.5 feet
		Samples were collected at 5.0 and 11.5 feet Slight groundwater seepage was encountered at 5.0 feet Test pit caving was not encountered Test pit was completed at 11.5 feet on 1/11/2013
TEST PIT SIX		
0.0 – 0.5	ML	Dark brown sandy silt with moss and grass roots (soft, moist) **(Topsoil)**
0.5 – 3.0	SM	Reddish-brown silty fine to medium sand (loose to medium dense, moist)
3.0 – 8.0	SM	Grayish-brown slightly mottled silty fine to medium sand with gravel and trace cobbles (dense, moist) **(Weathered Till)**
8.0 – 9.0	SM	Grayish-brown silty fine to medium sand with gravel and trace cobbles (very dense, moist) **(Glacial Till)** MC = 15.4% at 9.0 feet
		Sample was collected at 9.0 feet Groundwater seepage was not encountered Test pit caving was not encountered Test pit was completed at 9.0 feet on 1/11/2013

MC = Moisture Content

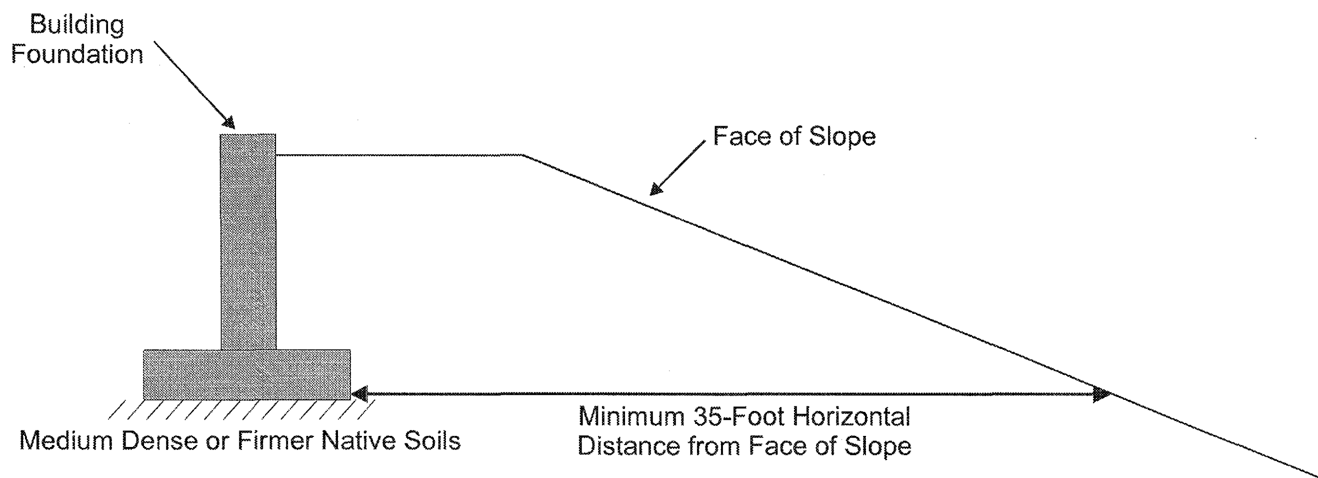
LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT SEVEN		
0.0 – 3.0	SM	Brown silty sandy gravel with trace roots (loose, moist) **(Fill)**
3.0 – 5.0	SM	Brown and reddish brown silty fine to medium sand with roots (loose to medium dense, moist)
5.0 – 11.5	SM	Grayish brown slightly mottled silty fine sand (medium dense, moist) **(Weathered Till)** MC = 20.9% at 11.5 feet
		Sample was collected at 11.5 feet Groundwater seepage was not encountered Test pit caving was not encountered Test pit was completed at 11.5 feet on 1/11/2013
TEST PIT EIGHT		
0.0 – 1.0	ML	Dark brown sandy silt with roots (soft, moist) **(Topsoil)**
1.0 – 3.0	ML	Brown silt with fine sand (soft to medium stiff, moist to wet)
3.0 – 5.0	ML	Brown slightly mottled silt with trace fine sand (medium stiff, moist) (PP=0.5 tsf) MC = 29.4% at 5.0 feet
5.0 – 13.0	ML	Brown silt with trace fine sand (medium stiff to stiff, moist) (PP=0.75 tsf) MC = 42.6% at 7.0 feet
13.0 – 17.0	ML	Gray silt with trace clay and trace sand (blocky) (very stiff to hard, moist) (PP=2.5 tsf) **(Older Alluvium/Colluvium)** MC = 29.8% at 17.0 feet
		Samples were collected at 5.0, 7.0 and 17.0 feet Groundwater seepage was encountered at 3.0 feet Test pit caving was not encountered Test pit was completed at 17.0 feet on 1/11/2013

MC = Moisture Content

Typical Foundation Embedment Detail with Horizontal Distance from Slope Face

(Not to Scale)



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Not to Scale

Figure 7

Foundation Embedment Detail

Sherman Building Company, LLC: Petrozeff-Jones Plat

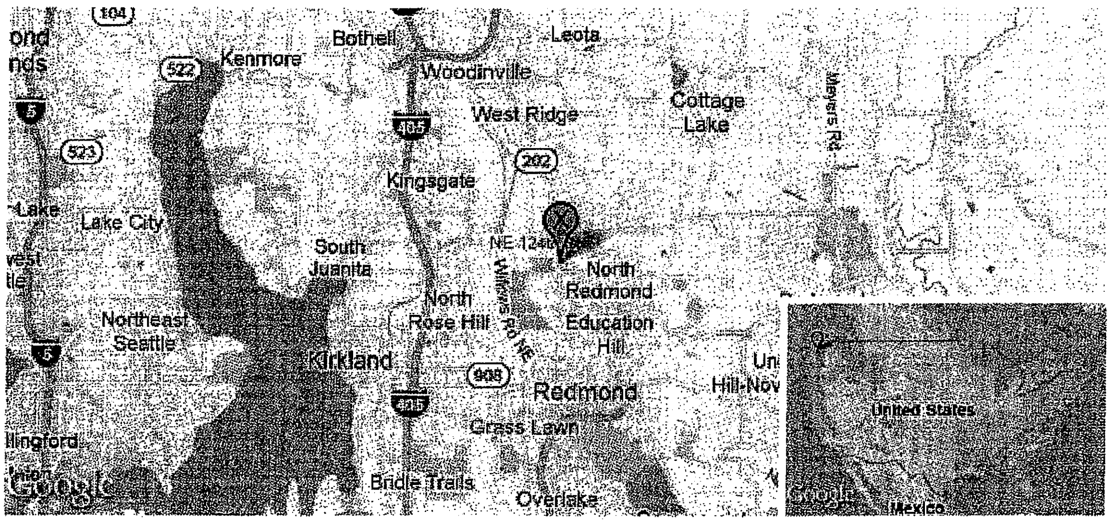
ATTACHMENT 24

Appendix A

USGS Design Maps Summary Report

User–Specified Input

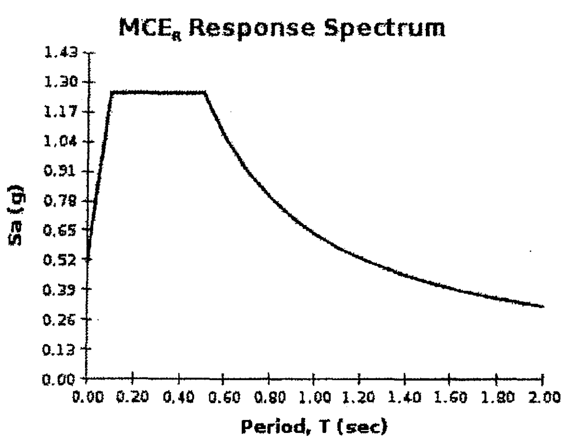
Report Title	Betrozoff-Jones Mon January 21, 2013 18:46:07 UTC
Building Code Reference Document	2012 International Building Code (which makes use of 2008 USGS hazard data)
Site Coordinates	47.70593°N, 122.13186°W
Site Soil Classification	Site Class C – "Very Dense Soil and Soft Rock"
Risk Category	I/II/III

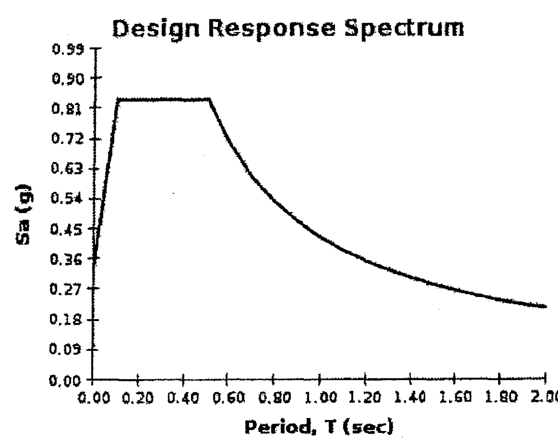


USGS–Provided Output

S_S =	1.254 g	S_{MS} =	1.254 g	S_{DS} =	0.836 g
S_1 =	0.482 g	S_{M1} =	0.636 g	S_{D1} =	0.424 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.





USGS Design Maps Summary Report

User–Specified Input

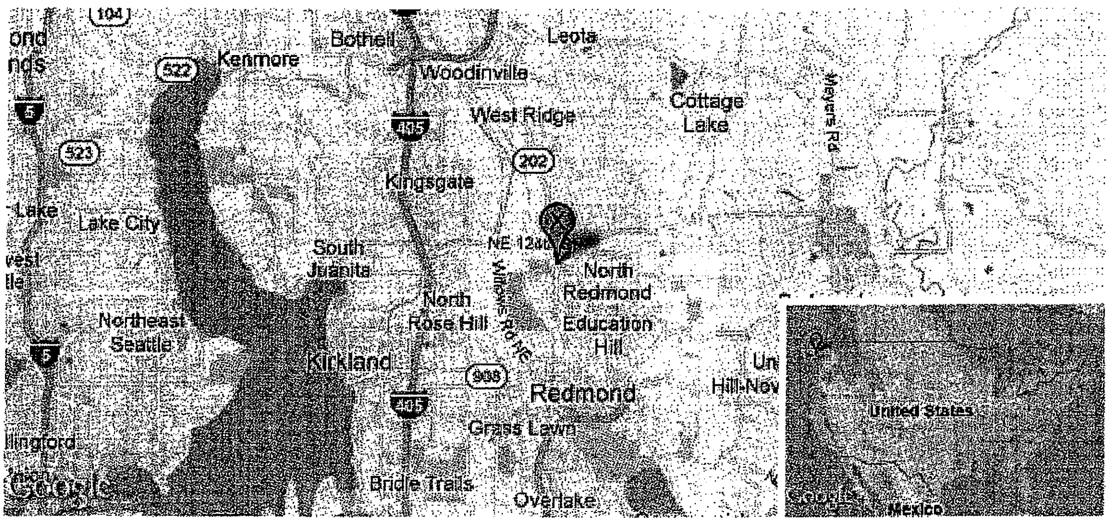
Report Title Betrozoff-Jones
Mon January 21, 2013 18:46:38 UTC

Building Code Reference Document 2006/2009 International Building Code
(which makes use of 2002 USGS hazard data)

Site Coordinates 47.70593°N, 122.13186°W

Site Soil Classification Site Class C – "Very Dense Soil and Soft Rock"

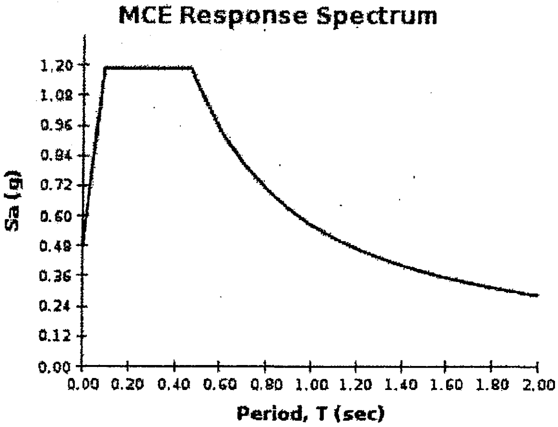
Occupancy Category Occupancy Category I



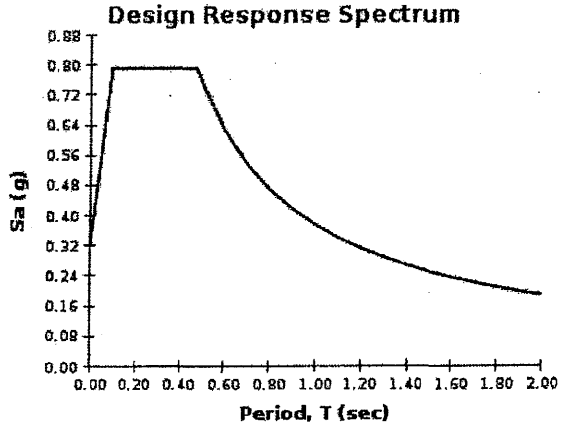
USGS–Provided Output

S_S =	1.187 g	S_{MS} =	1.187 g	S_{DS} =	0.791 g
S_1 =	0.403 g	S_{M1} =	0.563 g	S_{D1} =	0.376 g

MCE Response Spectrum



Design Response Spectrum



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