GEOLOGIC HAZARDS ASSESSMENT & CRITICAL AREAS REPORT

PROPOSED SMITH MULTIFAMILY PROJECT
BENTON COUNTY APNs 136983050007002 & 136983050008001
RICHLAND, BENTON COUNTY, WASHINGTON

GNN PROJECT NO. 214-540

DECEMBER 2014

Prepared for
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At GN Northern our mission is to serve our clients in the most efficient, cost effective way using the best resources and tools available while maintaining professionalism on every level. Our philosophy is to satisfy our clients through hard work, dedication and extraordinary efforts from all of our valued employees working as an extension of the design and construction team.
December 30, 2014

Tobiason & Company, Inc.
Land Use Consultant/Landscape Architect
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Attn: Mr. Laurey Tobiason

Subject: Geologic Hazards Assessment and Critical Areas Report
Proposed Smith Multifamily Project
Benton County Assessor’s Parcel Numbers 136983050007002, 136983050008001
East of Piper Street & West of Amon Creek
Richland, Benton County, Washington

Mr. Tobiason,

As requested, GN Northern, Inc. (GNN) has prepared this Critical Areas Report to assess potential geologic hazards for the site of the proposed Smith Multifamily Project development located west of the west fork of Amon Creek and east of the existing residences on Piper Street in the City of Richland, Washington.

Based on the finding of our evaluation, it is our professional opinion that risks related to potential geologic hazards at the site may be sufficiently mitigated through appropriate engineering/design and site grading for the proposed project. We further conclude that the site is suitable for the proposed development provided the recommendations contained in this report and any subsequent geotechnical engineering report(s) are followed during the design and construction phases.

The report, which follows, describes in detail our evaluation, summarizes our findings, and presents our recommendations. It is important that we provide consultation during the design and field-testing services during construction to review and monitor the implementation of our recommendations.

If you have any questions regarding this report, please contact us at 509-734-9320.

Respectfully submitted,

GN Northern, Inc.

Karl Harmon, LEG, PE
Senior Engineering Geologist/Geotechnical Engineer

Enclosures: Geologic Hazards Assessment / Critical Areas Report (digital PDF copy)
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EXECUTIVE SUMMARY

GN Northern, Inc. has prepared this executive summary solely to provide a general overview of the report. The report itself should be relied upon for information about the findings, conclusions, recommendations, and other concerns. Portions of the site are currently mapped on the City of Richland Geological Sensitive Areas Map (dated August 2013). The intent of this Geologic Hazards Assessment and Critical Areas report is to assess various geologic hazards that may impact the proposed development and provide recommendations for mitigation. Our site evaluation has been prepared in general accordance with the requirements of the City of Richland’s Sensitive Areas Regulations, Chapters 22.10.

The proposed multifamily residential development is generally located between the existing single-family residential developments along Piper Street (to the west) and the West Fork of Amon Creek (to the east) in the City of Richland, Washington (Figure 1, Appendix I). The project site currently consists of approximately 13.25 acres of undeveloped land. The site is situated in an area of rolling hills with relatively gentle overall slope toward the northeast. Portions of the project site are mapped within the City of Richland’s Geological Sensitive Areas including Geologic Hazards Area (Steep Slopes) and Flood Plain (Includes Wetlands).

This site assessment was performed to evaluate geologic conditions in the project region, including general and site specific soil and bedrock conditions, groundwater, slopes, drainage, erosion, and geologic hazards. A review of selected information pertaining to the project site and surrounding region was performed that included published technical literature, published geologic maps, available aerial photographs, and previous geologic and geotechnical studies prepared for nearby sites. Site-specific geologic and geotechnical data was obtained from subsurface exploration conducted at the project site for this assessment.

In our professional opinion, the proposed project may be constructed as planned, provided that the recommendations within this Critical Areas Report and subsequent geotechnical engineering report(s) are incorporated in the final design and construction. Based on our site evaluation and analysis, the existing site slopes are generally considered to be stable in their current state and will not require any significant mitigation measures to minimize risk of future slope instability of proposed site graded slopes.
INTRODUCTION

Project Description
This geologic hazards assessment and Critical Areas Report has been prepared for the proposed Smith Multifamily Project development located between Piper Street (to the west) and the West Fork of Amon Creek (to the east), in the City of Richland, Washington. We understand that the proposed development will ultimately include construction of six (6) multi-unit apartment buildings with associated drive lanes, parking areas, and landscaping.

Purpose and Scope of Services
The purpose of our services was to evaluate the surface and subsurface soil and bedrock conditions and potential geologic hazards as they relate to the proposed multifamily residential development and provide professional opinions and recommendations for mitigation (if deemed necessary) of any potential geologic hazards. This report does not constitute a geotechnical evaluation of the project site for purposes of future development. The scope of work included the following:

- Detailed reconnaissance of the site.
- Review of project plans.
- A review of selected published technical literature pertaining to the site, including geologic maps, soil maps, USGS topographic maps, geologic studies, as well as previously prepared geotechnical/geologic reports prepared for similar projects/sites in the vicinity.
- Analysis of the acquired data from our review and site evaluation.
- Stability analysis of the existing site slopes.
- A summary of our findings and recommendations in this written report.

This report contains the following:
- Discussions on subsurface soil, bedrock and groundwater conditions.
- Discussions on regional and local geologic conditions.
- Discussions on geologic and seismic hazards.
- Recommendations for appropriate mitigation of potential geologic hazards
METHODS OF EVALUATION

Literature Review
A review of selected information pertaining to the site and surrounding area was performed that included published technical literature, published geologic maps, aerial photographs and previous geotechnical and geologic reports prepared for other sites in the vicinity. The review was performed to identify typical geotechnical and geologic constraints that may affect the proposed development, including soil and bedrock conditions, groundwater, slopes, drainage, erosion, and geologic hazards.

Field Exploration
Field exploration was conducted on December 2, 2014. A utility clearance was obtained prior to the field exploration. Eight (8) test-pits were completed at the site and were logged by a GNN field engineer; test-pits to depths of approximately 6 to 9.5 feet below ground surface (BGS). Exploratory test-pits were excavated using a CAT 305E GR backhoe provided by the client. Upon completion, test-pits were loosely backfilled. Locations of test-pits are shown on Site & Exploration Map (Figure 2, Appendix I).

The soils observed during our field exploration were classified according to the Unified Soil Classification System (USCS), utilizing the field classification procedures as outlined in ASTM D2488. A copy of the USCS Classification Chart is included in Appendix II. Photographs of the site are presented in Appendix III following this report.

Depths referred to in this report are relative to the existing ground surface elevation at the time of our field investigation. The surface and subsurface conditions described in this report are as observed at the site at the time of our field investigation.

DISCUSSION

Site Description
The proposed Smith Multifamily Project residential development is to be constructed on two irregular shaped parcels located generally between Piper Street (to the west) and Amon Creek (to the east) in the City of Richland, Washington. The total 13.25-acre project site is generally bounded to the north and west by existing single-family residential developments, and to the east and south by the Amon Creek.
The site is situated in an area of rolling hills with relatively gentle overall slope toward the east. Moderate to dense native brush and grass covers the majority of the project site. The project site elevations range from approximately 520 to 485 feet above mean sea level (MSL), for a total relief of about 35 feet. Native site slope gradients range from approximately 2% to 33% within the project site.

**Subsurface Soil / Bedrock / Groundwater Conditions**

Subsurface soil conditions were generally consistent across the site, with soils typically classified as Sandy Silt / Silt with Sand (ML) with some fine grained Silty Sand (SM). Approximately 2 to 6 inches of organic-rich topsoil was typically observed across the surface. The onsite soils were generally observed to consist of loose to medium dense, dry to moist, interbedded fine grained sandy silts and silty sands. Occasional thin layers and lenses of apparent volcanic ash material were observed at various depths within a number of the test-pits. A deeper layer of poorly graded gravel with sand was noted at a depth of approximately 4 to 5 feet within test-pit TP-7 near the eastern portion of the site. Detailed logs of each of our test-pits are presented in Appendix II following this report. Photographs taken at selected test pit locations are presented in Appendix III.

The soil survey map of the vicinity prepared by the Natural Resources Conservation Service (NRCS) indicates mapped soils at the project site include Hezel loamy fine sand (HeD & HeD), Quincy loamy sand (QuD), and Warden very fine sandy loam (WfD2), situated on slopes ranging from 0 to 30%. The typical soil profiles are described to include an upper layer (< 18 inch) of loamy fine sand to loamy sand or sandy loam over stratified fine to very fine sandy loam to silt loam. The drainage class for these soils generally range from somewhat excessively drained to excessively drained with the capacity of the most limiting layer to transmit water (Ksat) ranging from moderately high (0.20 to 0.57 in/hr) and high to very high (5.95 to 19.98 in/hr). The landform settings are identified as terraces and parent materials are described as eolian (wind-blown) sands over silty lacustrian deposits. Refer to the Soil Survey Map in the Appendix VII for more details.

Groundwater was not encountered within any of the test pits excavated during our field exploration at the project site. Depths to groundwater are expected to fluctuate slightly with changes in local draws and precipitation in the area. Based on available well log data from the Washington State Department of Ecology within the area, groundwater conditions in the vicinity of the proposed development are anticipated at depths greater than 50 feet below existing grade with shallower depths anticipated in the
vicinity of the Amon Creek. Groundwater conditions beneath the site are not expected impact construction of the proposed development. Well logs from the surrounding areas are presented in Appendix VI, following this report.

**Geologic Setting**

The Tri-Cities lie on the Columbia Plateau, a broad plain situated between the Cascade Range to the west and the Rocky Mountains to the east. The Columbia Plateau was formed by a thick sequence of Miocene Age tholeiitic basalt flows, known as the Columbia River Basalt Group (CRBG), which erupted from fissures in north-central and northeastern Oregon, eastern Washington, and Western Idaho approximately 12 to 26 million years ago. The Columbia Plateau is often called the Columbia Basin because it forms a broad lowland surrounded by mountains. The Columbia River Basalt Group is underlain by continental sedimentary rocks from early in the Tertiary Period. Sediments of the Pliocene Age Ringold formation overlie the Columbia basalts. The Ringold Formation sediments consist of a heterogeneous mix of variably cemented and compacted gravel, sand, silt, and clay deposited by the ancestral Columbia, Snake, and Yakima Rivers.

The project site is located near the outlet of Badger Canyon, which was the ancestral route of the Yakima River. The site is situated near base of the Horse Heaven Hills and in line with the Rattlesnake Hills of the Yakima Fold Belt within the Columbia Basin physiographic province of southeastern Washington. The Rattlesnake and Horse Heaven Hills consist of east-west trending anticline ridges of the Yakima Fold Belt formed by north–south compression in the regional lava flows.

Near the end of the Pleistocene, the Columbia Basin was subjected to a series of massive, high energy floods known as the Missoula Floods. During this time, a lobe of the Cordilleran ice sheet extended south into Idaho, damming up the Clark Fork River and creating Glacial Lake Missoula, impounding as much as 500 cubic miles of water. These ice dams periodically failed and then reformed numerous times during this period, catastrophically draining the lake and unleashing a series of massive torrents of water that significantly scoured and altered landscapes in the Columbia Basin through erosion and deposition. Sediments from these glacial outburst flooding events filled the area including Badger Canyon resulting in the re-routing of the Yakima River near Benton City.


**Geologic Hazards**

Geologic hazards that may affect the development include seismic hazards (ground shaking, surface fault rupture, soil liquefaction, and other secondary earthquake-related hazards), slope instability, flooding, ground subsidence, and erosion. A discussion follows on the specific hazards to this site.

**Regional Faulting:** There are three main fault structures in the area around the site, consisting of the Rattlesnake fault structure, the Horse Heaven Hills structure, and the Wallula Fault system. These three structures are included in many of the regional lineaments in the area including the Olympic Wallowa Lineament (OWL), the Cle Elum-Wallula deformed zone (CLEW), and the Rattlesnake-Wallula trend (RAW).

The Horse Heaven Hills structure is one of the longest fold and fault systems in south-central Washington, and is part of the Yakima fold belt. No definitive evidence has been documented to show Quaternary movement in the Horse Heaven Hills.

The Rattlesnake fault structures are anticlinal segments cut and underlain by south- to southwest-dipping thrust or reverse faults in rocks of the Miocene Columbia River Basalt Group. These anticlinal segments characterize the southeastern part of the Rattlesnake Hills uplift and are en-echelon double-plunging anticline. For much of their length, the faults of the Rattlesnake structures are covered by loess, landslide, and glacial outburst flood deposits of Quaternary age.

The Wallula Fault System is a prominent northwest-striking fault zone that extends from near Milton-Freewater, Oregon to near the Tri-Cities. Unlike the two previously described structures, the Wallula Fault System is mostly mapped as linear, steeply dipping strike-slip, normal, or reverse faults in Quaternary surficial deposits and rocks of the Columbia River Basalt Group. The mapped fault pattern, and other evidence, supports a right-lateral strike-slip sense of movement on the Wallula Fault. Although poorly studied, some evidence suggests up to four surface-faulting events within the past 10,000 years along a portion of the Wallula Fault System in northeastern Oregon. Slip rate on all three faults is estimated to be less than 0.2 millimeters per year.

The seismic hazard in the project area and vicinity results from three seismic sources: interplate events, intraslab events, and crustal events (Geomatrix, 1995, 1996). Each of these events has different causes and therefore produces earthquakes with different characteristics (i.e., peak ground accelerations,
response spectra, and duration of strong shaking). Each is capable of generating a peak ground acceleration (pga) on rock larger than 0.05g.

Two of the potential seismic sources, interplate and intraslab events, are related to the subduction of the Juan De Fuca plate beneath the North American plate. Interplate events occur due to movement at the interface of these two tectonic plates. Intraslab events originate within the subducting tectonic plate, away from its edges, when built-up stresses within the subducting plate are released. These source mechanisms are referred to as the Cascadia Subduction Zone (CSZ) source mechanism. The CSZ originates off the coast of Oregon and Washington and subducts beneath both states.

Earthquakes caused by movements along crustal faults, generally in the upper 10 to 15 miles, result in the third source mechanism. These movements occur on the crust of the North American tectonic plate when built-up stresses near the surface are released. There are several crustal faults associated with structure in the vicinity of the project, including the Rattlesnake-Wallula Trend, Columbia Hills Anticline, and Horse Heaven Hills NW Fault (Geomatrix 1995, 1996). These faults are generally considered to be inactive or have a low probability of activity.

The most notable regional earthquake event in the past century occurred on July 15, 1936 near Umapine, Oregon, approximately 40 miles to the east-southeast. The Umapine quake has been set at magnitude 5.7 or 6.4 on the Richter scale by different resources, and was felt through large portions of Washington, Oregon, and Idaho, and caused ground cracking, small areas of soil liquefaction, structural damage, and isolated building collapses near Walla Walla, Washington and Milton-Freewater, Oregon. Damage was also reported in Waitsburg (approximately 50 miles east of the project site), and the quake was felt in the Tri-Cities (estimated Modified Mercalli (MM) Intensity of III) but no damage was reported.

Within the past 10 years there have been a total of 28 earthquakes within a 100-kilometer radius of the site. The largest of these episodes had a magnitude of 3.7 and a hypocenter of 20 kilometers below the surface. It occurred in 2008 and the epicenter was approximately 23 kilometers away from the project site at a location of N 46.17 W -119.55. Of the 28 total earthquakes in the past 10 years, 21 had a focus of 10 kilometers or less, 6 were between 25 kilometers and 11 kilometers, and 1 was greater than 25 kilometers deep (a focus of 36 kilometers below the surface). All 28 events have an average magnitude of 2.9 on the Richter scale.
Surface Fault Rupture: For the purposes of this report, an active fault is defined as a fault that has had displacement within the Holocene epoch or last 11,000 years. While the region is subject to areas of known faulting and deformation related to activity along the Yakima Fold Belts, due to the lack of any known active fault traces in the immediate site vicinity, surface fault rupture is unlikely to occur at the project site. While fault rupture would most likely occur along previously established fault traces, future fault rupture could occur at other locations.

Seismic Conditions: The Tri-Cities area is generally not considered to be located within an area of high seismic activity. As discussed above, there are no confirmed major faults in the Tri-Cities region capable of producing strong earthquakes. Anticipated ground motions in the region due to seismic activity along faults in other parts of the Northwest are relatively low.

The two largest crustal earthquakes felt in the state of Washington included the 1872, M 6.8 quake near Lake Chelan and the 1936, M 6.0 Walla Walla earthquake. The following list provides information regarding earthquakes within the past 25 years for epicenters within 100 miles of Richland (city center), Washington, listed by magnitude (list courtesy of www.city-data.com):

<table>
<thead>
<tr>
<th>Date of Event</th>
<th>Magnitude</th>
<th>Distance from Richland (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 28, 1991</td>
<td>4.3</td>
<td>50.4</td>
</tr>
<tr>
<td>July 14, 1992</td>
<td>4.1</td>
<td>50.6</td>
</tr>
<tr>
<td>January 30, 2000</td>
<td>4.1</td>
<td>85.2</td>
</tr>
<tr>
<td>October 9, 1998</td>
<td>4.0</td>
<td>68.5</td>
</tr>
<tr>
<td>August 7, 1992</td>
<td>3.9</td>
<td>32.6</td>
</tr>
<tr>
<td>May 18, 2008</td>
<td>3.7</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Secondary Seismic Hazards
Secondary seismic hazards related to ground shaking include soil liquefaction, ground subsidence, tsunamis, and seiches. The site is far inland, so the hazard from tsunamis is non-existent. At the present time, no significant water storage reservoirs or surface water bodies are located at a critical elevation or location within the immediate vicinity of the site. Therefore, hazards from seiches are considered nil as well.

Soil Liquefaction: Liquefaction is the loss of soil strength from sudden shock (usually earthquake shaking), causing the soil to become a fluid mass. In general, for the effects of liquefaction to be
manifested at the surface, groundwater levels must be within 50 feet of the ground surface and the soils within the saturated zone must also be susceptible to liquefaction. The potential for liquefaction to occur at this site is considered low because of the following factors: subsurface soil conditions include dense gravelly/cobbly soils at depth, depth of groundwater beneath the proposed development exceeds 50 feet, and seismic induced accelerations in the region are relatively low.

**Slope Stability**

Native slopes in the project site vicinity descend generally toward the east at gradients ranging from approximately 2% to 33%. Site elevations range from approximately 520 to 485 feet above mean sea level (MSL), for a total relief of about 35 feet from the upper site boundary down to the Amon Creek bed at the eastern boundary of the property.

A field reconnaissance of the project site was performed to observe site conditions and correlate the information gathered from our preliminary research. During our reconnaissance, we looked for common geomorphic features of landslides as well as indications of possible signs demonstrating recent activity and instability of slide masses. No evidence of any significant slope instability within the native conditions was noted at the site.

We have performed slope stability analyses of selected critical slope conditions of the site (see Slope Stability Analysis, below). In our modeling of the slope configurations, we have analyzed possible failure surfaces incorporating strength parameters, geology, and geometry based on our site investigation and research. Based on our analyses, it appears that both the native and proposed graded slopes are considered grossly stable with acceptable factors of safety against movement. The existing native onsite vegetation serves to provide protection from shallow surficial instability and erosional forces.

**Flooding and Erosion**

FEMA flood maps for the site vicinity along with USGS topographic maps were reviewed to evaluate the flooding potential at the site. Areas proposed for development at the project site are not located within flood plains (Flood Zone C). The project site is situated in an area where sheet flow and erosion may occur. See Appendix IX for FEMA Flood Map of the site vicinity.
Erosion susceptibility from water is based on several factors, including the intensity of rainfall and runoff, soil erodibility, length and steepness of slopes, and surface condition. The erodibility factor of the soils is a measure of the soils resistance to erosion based on its physical characteristics. Typically very fine sand, silt and clay soils are generally susceptible to erosion. Based on site specific field exploration, observations, and laboratory testing, the surficial soil exposed at the project site consists primarily of sandy silt (sandy loam).

Soil erodibility is only one of several factors affecting the erosion susceptibility. Soil erosion by water also increases with the length and steepness of the site slopes due to the increased velocity of runoff and resulting greater degree of scour and sediment transport. While isolated portions of the project site currently include limited areas of relatively steep slopes, the average native slope conditions within the mapped “Steep Slopes” area are relatively gentle. Proposed grading for the project will further moderate site slopes. Appropriate erosion and sediment control plan(s) and a drainage plan shall be prepared by the project civil engineer with the final construction drawings.

The need for and design of flood control and erosion protection measures is within the purview of the design civil engineer. In general, erosion should be mitigated with best management practices (BMPs) consisting of proper drainage design including collecting and disposal (conveyance) of water to approved points of discharge in a non-erosive manner. Appropriate project design, construction, and maintenance will be necessary to mitigate the site erosion concerns.

**Slope Stability Analysis**

Slope stability analyses were conducted on selected critical existing slopes to evaluate their present state of stability as well as probable proposed reconfigured slopes for the proposed project. The analyses were conducted using a generalized geologic cross section model developed from the existing site topography and data obtained from our subsurface explorations.

The slope stability analyses were conducted by a two-dimensional limit equilibrium stability analysis of selected trial failure surfaces using the computer program *SLIDE*. Potential circular-arc failure surfaces were evaluated using the Simplified Bishop method. The computer program searched for critical potential failure surfaces with low computed factors of safety.
The computed factor of safety (FS) against slope failure is simply the ratio of total resisting forces or moments (strength of the slope) to the total driving forces or moments for planar or circular failure surfaces respectively. A slope with a factor of safety of 1.0 is in equilibrium, indicating that the disturbing forces driving the slope down are equal to its strength to resist failure. Simply put, slope-failure results when the strength of the slope is overcome by gravity.

The selection of unit weight and shear strength parameters for the various earth materials were based on professional judgment and data obtained during our field investigation, laboratory testing, review of previous studies, research, and previous experience with similar materials in similar geotechnical and geologic settings. Engineering and geologic judgment must be applied to the results of shear tests in order to consider lateral and vertical variations in the subsurface conditions, such as degree of cementation, fracturing, planes of weakness, and gradational characteristics. The following geotechnical strength parameters were used in our stability calculations:

<table>
<thead>
<tr>
<th>Earth Material</th>
<th>Shear Strength Parameters</th>
<th>Unit Weight (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Friction Angle: $\phi$</td>
<td>Cohesion: $c$ (psf)</td>
</tr>
<tr>
<td>Native Loess / Sandy Silt (ML)</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Compacted Engineered Fill</td>
<td>32</td>
<td>15</td>
</tr>
</tbody>
</table>

The results of the stability analyses, using the shear strength data as described above, are presented on the following table. The factor of safety of against slope failure was computed for existing and proposed slope configurations as indicated on the attached table. The results of the slope stability analyses are attached to this report in Appendix V and summarized below:

<table>
<thead>
<tr>
<th>Slope Section</th>
<th>Approximate Maximum Slope Gradient</th>
<th>Slope Condition</th>
<th>Static Factor of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A-A’</td>
<td>32%</td>
<td>Native</td>
<td>1.8</td>
</tr>
<tr>
<td>Section B-B’</td>
<td>15%</td>
<td>Native</td>
<td>3.9</td>
</tr>
<tr>
<td>Re-Graded 2:1 Slope (10’ max height)</td>
<td>50%</td>
<td>Proposed</td>
<td>1.5</td>
</tr>
</tbody>
</table>

GNN Northern recommends that all project slopes should meet, or be designed and constructed to meet, a minimum factor of safety of 1.5 for the static condition. Based on our analysis, the existing native site slopes exceed the minimum recommended factor of safety. Our analysis further indicates that the proposed graded slopes can be properly designed and constructed to meet or exceed this minimum.
CONCLUSIONS

The following is a summary of our conclusions and professional opinions based on the data obtained from a review of selected technical literature and the site evaluation.

General

- Based on our understanding of the proposed development along with knowledge of the existing surface and subsurface conditions, from a geotechnical and geologic perspective, it is our professional opinion that the site is suitable for the proposed development, provided the recommendations in this report and any subsequent geotechnical evaluation(s) are followed in the design and construction of this project.

Geologic Hazard Constraints and Mitigation

- The primary geologic hazards and site constraints include the potential for surface erosion and slope instability. The potential hazards of slope instability and soil erosion are considered low for this site. Engineered design and appropriate remedial grading and construction as recommended within subsequent site-specific geotechnical report(s) will readily mitigate potential geologic hazards at the site.

- The near surface soils are considered susceptible to wind and water erosion. Preventative measures to control runoff and reduce erosion through the application and implementation of appropriate BMPs during all construction phases.

- The risk from other common geologic hazards, including fault rupture, liquefaction, and seismic shaking are considered low or negligible on this site.

- Adherence to the grading recommendations in subsequent geotechnical engineering report(s) should mitigate the potential risk of slope instability concerns.

- In our professional opinion, the proposed multifamily residential development at the site will not pose a threat to the health or safety of the citizens.

- In our professional opinion, the proposed multifamily residential development at the site does not and will not pose a risk of increased hazards to surrounding properties.
RECOMMENDATIONS

Graded Slope Construction

In order to mitigate the potential hazards of erosion and slope instability, site development should be completed with appropriate design and construction including drainage and erosion control measures to mitigate any potential geologic site constraints.

Based on our slope stability analyses, properly reconfigured slopes as high as 10-feet can be safely developed at gradients as steep as 2:1 provided the recommendations in this and any subsequent geotechnical engineering report(s) are followed during design and construction.

Appropriate BMPs to mitigate and control potential erosion on all graded slopes should be incorporated as necessary. Landscaping should take into consideration the engineering characteristics of the slopes, especially with regards to the surficial stability of the slopes.

Fill slopes should be constructed with suitable structural fill soil that has been properly moisture conditioned and compacted. Fill slopes should be overfilled and trimmed back to uniformly compacted material. The final slope surface should be track-walked or grid rolled to improve the slope's resistance to erosion.

Where fill slopes are to be constructed on natural slopes steeper than 5:1, the fill should be keyed and benched into firm natural soil. It is recommended that the project geotechnical engineer, or their representatives, be present during the fill construction to observe compliance with the above recommendations.

Slope Protection and Maintenance

Proper slope protection and maintenance should further minimize any potential slope erosion and improve the stability of the project slopes. Positive drainage should be provided at the tops of all slopes to divert runoff away from the face. Appropriate BMPs and erosion protection measures should be provided where concentrated runoff is anticipated.

As the exposed site soils are slightly susceptible to erosion, erosion control measures, such as planting, erosion control blankets or fabrics, sprayed tackifiers, or some combination of these, should be utilized on slopes within the project site. Landscaping should take into consideration the engineering characteristics of the slopes, especially with regards to the surficial stability.
Periodic maintenance and repair of slopes and drainage structures should be performed. Drainage inlets, outlets, and spillways should be periodically inspected and cleaned of soils and debris. Slope plantings and irrigation systems may wish to consider low water tolerant plants with drip irrigation.

LIMITATIONS AND ADDITIONAL SERVICES

Uniformity of Conditions and Limitations
Our findings and conclusions in this report are based on selected points of field exploration, laboratory testing, and our understanding of the project. Furthermore, our findings and conclusions are based on the assumption that soil conditions do not vary significantly from those found at specific exploratory locations. Variations in soil or groundwater conditions could exist between and beyond the exploration points.

Findings of this report are valid as of the issued date of the report. However, changes in conditions of a property can occur with passage of time, whether they are from natural processes or works of man, on this or adjoining properties. In addition, changes in applicable standards occur, whether they result from legislation or broadening of knowledge. Accordingly, findings of this report may be invalidated wholly or partially by changes outside our control.

In the event that any changes in the nature, design, or location of structures are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing.

This report is issued with the understanding that the owner or the owner’s representative has the responsibility to bring the information contained herein to the attention of the architect and engineers for the project so that they are incorporated into the plans and specifications for the project. The owner or the owner’s representative also has the responsibility to verify that the general contractor and all subcontractors follow such recommendations. It is further understood that the owner or the owner’s representative is responsible for submittal of this report to the appropriate governing agencies.

GN Northern (GNN) has striven to provide our services in accordance with generally accepted geotechnical/geologic practices in this locality at this time. No warranty or guarantee is express or
implied. This report was prepared for the exclusive use of the Client and the Client’s authorized agents.

Although available through GNN, the current scope of our services does not include a geotechnical investigation, an environmental assessment or an investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater, or air on, below, or adjacent to the subject property.

**Additional Services**

This report is based on the assumption that an adequate program of client consultation, construction monitoring, and testing will be performed during the final design and construction phases to check compliance with these recommendations. Maintaining GNN as the geologic/geotechnical consultant from beginning to end of the project will provide continuity of services.
APPENDICES
Appendix I

Figures (Fig. 1 to 4)
Notes:
1. Base map and image underlay provided by Bing Maps.
NOTES:
- Base map titled Conceptual Grading Plan, dated 8/20/14, prepared by Tobiason & Company, Inc.
- Overlay from City of Richland's Geological Sensitive Areas Map, dated August 2013

LEGEND:
- Geologic Hazard Area (Steep Slopes)
- Flood Plain (Includes Wetlands)
- Project boundary

Northern, Inc.
Consulting Engineers  Environmental Scientists  Geologists
Construction Materials Testing  Geophysical Services

Job No. 214-540

COR Geological Sensitive Areas & Plat Overlay Map
Proposed Smith Multifamily Project
Richland, Benton County, Washington

Date 12/29/2014
Drawn By MYM
Reviewed By KAH
Figure 3
NOTES:
- Project boundaries translated from Benton County Parcel Mapping service
- Overlay from City of Richland's Geological Sensitive Areas Map, dated August 2013

LEGEND:
- Geologic Hazard Area (Steep Slopes)
- Flood Plain (Includes Wetlands)
- Project boundary

COR Geological Sensitive Areas & Aerial Overlay Map
Proposed Smith Multifamily Project
Richland, Benton County, Washington

Job No. 214-540

Date: 12/29/2014
Drawn By: MYM
Reviewed By: KAH
Figure: 4
Appendix II

Exploratory Test-Pit Logs

Key Chart (for Soil Classification)
**TEST PIT NUMBER TP-1**

**CLIENT**
Tobaison & Company, Inc.

**PROJECT NAME**
Proposed Smith Multifamily Project

**PROJECT NUMBER**
214-540

**PROJECT LOCATION**
Richland, Benton County, Washington

**DATE STARTED**
12/2/14

**COMPLETED**
12/2/14

**GROUND ELEVATION**
500 ft

**TEST PIT SIZE**
36 x 96 inches

**EXCAVATION CONTRACTOR**
Jenkins Excavating

**EXCAVATION METHOD**
John Deere 410K Backhoe

**LOGGED BY**
MYM

**CHECKED BY**
KAH

**NOTES**
Approx. GPS Coords.: 46°12'42.36"N, 119°15'29.04"W

---

**DEPTH (ft)**

<table>
<thead>
<tr>
<th>SAMPLE TYPE NUMBER</th>
<th>TESTS</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>GB</td>
<td>MC = 7%</td>
<td></td>
<td>SANDY SILT, (ML) tan, dry, loose, trace rootlets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fines = 48%</td>
<td></td>
<td>- approx. 6-inch ash layer</td>
</tr>
<tr>
<td>2.5</td>
<td>ML</td>
<td></td>
<td></td>
<td>- soil becomes loose to medium dense, brown, slightly cemented, some ferrous staining</td>
</tr>
<tr>
<td>5.0</td>
<td>GB</td>
<td>MC = 8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fines = 47%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- No groundwater encountered at time of exploration
- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14
  Bottom of test pit at 6.0 feet.
**TEST PIT NUMBER TP-2**

**CLIENT**  
Tobiason & Company, Inc.

**PROJECT NUMBER**  
214-540

**DATE STARTED**  
12/2/14

**DATE COMPLETED**  
12/2/14

**PROJECT NAME**  
Proposed Smith Multifamily Project

**PROJECT LOCATION**  
Richland, Benton County, Washington

**GROUND ELEVATION**  
505 ft

**GROUND WATER LEVELS:**

- **AT TIME OF EXCAVATION**  
---

- **AT END OF EXCAVATION**  
---

- **AFTER EXCAVATION**  
---

---

**EXCAVATION CONTRACTOR**  
Jenkins Excavating

**EXCAVATION METHOD**  
John Deere 410K Backhoe

**LOGGED BY**  
MYM

**CHECKED BY**  
KAH

**NOTES**  
Approx. GPS Coords.: 46°12'45.02"N, 119°15'28.36"W

---

**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
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<tbody>
<tr>
<td>0.0</td>
<td></td>
<td>0.5</td>
<td></td>
<td>Approx. 2- to 6-inches of topsoil/dry grass</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td>SANDY SILT, (ML) tan, dry, loose</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td></td>
<td></td>
<td>- approx. 6-inch ash layer</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td>- soil becomes loose to medium dense</td>
</tr>
<tr>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
<td>- No groundwater encountered at time of exploration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14</td>
</tr>
</tbody>
</table>

Bottom of test pit at 7.0 feet.
SANDY SILT, (ML) tan, dry, loose

- approx. 6-inch ash layer

- No groundwater encountered at time of exploration

- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14

Bottom of test pit at 9.5 feet.
<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
<th>TESTS</th>
<th>U.S.C.S. LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>GB</td>
<td></td>
<td></td>
<td>SANDY SILT, (ML) tan, dry, loose to medium dense</td>
</tr>
<tr>
<td>2.5</td>
<td>MC = 8%</td>
<td></td>
<td></td>
<td>- approx. 12-inch ash layer</td>
</tr>
<tr>
<td>5.0</td>
<td>ML</td>
<td></td>
<td></td>
<td>- No groundwater encountered at time of exploration</td>
</tr>
<tr>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
<td>- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14</td>
</tr>
</tbody>
</table>

Bottom of test pit at 7.0 feet.
**TEST PIT NUMBER TP-5**

**CLIENT**: Tobiason & Company, Inc.  
**PROJECT NAME**: Proposed Smith Multifamily Project

**PROJECT NUMBER**: 214-540  
**PROJECT LOCATION**: Richland, Benton County, Washington

**DATE STARTED**: 12/2/14  
**COMPLETED**: 12/2/14  
**GROUND ELEVATION**: 495 ft  
**TEST PIT SIZE**: 36 x 96 inches

**EXCAVATION CONTRACTOR**: Jenkins Excavating  
**EXCAVATION METHOD**: John Deere 410K Backhoe

**LOGGED BY**: MYM  
**CHECKED BY**: KAH

**NOTES**: Approx. GPS Coords.: 46°12'51.89"N, 119°15'26.89"W

**GROUND WATER LEVELS**:
- **AT TIME OF EXCAVATION**: ---
- **AT END OF EXCAVATION**: ---
- **AFTER EXCAVATION**: ---

**TEST PIT SIZE**: 36 x 96 inches

**SAMPLE TYPE**: SANDY SILT, (ML) tan, dry, loose

<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLETYPE NUMBER</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td>SANDY SILT, (ML) tan, dry, loose</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td>ML</td>
<td></td>
<td>- soil becomes moist</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- No groundwater encountered at time of exploration  
- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14

Bottom of test pit at 8.5 feet.
<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
<th>TESTS</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Approx. 2- to 6-inches of topsoil/dry grass</td>
</tr>
<tr>
<td>2.5</td>
<td>GB</td>
<td></td>
<td>0.5</td>
<td></td>
<td>SILT WITH SAND, (ML) tan, dry, loose to medium dense</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- No groundwater encountered at time of exploration
- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14

Bottom of test pit at 7.5 feet.
<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
<th>TESTS</th>
<th>U.S.C.S. GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td>SILTY SAND, (SM) brown, fine grained, moist, loose</td>
</tr>
<tr>
<td>2.5</td>
<td>GB</td>
<td></td>
<td></td>
<td>SILT WITH SAND, (ML) olive brown, moist, loose to medium dense</td>
</tr>
<tr>
<td>5.0</td>
<td>GP</td>
<td></td>
<td></td>
<td>POORLY GRADED GRAVEL WITH SAND, (GP) gray black, dry to moist, medium dense to dense, with cobbles, fine to coarse sand, slightly cemented</td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- No groundwater encountered at time of exploration
- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14
Bottom of test pit at 8.5 feet.
<table>
<thead>
<tr>
<th>SAMPLE TYPE NUMBER</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>SILT WITH SAND, (ML) tan, dry, loose</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
</tr>
</tbody>
</table>

- No groundwater encountered at time of exploration
- Referenced elevations are approximate and are based on existing topography depicted on Conceptual Grading Plan dated 8/20/14

Bottom of test pit at 8.0 feet.
### Key Chart

#### Relative Density or Consistency versus SPT N-Value

<table>
<thead>
<tr>
<th>Density</th>
<th>Coarse-Grained Soils</th>
<th>Fine-Grained Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field Test</td>
<td>Consistency</td>
</tr>
<tr>
<td></td>
<td>N (blows/ft)</td>
<td>N (blows/ft)</td>
</tr>
<tr>
<td>Very Loose</td>
<td>0 – 4</td>
<td>Very Soft</td>
</tr>
<tr>
<td>Loose</td>
<td>4 – 10</td>
<td>Soft</td>
</tr>
<tr>
<td>Medium-Dense</td>
<td>10 – 30</td>
<td>Medium-Stiff</td>
</tr>
<tr>
<td>Dense</td>
<td>30 – 50</td>
<td>Stiff</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt; 50</td>
<td>Very Stiff</td>
</tr>
</tbody>
</table>

- **Coarse-Grained Soils**
  - Easily penetrated with ½-inch reinforcing rod pushed by hand

- **Fine-Grained Soils**
  - Easily penetrated with ½-inch reinding rod driven with a 5-lb hammer
  - Difficult to penetrate with ½-inch reinforcing rod pushed by hand

#### USCS Soil Classification

<table>
<thead>
<tr>
<th>Major Divisions</th>
<th>Group Description</th>
<th>Gravel (with little or no fines)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse-Grained Soils</td>
<td></td>
<td>Gravel (with &gt;12% fines)</td>
</tr>
<tr>
<td>&lt;50% passes #200 sieve</td>
<td></td>
<td>gravel (with &gt;12% fines)</td>
</tr>
<tr>
<td>Sand and Sandy Soils</td>
<td></td>
<td>Silty and Clay</td>
</tr>
<tr>
<td>&gt;50% coarse fraction passes #4 sieve</td>
<td></td>
<td>Silt and Clay (low plasticity)</td>
</tr>
<tr>
<td>Fine-Grained Soils</td>
<td></td>
<td>Silt and Clay</td>
</tr>
<tr>
<td>&gt;50% passes #200 sieve</td>
<td></td>
<td>Silt and Clay (med. to high plasticity)</td>
</tr>
<tr>
<td>Highly Organic Soils</td>
<td></td>
<td>Silt and Clay (med. to high plasticity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silt and Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silt and Clay</td>
</tr>
</tbody>
</table>

#### Log Symbols

- **2S** 2" OD Split Spoon (SPT)
- **3S** 3" OD Split Spoon
- **NS** Non-Standard Split Spoon
- **ST** Shelby Tube
- **CR** Core Run
- **BG** Bag Sample
- **TV** Torvane Reading
- **PP** Penetrometer Reading
- **GW** Groundwater Table

#### Conditions

- Modifications based on lab test, analysis, and geological and engineering judgment.
- These conditions may not exist at other times and locations.
- This information was gathered as part of our investigation, and we are not responsible for any use or interpretation of the information by others.
Appendix III

Site & Exploration Photographs
View of proposed site, looking east

View of proposed site, looking north

View of proposed site, looking northeast

View of proposed site, east

Site & Exploration Photos
Proposed Smith Multifamily Project
Richland, Benton County, Washington

Job Number: 214-540

Date: 12/29/2014
Mounted By: MYM
Reviewed By: KAH
Plate: 2
Soil profile inside test-pit TP-1

Soil profile inside test-pit TP-4

Soil profile inside test-pit TP-7

Soil profile inside test-pit TP-8

Site & Exploration Photos
Proposed Smith Multifamily Project
Richland, Benton County, Washington

Job Number: 214-540

Date: 12/29/2014
Mounted By: MYM
Reviewed By: KAH
Plate: 3
Appendix IV

Laboratory Testing Results
GRAIN SIZE DISTRIBUTION

CLIENT   Tobiason & Company, Inc.
PROJECT NUMBER   214-540
PROJECT NAME   Proposed Smith Multifamily Project
PROJECT LOCATION   Richland, Benton County, Washington

U.S. SIEVE NUMBERS  6  10  14  16  20  30  40  50  60  100  140  200
HYDROMETER  0.001 0.01 0.1 1 10

GRAIN SIZE IN MILLIMETERS

COBBLES

<table>
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<tr>
<th>BOREHOLE</th>
<th>DEPTH</th>
<th>Classification</th>
</tr>
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<tbody>
<tr>
<td>TP-1</td>
<td>1.0</td>
<td>SANDY SILT (ML)</td>
</tr>
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</tr>
<tr>
<td>TP-4</td>
<td>1.5</td>
<td>SANDY SILT (ML)</td>
</tr>
<tr>
<td>TP-6</td>
<td>2.0</td>
<td>SILT with SAND (ML)</td>
</tr>
<tr>
<td>TP-7</td>
<td>2.5</td>
<td>SILT with SAND (ML)</td>
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</tbody>
</table>

GRAVEL

<table>
<thead>
<tr>
<th>BOREHOLE</th>
<th>DEPTH</th>
<th>D100</th>
<th>D60</th>
<th>D30</th>
<th>D10</th>
<th>%Gravel</th>
<th>%Sand</th>
<th>%Silt</th>
<th>%Clay</th>
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</thead>
<tbody>
<tr>
<td>TP-1</td>
<td>1.0</td>
<td>19</td>
<td>0.298</td>
<td>0.298</td>
<td>10.9</td>
<td>40.6</td>
<td>48.4</td>
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</tr>
<tr>
<td>TP-1</td>
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<td>19</td>
<td>0.161</td>
<td>0.161</td>
<td>7.5</td>
<td>45.5</td>
<td>47.0</td>
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<tr>
<td>TP-4</td>
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<td>0.0</td>
<td>36.8</td>
<td>63.2</td>
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<tr>
<td>TP-6</td>
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<td>76.9</td>
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</tr>
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<td>TP-7</td>
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<td>4.75</td>
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<td>0.0</td>
<td>0.0</td>
<td>21.5</td>
<td>78.5</td>
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</table>

SAND

<table>
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<tr>
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<th>D100</th>
<th>D60</th>
<th>D30</th>
<th>D10</th>
<th>%Gravel</th>
<th>%Sand</th>
<th>%Silt</th>
<th>%Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-1</td>
<td>1.0</td>
<td>19</td>
<td>0.298</td>
<td>0.298</td>
<td>10.9</td>
<td>40.6</td>
<td>48.4</td>
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<tr>
<td>TP-1</td>
<td>3.0</td>
<td>19</td>
<td>0.161</td>
<td>0.161</td>
<td>7.5</td>
<td>45.5</td>
<td>47.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP-4</td>
<td>1.5</td>
<td>4.75</td>
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<td>0.0</td>
<td>0.0</td>
<td>36.8</td>
<td>63.2</td>
<td></td>
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<tr>
<td>TP-6</td>
<td>2.0</td>
<td>4.75</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>23.1</td>
<td>76.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP-7</td>
<td>2.5</td>
<td>4.75</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>21.5</td>
<td>78.5</td>
<td></td>
<td></td>
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</table>

SILT OR CLAY

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<tr>
<th>BOREHOLE</th>
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<th>%Gravel</th>
<th>%Sand</th>
<th>%Silt</th>
<th>%Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-1</td>
<td>1.0</td>
<td>10.9</td>
<td>40.6</td>
<td>48.4</td>
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</tr>
<tr>
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<td>7.5</td>
<td>45.5</td>
<td>47.0</td>
<td></td>
</tr>
<tr>
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<td>0.0</td>
<td>36.8</td>
<td>63.2</td>
<td></td>
</tr>
<tr>
<td>TP-6</td>
<td>2.0</td>
<td>0.0</td>
<td>23.1</td>
<td>76.9</td>
<td></td>
</tr>
<tr>
<td>TP-7</td>
<td>2.5</td>
<td>0.0</td>
<td>21.5</td>
<td>78.5</td>
<td></td>
</tr>
</tbody>
</table>
Appendix V

Slope Stability Analyses
## Analysis Description

**Project:** Proposed Smith Multifamily Project  
**Analysis Description:**  
**Drawn By:** MYM  
**Scale:** 1:437  
**Company:** GN Northern, Inc.  
**File Name:** Sec B-B.slim

### Material Properties

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Color</th>
<th>Unit Weight (lbs/ft³)</th>
<th>Strength Type</th>
<th>Cohesion (psf)</th>
<th>Phi (deg)</th>
<th>Water Surface</th>
<th>Ru</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native ML</td>
<td>118</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>30</td>
<td>None</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Safety Factor

- 0.000
- 0.250
- 0.500
- 0.750
- 1.000
- 1.250
- 1.500
- 1.750
- 2.000
- 2.250
- 2.500
- 2.750
- 3.000
- 3.250
- 3.500
- 3.750
- 4.000
- 4.250
- 4.500
- 4.750
- 5.000
- 5.250
- 5.500
- 5.750
- 6.000+

### Company Information

- GN Northern, Inc.
- GN Northern, Inc.
<table>
<thead>
<tr>
<th>Material Name</th>
<th>Color</th>
<th>Unit Weight (lbs/ft³)</th>
<th>Strength Type</th>
<th>Cohesion (psf)</th>
<th>Phi (deg)</th>
<th>Water Surface</th>
<th>Ru</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native ML</td>
<td></td>
<td>118</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>30</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Recomp. ML</td>
<td></td>
<td>122</td>
<td>Mohr-Coulomb</td>
<td>15</td>
<td>32</td>
<td>None</td>
<td>0</td>
</tr>
</tbody>
</table>

Analysis Description
Regraded 2H:1V Slope (10-foot high)

Project
Proposed Smith Multifamily Project

Drawn By
MYM

Scale
1:61

Company
GN Northern, Inc.

Date

File Name
Regraded 2to1.slim
Appendix VI

Washington Department of Ecology Well Logs
WATER WELL REPORT

Construction/Decommission ("x" in circle)
☐ Construction
☐ Decommission ORIGINAL INSTALLATION Notice of Intent Number

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal
☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

TYPE OF WORK: Owner's number of well (if more than one)
☐ New well ☐ Reconditioned Method: ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well inches, drilled ft.
Depth of completed well ft.

CONSTRUCTION DETAILS
Casing: ☐ Welded 6 in. Diam. from ft. to ft.
Installed: □ Liner installed Diam. from ft. to ft.
□ Threaded Diam. from ft. to ft.

Perforations: ☐ Yes ☐ No
Type of perforator used

SIZE OF perfor. in. by in. and no. of perfor. from ft. to ft.

Screens: ☐ Yes ☐ No Dr - Fac Location 23

Manufacturer's Name

Type

Well No. 1031 Slot size 2.4 in. from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel/Filter packed: ☐ Yes ☐ No Size of gravel/sand
Materials placed from ft. to ft.

Surface Seal: ☐ Yes ☐ No To what depth? ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? Depth of strata
Method of sealing strata off

PUMP: Manufacturer's Name H.P.

WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield gal./min. with ft. drawdown after hrs.
Yield gal./min. with ft. drawdown after hrs.
Yield gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)
Time Water Level Time Water Level Time Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water °F. Was a chemical analysis made? ☐ Yes ☐ No

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Driller ☐ Engineer ☐ Trainee Name (Print)
Driller/Engineer/Trainee Signature
Driller or trainee License No. 1224

IF TRAINEE, Driller's Licensed No. 1224
Driller's Signature

CURRENT
Notice of Intent No. WE 18201
Unique Ecology Well ID Tag No. BIF 407
Water Right Permit No.
Property Owner Name David Bowers
Well Street Address 415 Lar Khaven
City Richland County Benton
Location Sw 1/4 1/4 Sec 36 Twn 9N R 28W N 29圈 W 1/2
Lat/Long (s, t, r) Lat Deg Long Min/Sec
Still REQUIRED Long Deg Long Min/Sec

Tax Parcel No. 136983020002002

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL
Topsoil Silty Sand gravel + Sand
FROM 0 3 20
TO 30

Start Date 5-17-2014 Completed Date 5-21-2014

The Department of Ecology does NOT warranty the data and/or information on this Well Report.
WATER WELL REPORT
STATE OF WASHINGTON

(1) OWNER: The Quadrant Corporation
Address: P.O. Box 130; Bellevue, WA 98009

(4) LOCATION OF WELL: Benton County
SE ¼ SW ¼ Sec. 36 T. 9 N., R. 28E, W.M.

(3) PROPOSED USE: Domestic [] Industrial [] Municipal [XX]
Irrigation [] Test Well [] Other []

(5) DIMENSIONS: Diameter of well 14" x 12" ft.
Drilled...1208...ft. Depth of completed well...1208...ft.

(6) CONSTRUCTION DETAILS:
Casing installed:...
Threaded...14"...Diam. from...0...ft. to...90...ft.
Welded...14"...Diam. from...0...ft. to...940...ft.

Perforations: Yes [XX] No [XX]
Type of perforator used...
Size of perforations...in. by...
perforations from...ft. to...

Screens: Yes [XX] No [XX]
Manufacturer's Name...
Type...
Model No...
Diam...
Slot size...

Gravel packed:...
Gravel placed from...

Surface seal: Yes [XX] No [XX]
To what depth...
Material used in seal...
Neat Cement...

Screen and Gravel pack...

(7) PUMP: Manufacturer's Name: None
Type: H.P.

(8) WATER LEVELS:
Static level...88...ft. below top of well
Artesian pressure...
Artesian water is controlled by...

(9) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [XX] No [XX]
Yield...

Recovery rate (time taken as...sec. when pump turned off)...

Date of test...

Bailer test...

Artesian flow...

Temperature of water...

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME: Layne - Western Company, Inc.
Address: P.O. Box 336; Moses Lake, WA 98837

(USE ADDITIONAL SHEETS IF NECESSARY)
WATER WELL REPORT
STATE OF WASHINGTON

(1) OWNER: Name The Quadrant Corporation -- Address P.O. Box 130, Bellevue, WA 98002 --

(1) LOCATION OF WELL: County Benton -- Section 36, T 9 N R 28 E W M

(3) PROPOSED USE: Domestic [] Industrial [] Municipal [] Irrigation [] Test Well [] Other []

(4) TYPE OF WORK: Owner's number of well 111-New well [] Method Dug [] Bored []

(5) DIMENSIONS: Diameter of well 8 inches. Drilled - ft Depth of completed well -- ft.

(6) CONSTRUCTION DETAILS:

- Casing installed: " Diameter from ft to ft.
- Threaded [] Diameter from ft to ft.
- Welded [] Diameter from ft to ft.

- Perforations: Yes [ ] No [ ]
- Type of perforator used:
- SIZE OF perforations: in. by in. per ft.
- perforations from ft to ft.
- perforations from ft to ft.
- perforations from ft to ft.
- perforations from ft to ft.

Screen: Yes [ ] No [ ]

- Manufacturers Name
- Type
- Diameter Slot size from ft to ft.
- Diameter Slot size from ft to ft.

Gravel packed: Yes [ ] No [ ]

- Gravel packed from ft to ft.

Surface seal: Yes [ ] No [ ]

- Material used in seal
- Did any strata contain unusable water? Yes [ ] No [ ]
- Type of water
- Depth of strata
- Method of sealing strata off

(7) PUMP: Manufacturer's Name

- Type
- M.P.

(8) WATER LEVELS:

- Land-surface elevation above mean sea level ft.
- Static level ft. below top of well Date
- Artesian pressure Date per square inch Date
- Artesian water is controlled by

- (Cap, valve, etc.)

(9) WELL TESTS:

- Drawdown is amount water level is lowered below static level

- Was a pump test made? Yes [ ] No [ ] If yes by whom

- Yield gal/min with ft. drawdown after hrs.

- Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

- Date of test
- Bailer test: gal/min with ft. drawdown after hrs.
- Artesian flow: gpm Date
- Temperature of water

- Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG:

- Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>FROM</th>
<th>TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black medium basalt</td>
<td>728</td>
<td>732</td>
</tr>
<tr>
<td>Gray hard basalt</td>
<td>732</td>
<td>748</td>
</tr>
<tr>
<td>Fine gravel, siltstone, hard</td>
<td>748</td>
<td>770</td>
</tr>
<tr>
<td>Clay, gray basalt, black chips</td>
<td>770</td>
<td>783</td>
</tr>
<tr>
<td>Green clay</td>
<td>783</td>
<td>807</td>
</tr>
<tr>
<td>Black basalt, medium soft basalt</td>
<td>807</td>
<td>821</td>
</tr>
<tr>
<td>Gray clay, clay mixed with mud</td>
<td>821</td>
<td>833</td>
</tr>
<tr>
<td>Black fine grained, medium hard siltstone</td>
<td>833</td>
<td>854</td>
</tr>
<tr>
<td>Gray clay streaked with soft beds of basalt</td>
<td>854</td>
<td>924</td>
</tr>
<tr>
<td>Clay, sand</td>
<td>924</td>
<td>934</td>
</tr>
<tr>
<td>Basalt, highly vesicular</td>
<td>934</td>
<td>961</td>
</tr>
<tr>
<td>Fractured, water bearing</td>
<td>961</td>
<td>986</td>
</tr>
<tr>
<td>Black &amp; gray basalt, water bearing</td>
<td>986</td>
<td>1075</td>
</tr>
<tr>
<td>Black basalt</td>
<td>1075</td>
<td>1125</td>
</tr>
<tr>
<td>Siltstone</td>
<td>1125</td>
<td>1128</td>
</tr>
<tr>
<td>Gray basal, water bearing</td>
<td>1128</td>
<td>1195</td>
</tr>
<tr>
<td>Green siltstone, water bearing</td>
<td>1195</td>
<td>1208</td>
</tr>
</tbody>
</table>

Work started 10-10-79 Completed 1--18 10-79

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief

NAME Layne Western Company, Inc. (Person, firm, or corporation) (Type or print)

Address P.O. Box 336; Moses Lake, Wa 98837

License No 0733. Date Feb 20, 1980

(Signed) [Signature]

The Dep. The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.
Appendix VII
NRCS Soil Survey
Custom Soil Resource Report for
Benton County Area, Washington
Smith Multifamily Project

December 29, 2014
Map Unit Legend

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FfE</td>
<td>Finley stony fine sandy loam, 0 to 30 percent slopes</td>
<td>1.3</td>
<td>8.0%</td>
</tr>
<tr>
<td>HeD</td>
<td>Hezel loamy fine sand, 2 to 15 percent slopes</td>
<td>3.1</td>
<td>19.7%</td>
</tr>
<tr>
<td>HeE</td>
<td>Hezel loamy fine sand, 0 to 30 percent slopes</td>
<td>0.3</td>
<td>2.1%</td>
</tr>
<tr>
<td>QuD</td>
<td>Quincy loamy sand, 2 to 15 percent slopes</td>
<td>2.8</td>
<td>18.0%</td>
</tr>
<tr>
<td>WdC</td>
<td>Warden silt loam, 5 to 8 percent slopes</td>
<td>0.0</td>
<td>0.1%</td>
</tr>
<tr>
<td>WfD2</td>
<td>Warden very fine sandy loam, 8 to 15 percent slopes, eroded</td>
<td>8.1</td>
<td>52.0%</td>
</tr>
<tr>
<td><strong>Totals for Area of Interest</strong></td>
<td></td>
<td><strong>15.6</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially
where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.
Benton County Area, Washington

**FfE—Finley stony fine sandy loam, 0 to 30 percent slopes**

**Map Unit Setting**
- **National map unit symbol:** 2bc
- **Elevation:** 300 to 1,500 feet
- **Mean annual precipitation:** 6 to 9 inches
- **Mean annual air temperature:** 48 to 50 degrees F
- **Frost-free period:** 135 to 180 days
- **Farmland classification:** Not prime farmland

**Map Unit Composition**
- **Finley and similar soils:** 90 percent
- **Estimates are based on observations, descriptions, and transects of the map unit.**

**Description of Finley**

**Setting**
- **Landform:** Terraces, flood plains
- **Parent material:** Alluvium

**Typical profile**
- **H1 - 0 to 3 inches:** stony fine sandy loam
- **H2 - 3 to 13 inches:** fine sandy loam
- **H3 - 13 to 28 inches:** very gravelly loam
- **H4 - 28 to 60 inches:** extremely cobbly loamy sand

**Properties and qualities**
- **Slope:** 0 to 30 percent
- **Depth to restrictive feature:** More than 80 inches
- **Natural drainage class:** Well drained
- **Capacity of the most limiting layer to transmit water (Ksat):** High (1.98 to 5.95 in/hr)
- **Depth to water table:** More than 80 inches
- **Frequency of flooding:** None
- **Frequency of ponding:** None
- **Calcium carbonate, maximum in profile:** 20 percent
- **Salinity, maximum in profile:** Nonsaline (0.0 to 2.0 mmhos/cm)
- **Available water storage in profile:** Low (about 4.2 inches)

**Interpretive groups**
- **Land capability classification (irrigated):** 6e
- **Land capability classification (nonirrigated):** 7s
- **Hydrologic Soil Group:** A
- **Ecological site:** Sandy 6-10 pz (R007XY501WA)

**HeD—Hezel loamy fine sand, 2 to 15 percent slopes**

**Map Unit Setting**
- **National map unit symbol:** 2bc
- **Elevation:** 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Hezel and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hezel

Setting
Landform: Terraces
Parent material: Eolian sands over silty lacustrine deposits

Typical profile
H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 16 inches: loamy fine sand
H3 - 16 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities
Slope: 2 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 20 percent
Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 9.1 inches)

Interpretive groups
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C

HeE—Hezel loamy fine sand, 0 to 30 percent slopes

Map Unit Setting
National map unit symbol: 2bcj
Elevation: 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition
Hezel and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.
Description of Hezel

Setting

*Landform:* Terraces  
*Parent material:* Eolian sands over silty lacustrine deposits

Typical profile

*H1 - 0 to 3 inches:* loamy fine sand  
*H2 - 3 to 16 inches:* loamy fine sand  
*H3 - 16 to 60 inches:* stratified fine sandy loam to silt loam

Properties and qualities

*Slope:* 0 to 30 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Somewhat excessively drained  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 20 percent  
*Salinity, maximum in profile:* Nonsaline (0.0 to 2.0 mmhos/cm)  
*Available water storage in profile:* High (about 9.1 inches)

Interpretive groups

*Land capability classification (irrigated):* 6e  
*Land capability classification (nonirrigated):* 7s  
*Hydrologic Soil Group:* C  
*Ecological site:* Sands 6-10 pz (R007XY502WA)

QuD—Quincy loamy sand, 2 to 15 percent slopes

Map Unit Setting

*National map unit symbol:* 2bd4  
*Elevation:* 200 to 4,500 feet  
*Mean annual precipitation:* 6 to 12 inches  
*Mean annual air temperature:* 46 to 54 degrees F  
*Frost-free period:* 100 to 200 days  
*Farmland classification:* Farmland of statewide importance

Map Unit Composition

*Quincy and similar soils:* 100 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

Description of Quincy

Setting

*Landform:* Terraces  
*Parent material:* Eolian sands

Typical profile

*H1 - 0 to 9 inches:* loamy sand
H2 - 9 to 60 inches: loamy fine sand

**Properties and qualities**

- **Slope:** 2 to 15 percent
- **Depth to restrictive feature:** More than 80 inches
- **Natural drainage class:** Excessively drained
- **Capacity of the most limiting layer to transmit water (Ksat):** High to very high (5.95 to 19.98 in/hr)
- **Depth to water table:** More than 80 inches
- **Frequency of flooding:** None
- **Frequency of ponding:** None
- **Calcium carbonate, maximum in profile:** 3 percent
- **Salinity, maximum in profile:** Nonsaline (0.0 to 2.0 mmhos/cm)
- **Available water storage in profile:** Moderate (about 6.1 inches)

**Interpretive groups**

- **Land capability classification (irrigated):** 4e
- **Land capability classification (nonirrigated):** 3e
- **Hydrologic Soil Group:** A

---

**WdC—Warden silt loam, 5 to 8 percent slopes**

**Map Unit Setting**

- **National map unit symbol:** 2bfm
- **Elevation:** 600 to 1,300 feet
- **Mean annual precipitation:** 6 to 9 inches
- **Mean annual air temperature:** 48 to 52 degrees F
- **Frost-free period:** 135 to 200 days
- **Farmland classification:** Farmland of statewide importance

**Map Unit Composition**

- **Warden and similar soils:** 100 percent
- **Estimates are based on observations, descriptions, and transects of the mapunit.**

**Description of Warden**

**Setting**

- **Landform:** Terraces
- **Parent material:** Loess over lacustrine deposits

**Typical profile**

- **H1 - 0 to 9 inches:** silt loam
- **H2 - 9 to 19 inches:** silt loam
- **H3 - 19 to 60 inches:** stratified very fine sandy loam to silt loam

**Properties and qualities**

- **Slope:** 5 to 8 percent
- **Depth to restrictive feature:** More than 80 inches
- **Natural drainage class:** Well drained
- **Capacity of the most limiting layer to transmit water (Ksat):** Moderately high to high (0.57 to 1.98 in/hr)
- **Depth to water table:** More than 80 inches
- **Frequency of flooding:** None

---
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.8 inches)

Interpretive groups
Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B

WfD2—Warden very fine sandy loam, 8 to 15 percent slopes, eroded

Map Unit Setting
National map unit symbol: 2bfv
Elevation: 600 to 1,300 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 200 days
Farmland classification: Farmland of unique importance

Map Unit Composition
Warden and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Warden
Setting
Landform: Terraces
Parent material: Loess over lacustrine deposits

Typical profile
H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 14 inches: silt loam
H3 - 14 to 60 inches: stratified very fine sandy loam to silt loam

Properties and qualities
Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.5 inches)

Interpretive groups
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B