Exhibit 14

GeoDesign Inc

REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Larkspur Estates Phase II
6215 NW Larkspur Street
Camas, Washington

For
Marnella Homes, LLC
September 21, 2016

GeoDesign Project: Marnella-13-01

September 21, 2016

Marnella Homes, LLC
18318 SE Abernathy
Milwaukie, OR 97207

Attention: Tony Marnella

Report of Geotechnical Engineering Services
Larkspur Estates Phase II
6215 NW Larkspur Street
Camas, Washington
GeoDesign Project: Marnella-13-01

GeoDesign, Inc. is pleased to submit this report of geotechnical engineering services for the proposed Larkspur Estates Phase II located at 6215 NW Larkspur Street in Camas, Washington. Our services were completed in general conformance with our August 9, 2016 proposal.

We appreciate the opportunity to be of service to you. Please call if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

Shawn M. Dimke, P.E.
Principal Engineer

cc: Eric Golemo, SGA Engineering, PLLC (via email only)

RSK:SMD:kt
Attachments
One copy submitted (via email only)
Document ID: Marnella-13-01-092116-geor.docx

EXECUTIVE SUMMARY

SUBSURFACE CONDITIONS

We explored the subsurface conditions at the site by excavating four test pits (TP-1 through TP-4) to depths ranging between 6.0 and 7.0 feet BGS. The subsurface conditions generally consist of medium stiff to very stiff silt with variable amounts of gravel transitioning to dense to very dense gravel conglomerate. The gravel conglomerate is weakly to strongly cemented. Excavation refusal with a CASE CX130 trackhoe occurred at depths between 6.0 and 7.0 feet BGS.

As part of our subsurface investigation, we conducted infiltration tests at the location of test pits TP-1 and TP-2 at depths of 6.5 and 3.5 feet BGS, respectively. Infiltration tests were conducted in general accordance with the Clark County Stormwater Manual 2015 standards. Observed infiltration rates were negligible.

CONCLUSIONS

The following factors will have an impact on design and construction of the proposed subdivision and associated improvements. Our specific recommendations for site development are provided in this report.

- Based on the results of our investigation, it is our opinion the site soil should be capable of supporting the proposed structures on conventional spread footings underlain by firm, undisturbed native soil or on structural fill.
- Very dense, cemented gravel conglomerate is present at relatively shallow depths across the site. The presence of shallow cemented soil can present several obstacles during construction, including the following:
    - Excavations can become difficult with conventional equipment and may require specialized equipment.
    - Perched water may be present on top of the very dense gravel layer, and the earthwork contractor may need to use temporary dewatering techniques during construction.
- The near-surface fine-grained soil is susceptible to disturbance. We recommend that construction be staged to prevent disturbance of the subgrade from construction traffic. Granular haul roads and working pads or cement amendment should be employed to protect subgrades that will be exposed to construction traffic if earthwork will occur during wet weather.
- The on-site soil can be sensitive to small changes in moisture content and difficult, if not impossible, to adequately compact during wet weather or when the moisture content of the soil is more than a couple of percent above the optimum required for compaction. As discussed in this report, the moisture content of the soil currently is above optimum, and drying will be required if used as structural fill.
- Considering the shallow depth to the impervious cemented gravel and the anticipated perched groundwater at the interface of the near-surface silt and the cemented gravel layer during the wet season, we do not recommend relying on infiltration for the design of the stormwater system at the site. Foundation drains are also recommended for finish floors at or below existing grades or fore slab-on-grades with flooring sensitive to moisture.

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1.0 INTRODUCTION

GeoDesign, Inc. is pleased to submit this report of geotechnical engineering services for the proposed Larkspur Estates Phase II located at 6215 NW Larkspur Street in Camas, Washington. Figure 1 shows the site relative to existing topographic and physical features.

We understand the proposed Larkspur Phase II development will consist of up to eight single-family homes. We understand that improvements will also include new AC-paved streets and on-site stormwater disposal. We have assumed the residences will be established on shallow foundations supporting loads typical of light, wood-framed structures.

Acronyms and abbreviations used herein are defined at the end of this document.

2.0 PURPOSE AND SCOPE

The purpose of our work was to provide geotechnical engineering recommendations for use in design and construction of the proposed subdivision. Specifically, we completed the following scope of services:

- Reviewed readily available geotechnical information for the site.
- Explored subsurface conditions by completing four test pits to depths ranging from 6.0 to 7.0 feet BGS.
- Conducted two falling-head infiltration tests at depths of 3.5 and 6.5 feet BGS in general accordance with Clark County standards.
- Maintained continuous logs of the explorations, collected samples at representative intervals, and observed groundwater conditions.
- Completed a laboratory testing program consisting of the following tests:
  - Nine moisture content determinations in general accordance with ASTM D 2216
  - Two fines content analyses in general accordance with ASTM D 1140
- Conducted two falling head infiltration tests.
- Evaluated the geological hazards at the site.
- Provided recommendations for site preparation, grading and drainage, stripping depths, fill type for imported material, compaction criteria, trench excavation and backfill, use of on-site soil, and wet/dry weather earthwork.
- Provided recommendations for the design and construction of shallow foundations, including allowable design bearing pressure and minimum footing depth and width.
- Provided recommendations for use in the design of conventional retaining walls, including backfill and drainage requirements and lateral earth pressures.
- Evaluated groundwater conditions at the site, and provided general recommendations for dewatering during construction and subsurface drainage, if required.
- Provided recommendations for AC pavement design sections and pavement subgrade preparation based on reasonable traffic assumptions.
- Provided recommendations for IBC seismic coefficients.
- Prepared this geotechnical engineering report that presents our findings, conclusions, and recommendations.

3.0 SITE CONDITIONS

3.1 SURFACE CONDITIONS

The approximately 2.4-acre site is located at 6215 NW Larkspur Street in Camas, Washington. The site is generally undeveloped; however, remnants of a previous wood-framed structure are present. The ground surface is predominantly covered with low-lying vegetation; however, trees are established along the northern and western borders of the site. The ground surface at the site slopes downward from the southwest corner towards the northeast corner. The steepest slopes are found on the southwest portion of the site. In general, site elevations range from approximately 245 to 290 feet above MSL.

3.2 SUBSURFACE CONDITIONS

Our subsurface exploration program consisted of excavating four test pits (TP-1 through TP-4) to depths ranging from 6.0 to 7.0 feet BGS. The exploration logs are presented in the Appendix. Approximate exploration locations are shown on Figure 2.

The subsurface conditions generally consist of medium stiff to very stiff silt with variable amounts of gravel transitioning to dense to very dense cemented gravel conglomerate. The upper silt layer was encountered in all explorations from the ground surface to depths ranging between 3.0 and 4.0 feet BGS. The encountered underlying cemented gravel is weakly to strongly cemented. Excavation refusal with a CASE CX130 trackhoe occurred at depths between 6.0 and 7.0 feet BGS. We encountered an approximately 3-inch-thick near-surface root zone. Laboratory testing of selected samples indicates the near-surface soil had in-place moisture contents ranging from 24 to 46 percent at the time of our explorations.

3.2.1 Groundwater

Groundwater was not encountered in our explorations. The Clark County GIS depth to water layer indicates groundwater is roughly 20 feet deep at the site. Shallower groundwater is expected to perch atop the cemented gravel during the wet season and/or following periods of heavy rainfall. The depth to groundwater may fluctuate in response to seasonal changes, changes in surface topography, and other factors not observed during our explorations.

3.3 INFILTRATION TESTING

As part of our subsurface investigation, we conducted infiltration tests at the location of test pits TP-1 and TP-2 at depths of 6.5 and 3.5 feet BGS, respectively. Infiltration tests were conducted in general accordance with the Clark County Stormwater Manual 2015 standards. Observed infiltration rates were negligible. Our infiltration recommendations are provided in the "Stormwater Infiltration Systems" section of this report.

4.0 SITE DEVELOPMENT RECOMMENDATIONS

The following sections present general recommendations based on the geotechnical investigation of the site and our understanding of the proposed development.

4.1 SITE PREPARATION

4.1.1 Demolition

Buried and abandoned utilities, septic systems, wells, and foundations associated with the previous structure at the site may affect construction. Water wells and septic systems, if encountered, should be abandoned in accordance with state and local regulations prior to site development. Abandoned improvements encountered in areas of new improvements should be completely removed. Existing pipes may be grouted full if left in place. Excavations required for removal of utilities, septic systems, and foundations should be excavated to expose a firm subgrade before filling and their sides sloped at a minimum of 1H:1V to allow for uniform compaction at the edges of the excavations. All excavations resulting from removal of improvements and existing excavations at the site should be backfilled with compacted structural fill, as discussed in the "Structural Fill" section of this report.

4.1.2 Stripping and Grubbing

The near-surface root zone should be stripped and removed from the site in all proposed building and pavement areas and for a 5-foot margin around such areas. Based on our explorations, the depth of stripping will be approximately 3 inches, although greater stripping depths will be required surrounding trees and heavily forested areas and to remove localized zones of loose or organic soil. The actual stripping depth should be based on field observations at the time of construction. Stripped material should be transported off site for disposal or used in landscaped areas. Trees and their root balls should be grubbed to the depth of the roots, which could exceed 3 feet BGS. Depending on the methods used to remove the preceding material, considerable disturbance and loosening of the subgrade could occur. We recommend that disturbed soil be removed to expose stiff native soil. The resulting excavations should be backfilled with structural fill.

4.1.3 Subgrade Evaluation

A member of our geotechnical staff should observe the exposed subgrades after stripping, site cutting, and subgrade improvement have been completed to determine if there are areas of unsuitable or unstable soil. The subgrade should be proof rolled with a fully loaded dump truck or similar heavy, rubber-tired construction equipment to identify soft, loose, or unsuitable areas after subgrade compaction is complete. Proof rolling should be observed by a qualified geotechnical engineer or their representative. Areas that appear to be too wet and soft to support proof rolling equipment should be evaluated by probing and prepared in accordance with the recommendations for wet weather construction presented in the "Construction Considerations" section of this report.

4.1.4 Test Pit Locations

The test pit excavations were backfilled using the relatively minimal compactive effort of the hoe bucket; therefore, soft spots can be expected at these locations. We recommend that the relatively uncompacted soil be removed from the test pits to a depth of 3 feet below finished subgrade. If a test pit is located within 5 feet of a footing, we recommend full-depth removal of the uncompacted soil. The resulting excavation should be brought back to grade with structural fill.

4.1.5 Fills on Slopes

Where fills are to be placed on slopes steeper than 5H:1V, level benches should be cut into the existing sloping surfaces. The benches should be a minimum of 5 feet wide or the width of the compaction equipment, whichever is wider.

4.2 CONSTRUCTION CONSIDERATIONS

The near-surface fine-grained soil present on this site is easily disturbed during the wet season. If not carefully executed, site preparation, utility trench work, and roadway excavation can create extensive soft areas and significant repair costs can result. Earthwork planning should include considerations for minimizing subgrade disturbance.

If construction occurs during the wet season, or if the moisture content of the surficial soil is more than a couple percentage points above optimum, site stripping and cutting may need to be accomplished using track-mounted equipment, loading removed material into trucks supported on granular haul roads.

The thickness of the granular material for haul roads and staging areas will depend on the amount and type of construction traffic. Generally, a 12- to 18-inch-thick mat of granular material is sufficient for light staging areas and the basic building pad but is generally not expected to be adequate to support heavy equipment or truck traffic. The granular mat for haul roads and areas with repeated heavy construction traffic typically needs to be increased to between 18 and 24 inches. The actual thickness of haul roads and staging areas should be based on the contractor's approach to site development and the amount and type of construction traffic. The imported granular material should meet the requirements provided in the "Structural Fill" section of this report. Stabilization material may be used as a substitute provided the top 4 inches of material consists of imported granular material. The requirements for stabilization material are provided in the "Structural Fill" section of this report. In addition, we recommend that a separation geotextile meeting the requirements in the "Structural Fill" section of this report be placed as a barrier between silty subgrade material and imported granular material in areas of repeated construction traffic.

As an alternative to placing 12 to 24 inches of granular material, the subgrade can be stabilized using cement amendment. If this approach is used, the thickness of granular material in staging areas and along haul roads can be reduced to 4 inches. This recommendation is based on an assumed minimum unconfined compressive strength of 80 psi and a treatment depth of 12 inches for staging areas and 16 inches for haul roads. Cement amendment is further addressed in the "Structural Fill" section of this report.

4.3 EXCAVATION

As previously discussed, very dense, cemented gravel conglomerate is present at shallow depths below the surface at the site. The earthwork contractor should be prepared for difficult excavation conditions, which could require the use of specialized equipment to penetrate the cemented soil.

4.3.1 Trench Cuts and Shoring

Trench cuts should stand vertical to a depth of approximately 4 feet, provided groundwater seepage does not occur. Open excavation techniques may be used to excavate trenches with depths between 4 and 8 feet BGS, provided the walls of the excavation are cut at a slope of 1H:1V and groundwater seepage is not present. Sloughing and caving will likely occur if the excavation extends below the groundwater table or if seepage is present. The walls of the trench should be flattened or braced for stability and the area dewatered if seepage is encountered. Use of a trench box or other approved temporary shoring is recommended for cuts below the water table. If shoring is used, we recommend that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation.

4.3.2 Dewatering

We anticipate that a sump located within the trench excavation likely will be sufficient to remove the accumulated water, depending on the amount and persistence of water seepage and the length of time the trench is left open. Flow rates for dewatering are likely to vary depending on location, soil type, and the season during which the excavation occurs. The dewatering systems should be capable of adapting to variable flows. If groundwater and fine-grained soil are present in the base of the utility trench excavation, we recommend over-excavating the trench by 12 to 18 inches and placing trench stabilization material in the base.

4.3.3 Safety

All excavations should be made in accordance with applicable OSHA and state regulations. While we have described certain approaches to utility trench excavations in the foregoing discussion, the contractor should be responsible for selecting the excavation and dewatering methods, monitoring the trench excavations for safety, and providing shoring as required to protect personnel and adjacent areas.

4.4 STRUCTURAL FILL

4.4.1 General

Structural fill includes fill beneath foundations, slabs, pavements, other areas intended to support structures, or within the influence zones of structures. Fills should only be placed over a subgrade that has been prepared in conformance with the "Site Preparation" section of this report. However, all material used as structural fill should be free of organic matter or other unsuitable material and should meet the specifications provided in WSS 9-03 – Aggregates, depending on the application. A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill are provided below.

4.4.2 On-Site Fine-Grained Soil

Near-surface soil at the site consists primarily of silt. This soil can be used for structural fill provided it can be adequately moisture conditioned. The site soil is sensitive to small changes in moisture content and is highly susceptible to disturbance when wet. Use of the on-site material as structural fill will not be possible during the wet season, which typically extends from mid-October to early June. If construction is planned for the wet season, then careful consideration of the construction methods and schedule should be made to reduce over-excavation of disturbed site soil.

Typically, the moisture content for the on-site soil will be greater than the anticipated optimum moisture content required for adequate compaction. It is likely that even during the dry season, drying will be required to achieve adequate compaction. We recommend using imported granular material for structural fill or cement amending soil if the on-site material cannot be properly moisture conditioned.

When used as structural fill, the on-site soil should be placed in lifts with a maximum uncompacted thickness of 8 inches. The silt should be compacted to not less than 92 percent of the maximum dry density, as determined by ASTM D 1557.

4.4.3 Imported Granular Material

Imported granular material used for structural fill should be pit- or quarry-run rock, crushed rock, or crushed gravel and sand. Imported granular material should be fairly well graded between coarse and fine material, have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, and have at least two mechanically fractured faces. Material with higher fines content is permissible provided compaction can be achieved.

When used as structural fill, imported granular material should be placed in lifts with a maximum uncompacted thickness of 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 1557.

4.4.4 Stabilization Material

Stabilization material should consist of pit- or quarry-run rock, crushed rock, or crushed gravel and sand that consists of 4- to 6-inch-minus material. It should have less than 5 percent by dry weight passing the U.S. Standard No. 4 sieve and at least two mechanically fractured faces. The material should be free of organic matter and other deleterious material. Stabilization material should be placed in one lift and compacted to a firm condition.

Where the stabilization material is used to stabilize soft subgrade beneath pavements or construction haul roads, a geotextile should be placed as a barrier between the soil subgrade and the imported granular material. The geotextile fabric should meet the specifications provided below for subgrade geotextiles. Geotextile is not required where stabilization material is used at the base of utility trenches

4.4.5 Trench Backfill

Trench backfill for the utility pipe base and pipe zone should consist of well-graded, durable crushed granular material with a maximum particle size of ¾ inch and less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve. The material should be free of roots, organic matter, and other unsuitable material. Backfill for the pipe base and pipe zone should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D 1557, or as recommended by the pipe manufacturer.

Within building, pavement, and other structural areas, trench backfill placed above the pipe zone should consist of imported granular material as specified above. The backfill should be compacted to at least 92 percent of the maximum dry density, as determined by ASTM D 1557, at depths greater than 2 feet below the finished subgrade and 95 percent of the maximum dry density, as determined by ASTM D 1557, within 2 feet of finished subgrade. In all other areas, trench backfill above the pipe zone should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D 1557.

4.4.6 Aggregate Base Rock

Imported granular material used as base rock for building floor slabs and pavements should consist of ¾- or 1½-inch-minus material. The aggregate should have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve and have at least two fractured faces. The aggregate base should be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 1557.

4.4.7 Drain Rock Material

Drain rock should consist of open-graded, angular granular material with a maximum particle size of 2 inches. The material should be free of roots, organic matter, and other unsuitable material and have less than 2 percent by dry weight passing the U.S. Standard No. 200 sieve (washed analysis).

4.4.8 Recycled Material

AC, conventional concrete, and oversized rock may be used as fill if they are processed to meet the requirements for their intended use and do not pose an environmental concern. Processing includes crushing and screening, grinding in place, or other methods to meet the requirements for structural fill as described above. The processed material should be fairly well graded and not contain metal, organic, or other deleterious material. The processed material may be mixed with on-site soil or imported fill to assist in achieving the gradation requirements. Processed recycled fill should have a maximum particle size of 4 inches.

Recycled granular fill material is generally not suitable for the top 4 inches of pavement base rock or floor slab base rock. We also caution that excavation through recycled material that is placed as structural fill may be difficult. In addition, these excavations may also be prone to raveling and caving.

4.4.9 Geotextile Fabric

A geotextile drainage fabric will be required at the interface of the on-site soil and drainage rock. In addition, geotextile separation fabric may be required where soft subgrade is encountered. Drainage fabric should meet the specifications provided in WSS 9-33.2(1) – Geotextile Properties (Tables 1 and 2) for underground drainage, and separation fabric should meet the specifications provided in WSS 9-33.2(1) – Geotextile Properties (Table 3). The geotextiles should be installed in conformance the specifications provided in WSS 2-12 – Construction Geosynthetic.

4.4.10 Soil Amendment

As an alternative to the use of imported granular material for wet weather structural fill, an experienced contractor may be able to amend the on-site soil with portland cement or with limekiln dust and portland cement to obtain suitable support properties. Successful use of soil amendment depends on the use of correct mixing techniques, soil moisture content, and amendment quantities.

Specific recommendations, based on exposed site conditions, for soil amending can be provided if necessary. However, for preliminary design purposes, we recommend a target strength of 80 psi for cement-amended soil. The amount of cement used to achieve this target generally varies with moisture content and soil type. It is difficult to predict field performance of soil to cement amendment due to variability in soil response, and we recommend laboratory testing to confirm expectations. Generally, 4 percent cement by weight of dry soil can be used when the soil moisture content does not exceed approximately 20 percent. If the soil moisture content is in the range of 20 to 35 percent, 5 to 8 percent by weight of dry soil is recommended. The amount of cement added to the soil may need to be adjusted based on field observations and performance. Moreover, depending on the time of year and moisture content levels during amendment, water may need to be applied during tilling to appropriately condition the soil moisture content. The amount of cement used during treatment should be based on an assumed soil dry unit weight of 100 pcf.

Typically, a minimum curing of four days is required between treatment and construction traffic access. The amended surface should be protected from abrasion by placing a minimum of 4 inches crushed rock. As discussed in the "Pavement Design Recommendations" and "Construction Considerations" sections of this report, thicker layers of crushed rock may be required for the pavement section or for staging and haul roads. The crushed rock may typically become contaminated with soil during construction. Contaminated base rock should be removed and replaced with clean rock in pavement areas such that the minimum thickness of free-draining base at the surface is 4 inches.

Portland cement-amended soil is hard and has low permeability. Therefore, this soil does not drain well, nor is it suitable for planting. Future planted areas should not be cement amended (if practical) or accommodations should be planned for drainage and planting.

4.5 EROSION CONTROL

The near surface fine-grained soil at this site is eroded easily by wind and water; therefore, erosion control measures should be carefully planned and in place before construction begins. Surface water runoff should be collected and directed away from slopes to prevent water from running down the slope face. Erosion control measures (such as straw bales, sediment fences, and temporary detention and settling basins) should be used in accordance with local and state ordinances.

4.6 PERMANENT SLOPES

Permanent slopes for soil should not exceed 2H:1V. Slopes that will be maintained by mowing should not be constructed steeper than 3H:1V. Footings, buildings, access roads, and pavements should be located at least 5 feet horizontally from the slope face. The slopes should be planted with appropriate vegetation as soon as possible after grading to provide protection against erosion. Surface water runoff should be collected and directed away from slopes to prevent water from running down the face of the slope.

5.0 DRAINAGE CONSIDERATIONS

5.1 TEMPORARY

During earthwork at the site, the contractor should be made responsible for temporary drainage of surface water as necessary to prevent standing water and/or erosion at the working surface.

5.2 SITE DRAINAGE

We recommend all roof drains be connected to a tightline leading to storm drain facilities. Pavement surfaces and open space areas should be sloped such that surface water runoff is collected and routed to suitable discharge points. We also recommend that ground surfaces adjacent to buildings be sloped away from the buildings to facilitate drainage away from the buildings. Trapped planter areas should not be created adjacent to pavements and structures without providing means for positive drainage (e.g., swales or catch basins).

5.3 FOUNDATION DRAINS

We recommend using foundation drains around the perimeter of buildings if floor slabs are constructed at or below existing grades or if slab-on-grade flooring is sensitive to moisture. The foundation drains should be installed at least 2 feet below the finished floor grade, constructed at a minimum slope of approximately ½ percent, and routed to a suitable discharge (e.g., connected to the storm drain system).

The foundation drains should consist of 4-inch-diameter, perforated drainpipe embedded in a minimum 2-foot-wide zone of drain rock. The drain rock should be wrapped in a drainage geotextile fabric meeting the requirements in the "Structural Fill" section of this report. Foundation drains for embedded walls should be constructed as recommended in the "Retaining Structures" section of this report.

5.4 STORMWATER INFILTRATION SYSTEMS

Considering the shallow depth to the impervious cemented gravel and the anticipated perched groundwater at the interface of the near-surface silt and the cemented gravel layer during the wet season, we do not recommend relying on infiltration for the design of the stormwater system at the site.

6.0 FOUNDATION SUPPORT RECOMMENDATIONS

Based on the results of our investigation, it is our opinion the site soil should be capable of supporting the proposed structures on conventional spread footings underlain by firm, undisturbed native soil or on structural fill.

6.1 SHALLOW FOUNDATIONS

Isolated spread footings should be at least 18 inches wide. If used, continuous spread footings should be a minimum of 12 inches wide. The bottom of perimeter footings should extend at least 18 inches below the lowest adjacent grade. The bottom of interior footings should be established at least 12 inches below the base of the floor slab. Footings should bear on undisturbed, firm native soil or on structural fill overlying native soil. We recommend an allowable bearing pressure of 2,000 psf.

The above values represent net bearing pressures; the weight of the footings and overlying backfill can be ignored in calculating footing sizes. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads and may be increased by one-half for short-term loads (such as those resulting from wind or seismic forces). Based on our analysis and experience with similar soil, total post-construction settlement should be less than 1 inch, with differential settlement of less than half of the total between adjacent foundation elements.

In wet weather, we recommend placing a sufficient amount of crushed rock (typically 2 to 4 inches) to prevent disturbance to the foundation subgrades. The contractor is responsible for the construction sequencing and methodology for footing excavation and construction. Consequently, the actual amount of rock placed to protect foundation subgrades from disturbance in wet weather should be selected by the contractor. Rock used to protect the subgrades during wet weather should cover the foundation bearing surfaces and be compacted until "well keyed." Any foundation subgrade soil that is disturbed should be removed prior to the placement of crushed rock and/or pouring of the foundations.

6.1.1 Resistance to Sliding

Lateral loads on footings can be resisted by passive earth pressure on the sides of the structures and by friction on the base of the footings. Our analysis indicates the available passive earth pressure for footings confined by structural fill or footings constructed in direct contact with the undisturbed native soil or structural fill is 350 pcf. Typically, the movement required to develop the available passive resistance may be relatively large; therefore, we recommend using a reduced passive pressure of 250 pcf. Adjacent floor slabs, pavements, or the upper 12-inch depth of adjacent unpaved areas should not be considered when calculating passive resistance.

A coefficient of friction equal to 0.35 may be used when calculating resistance to sliding. The passive earth pressure and friction components may be combined, provided that the passive component does not exceed two-thirds of the total.

6.2 FLOOR SLABS

Satisfactory subgrade support for building floor slabs supporting up to 100 psf floor loading can be obtained provided the subgrade is prepared in accordance with the "Site Preparation" section of this report. A minimum 6-inch-thick layer of imported granular material should be placed and compacted over the prepared subgrade to assist as a capillary break. The floor slab base rock should be crushed rock or crushed gravel and sand meeting the requirements outlined in the "Structural Fill" section of this report. The imported granular material should be placed in one lift and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 1557. Floor slab base rock contaminated with excessive fines (greater than 5 percent by dry weight passing the U.S. Standard No. 200 sieve) should be replaced.

Flooring manufacturers often require vapor barriers to protect flooring and flooring adhesives. Many flooring manufacturers will warrant their product only if a vapor barrier is installed according to their recommendations. Selection and design of an appropriate vapor barrier, if needed, should be based on discussions among members of the design team. We can provide additional information to assist you with your decision.

7.0 RETAINING STRUCTURES

7.1 ASSUMPTIONS

Our retaining wall design recommendations are based on the following assumptions: (1) the walls consist of conventional, cantilevered retaining walls, (2) the walls are less than 12 feet in height, (3) the backfill is drained and consists of imported granular material, and (4) the retained soil has a slope flatter than 4H:1V. Re-evaluation of our recommendations will be required if the retaining wall design criteria for the project varies from these assumptions.

7.2 WALL DESIGN PARAMETERS

For unrestrained retaining walls, an active pressure of 35 pcf equivalent fluid pressure should be used for design. Where retaining walls (such as basement stem walls) are restrained from rotation prior to being backfilled, a pressure of 55 pcf equivalent fluid pressure should be used for design. For embedded building walls, a superimposed seismic lateral force should be calculated based on a dynamic force of $6H^2$ pounds per lineal foot of wall (where H is the height of the wall in feet) and applied as a distributed load with the centroid located at a distance of 0.6H from the base of the wall.

If surcharges (e.g., retained slopes, building foundations, vehicles, steep slopes, terraced walls, etc.) are located within a horizontal distance from the back of a wall equal to the height of the wall, then additional pressures will need to be accounted for in the wall design. Our office should be contacted for appropriate wall surcharges based on the actual magnitude and configuration of the applied loads.

The base of the wall footing excavations should extend a minimum of 18 inches below the lowest adjacent grade. The wall footings should be designed in accordance with the guidelines provided in the appropriate portion of the "Shallow Foundations" section of this report.

7.3 WALL DRAINAGE AND BACKFILL

The above design parameters have been provided assuming that drains will be installed behind the walls to prevent buildup of hydrostatic pressures. If a drainage system is not installed, then our office should be contacted for revised design forces.

Backfill material placed behind retaining walls and extending a horizontal distance of ½H (where H is the height of the retaining wall) should consist of imported granular material meeting the requirements described in the "Structural Fill" section of this report. Alternatively, the native soil can be used as backfill material provided a minimum 2-foot-wide column of angular drain rock wrapped in a drainage geotextile is placed against the wall and the native soil can be adequately moisture conditioned for compaction. The rock column should extend from the perforated drainpipe or foundation drains to within approximately 1 foot of the ground surface. The angular drain rock and drainage geotextile for walls should meet the requirements provided in the "Structural Fill" section of this report.

Perforated collector pipes should be placed at the base of the granular backfill behind the walls. The pipe should be embedded in a minimum 2-foot-wide zone of angular drain rock wrapped in a drainage geotextile fabric. The collector pipes should discharge at an appropriate location away from the base of the wall. Unless measures are taken to prevent backflow into the drainage system of the wall, the discharge pipe should not be tied directly into stormwater drain systems.

Backfill should be placed and compacted as recommended for structural fill, with the exception of backfill placed immediately adjacent to walls. Backfill adjacent to walls should be compacted to a lesser standard to reduce the potential for compaction-induced earth pressures on the walls. Backfill located within a horizontal distance of 3 feet from the retaining walls should be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D 1557. Backfill placed within 3 feet of the wall should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (such as a jumping jack or vibratory plate compactor). If flatwork (such as slabs, sidewalk, or pavement) will be placed adjacent to the wall, we recommend that the upper 2 feet of fill be compacted to 95 percent of the maximum dry density, as determined by ASTM D 1557.

Settlement of up to 1 percent of the wall height commonly occurs immediately adjacent to the wall as the wall rotates and develops active lateral earth pressures. Consequently, we recommend that construction of flatwork adjacent to retaining walls be postponed at least four weeks after construction, unless survey data indicates that settlement is complete prior to that time.

8.0 SEISMIC DESIGN CONSIDERATIONS

Seismic design is prescribed by ASCE 7-10 and 2015 IBC. Table 1 presents the site design parameters prescribed by the 2015 IBC and ASCE 7-10 for the site. Based on the subsurface conditions encountered at the site, the site class is C.

Table 1. IBC Seismic Design Parameters

Parameter	Short Period (T_s = 0.2 second)	1 Second Period (T_1 = 1.0 second)
MCE Spectral Acceleration, S	S_s = 0.895 g	S_1 = 0.377 g
Site Class	C	
Site Coefficient, F	F_a = 1.042	F_v = 1.423
Adjusted Spectral Acceleration, S_M	S_{MS} = 0.933 g	S_{M1} = 0.537 g
Design Spectral Response Acceleration Parameters, S_D	S_{DS} = 0.622 g	S_{D1} = 0.358 g

9.0 GEOLOGIC HAZARDS

Based on review of the Clark County GIS, we understand that slopes ranging from 15 to 25 percent are present on the southwest portion of the site. At the time of this report, site grading has not been determined. If areas of preferred seepage are encountered during site grading, GeoDesign should be contacted and additional drainage may be required. If cuts and fills will steepen slopes in the identified existing slope area, GeoDesign should also be contacted to review the grading plans to evaluate if additional recommendations are appropriate. If significant cut and fills are planned within this area, we should be contacted. Provided the site is developed in accordance with the recommendations provided in this report, the risk of slope instability within the identified steeper slope hazard area is low.

Liquefaction settlement is the result of seismically induced densification and subsequent ground settlement of loose sand and silty sand below the groundwater table. Based on the findings of our subsurface exploration and the anticipated groundwater elevation, it is our opinion that liquefaction is not considered a hazard at the site.

10.0 PAVEMENT DESIGN RECOMMENDATIONS

The pavement subgrade should be prepared in accordance with the previously described recommendations described in the "Site Preparation," "Construction Considerations," and "Structural Fill" sections of this report. Our pavement recommendations are based on a minimum California Bearing Ratio value of 3 and a design life of 20 years. We do not have specific information on the frequency and type of vehicles that will use the area; however, we have assumed that post-construction traffic conditions will consist of no more than five heavy trucks per day.

We recommend a pavement section consisting of a minimum of 3.0 inches of AC pavement underlain by a minimum of 10.0 inches of crushed base rock. For areas subjected to passenger car traffic only, we recommend a pavement section consisting of a minimum of 2.5 inches of AC pavement underlain by a minimum of 8.0 inches of crushed base rock. All thicknesses are intended to be the minimum acceptable. The design of the recommended pavement section is based on the assumption that construction will be completed during an extended period of dry weather. Wet weather construction could require an increased thickness of aggregate base.

The AC for should conform to the specifications provided in WSS 5-04 – Hot Mix Asphalt and WSS 9-03.8 – Aggregates for Hot Mix Asphalt. The asphalt cement binder should be PG 64-22 Performance Grade Asphalt Cement per WSS 9-02.1(4) – Performance Graded Asphalt Binder. The AC should be ½-inch hot mix asphalt. The lift thicknesses should be 2.0 to 3.5 inches. The AC should be compacted to 91 percent of the maximum specific gravity of the mix, as determined by ASTM D 2041. The aggregate base should meet the specifications for aggregate base provided in the "Structural Fill" section of this report.

11.0 OBSERVATION OF CONSTRUCTION

Satisfactory earthwork and foundation performance depends to a large degree on the quality of construction. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated. In addition, sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications.

12.0 LIMITATIONS

We have prepared this report for use by Marnella Homes, LLC and members of their design and construction teams for the proposed project. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Soil explorations indicate soil conditions only at specific locations and only to the depths penetrated. The soil explorations do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary. In addition, if design changes are made, we should be retained to review our conclusions and recommendations and to provide a written evaluation or modification.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

♦ ♦ ♦

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc.

Reed S. Kistler, P.E. (Oregon)
Staff Engineer

Shawn M. Dimke, P.E.
Principal Engineer

SHAWN M. DIMKE
STATE OF WASHINGTON
46635
REGISTERED
PROFESSIONAL ENGINEER

Signed 09/21/2016

FIGURES

GEODESIGN INC
15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

MARNELLA-13-01	**VICINITY MAP**	
SEPTEMBER 2016	LARKSPUR ESTATES PHASE II CAMAS, WA	**FIGURE 1**

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LEGEND:

TP-1 ▪ TEST PIT

— - — SITE BOUNDARY

N

0 60 120

(SCALE IN FEET)

SITE PLAN BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®, AUGUST 26, 2016

FIGURE 2

SITE PLAN

LARKSPUR ESTATES PHASE II
CAMAS, WA

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SEPTEMBER 2016

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APPENDIX

APPENDIX

FIELD EXPLORATIONS

GENERAL

Subsurface conditions at the site were explored by excavating four test pits (TP-1 through TP-4) to depths ranging from 6.0 to 7.0 feet BGS. Figure 2 shows the approximate exploration locations. Breaking Ground Excavation provided excavation services for the test pits using a CASE CX130 trackhoe on August 19, 2016. The exploration logs are presented in this appendix.

The explorations were observed by a member of our geotechnical staff. The locations of the explorations were determined in the field by pacing from site features. This information should be considered accurate to the degree implied by the methods used.

SOIL SAMPLING

Representative grab samples of the soil from the test pit explorations were obtained from the walls and/or base of the test pits using the trackhoe bucket. Sampling intervals are shown on the exploration logs.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the “Exploration Key” (Table A-1) and “Soil Classification System” (Table A-2), which are presented in this appendix. The exploration logs indicate the depths at which the soils or their characteristics change, although the change could be gradual. If the change occurred between sample locations, the depth was interpreted. Classifications are shown on the exploration logs.

LABORATORY TESTING

CLASSIFICATION

The soil samples were classified in the laboratory to confirm field classifications. The laboratory classifications are shown on the exploration logs if those classifications differed from the field classifications.

MOISTURE CONTENT

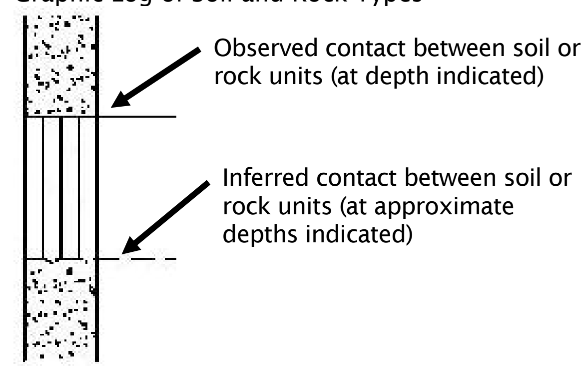
We determined the natural moisture content of selected samples in general accordance with ASTM D 2216. The natural moisture content is a ratio of the weight of the water to soil in a test sample and is expressed as a percentage. The test results are presented in this appendix.

GRAIN-SIZE TESTING

Grain-size testing was performed on selected samples. The testing consisted of percent fines determinations (percent passing the U.S. Standard No. 200 sieve) completed in general accordance with ASTM D 1140. The test result is presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
	Location of sample obtained in general accordance with ASTM D 1586 Standard Penetration Test with recovery
	Location of sample obtained using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D 1587 with recovery
	Location of sample obtained using Dames & Moore sampler and 300-pound hammer or pushed with recovery
	Location of sample obtained using Dames & Moore and 140-pound hammer or pushed with recovery
	Location of sample obtained using 3-inch-O.D. California split-spoon sampler and 140-pound hammer
	Location of grab sample
	Rock coring interval
	Water level during drilling
	Water level taken on date shown

Graphic Log of Soil and Rock Types



GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	PP	Pocket Penetrometer
CBR	California Bearing Ratio	P200	Percent Passing U.S. Standard No. 200 Sieve
CON	Consolidation		
DD	Dry Density	RES	Resilient Modulus
DS	Direct Shear	SIEV	Sieve Gradation
HYD	Hydrometer Gradation	TOR	Torvane
MC	Moisture Content	UC	Unconfined Compressive Strength
MD	Moisture-Density Relationship	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal
P	Pushed Sample		

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

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EXPLORATION KEY

TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOILS

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 - 11	0 - 4
Loose	4 – 10	11 - 26	4 - 10
Medium Dense	10 – 30	26 - 74	10 - 30
Dense	30 – 50	74 - 120	30 - 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOILS

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 - 4	3 – 6	2 - 5	0.25 - 0.50
Medium Stiff	4 - 8	6 – 12	5 - 9	0.50 - 1.0
Stiff	8 - 15	12 – 25	9 - 19	1.0 - 2.0
Very Stiff	15 - 30	25 – 65	19 – 31	2.0 - 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL 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 GRAVELS (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVELS WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SANDS (<5% fines)	SW or SP	SAND
		SANDS WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SANDS WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOILS			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.

Percent	Silt and Clay In: Fine-Grained Soils	Silt and Clay In: Coarse-Grained Soils	Percent	Sand and Gravel In: Fine-Grained Soils	Sand and Gravel In: Coarse-Grained Soils
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

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SOIL CLASSIFICATION SYSTEM

TABLE A-2

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%)	COMMENTS
TP-1						0 50 100	
0.0		Medium stiff to stiff, brown SILT (ML), trace gravel; moist, gravel is intensely weathered (topsoil to 8 inches, 2- to 3-inch-thick root zone).					
2.5					☒	●	
		Medium dense to dense, brown, silty GRAVEL (GM), minorsand; moist, weak cementation.	3.0	P200	☒	●	P200 = 45%
5.0		dense to very dense at 5.0 feet					
		very dense; strong cementation at 6.0 feet					Infiltration test: ~0 inches per hour at 6.5 feet.
7.5		Exploration terminated at a depth of 7.0 feet due to refusal.	7.0		☒		No groundwater seepage observed the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
						0 50 100	
TP-2						0 50 100	
0.0		Stiff to very stiff, brown SILT (ML), trace gravel; moist, gravel is intensely weathered (topsoil to 6 inches, 3-inch-thick root zone).					
2.5					☒	●	
		very stiff, brown with yellow spots, gravelly at 3.0 feet					Infiltration test: ~0 inches per hour at 3.5 feet.
		Very dense, brown with yellow spotted, silty GRAVEL (GM), minorsand; moist, weak cementation.	4.0				
5.0					☒	●	
		strong cementation at 5.5 feet					
7.5		Exploration terminated at a depth of 7.0 feet due to refusal.	7.0				No groundwater seepage observed the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
						0 50 100	

EXCAVATED BY: Breaking Ground Excavation LOGGED BY: RSK COMPLETED: 08/19/16

EXCAVATION METHOD: trackhoe (see document text)

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TEST PIT

LARKSPUR ESTATES PHASE II
CAMAS, WA

FIGURE A-1

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
TP-3							
0.0		Stiff, brown SILT (ML), trace gravel; moist (topsoil to 6 inches, 3-inch-thick root zone).					
2.5		very stiff, gravelly; gravel is intensely weathered at 2.0 feet			☒	●	
		Dense, brown with yellow spotted, silty GRAVEL (GM), minorsand; moist, weak cementation. very dense; moderate to strong cementation at 4.0 feet	3.0	P200	☒	●	P200 = 5%
5.0							
		Exploration terminated at a depth of 6.0 feet due to refusal.	6.0				No groundwater seepage observed the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
7.5							
TP-4							
0.0		Medium stiff to stiff, brown SILT (ML), trace gravel; moist (topsoil to 6 inches, 3-inch-thick root zone).					
2.5		very stiff, gravelly; gravel is intensely weathered at 2.5 feet			☒		
		Dense, brown with yellow spotted, silty GRAVEL (GM), minorsand; moist, weak cementation. very dense; moderate to strong cementation at 4.0 feet	3.5		☒	●	
5.0							
7.5		Exploration terminated at a depth of 7.0 feet due to refusal.	7.0				No groundwater seepage observed the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Breaking Ground Excavation LOGGED BY: RSK COMPLETED: 08/19/16

EXCAVATION METHOD: trackhoe (see document text)

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MARNELLA-13-01	TEST PIT	
SEPTEMBER 2016	LARKSPUR ESTATES PHASE II CAMAS, WA	FIGURE A-2

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
TP-1	2.0		24							
TP-1	3.0		27				45			
TP-2	2.0		25							
TP-2	5.0		46							
TP-3	2.0		28							
TP-3	4.0		20				5			
TP-4	4.0		33							

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SUMMARY OF LABORATORY DATA

LARKSPUR ESTATES PHASE II
CAMAS, WA

FIGURE A-3

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

AC	asphalt concrete
ASTM	American Society for Testing and Materials
ASCE	American Society of Civil Engineers
BGS	below ground surface
g	gravitational acceleration (32.2 feet/second^2)
GIS	geographic information system
H:V	horizontal to vertical
IBC	International Building Code
MCE	maximum considered earthquake
MSL	mean sea level
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
PG	performance grade
psf	pounds per square foot
psi	pounds per square inch
WSS	Washington Standard Specifications for Road, Bridge, and Municipal Construction (2016)

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