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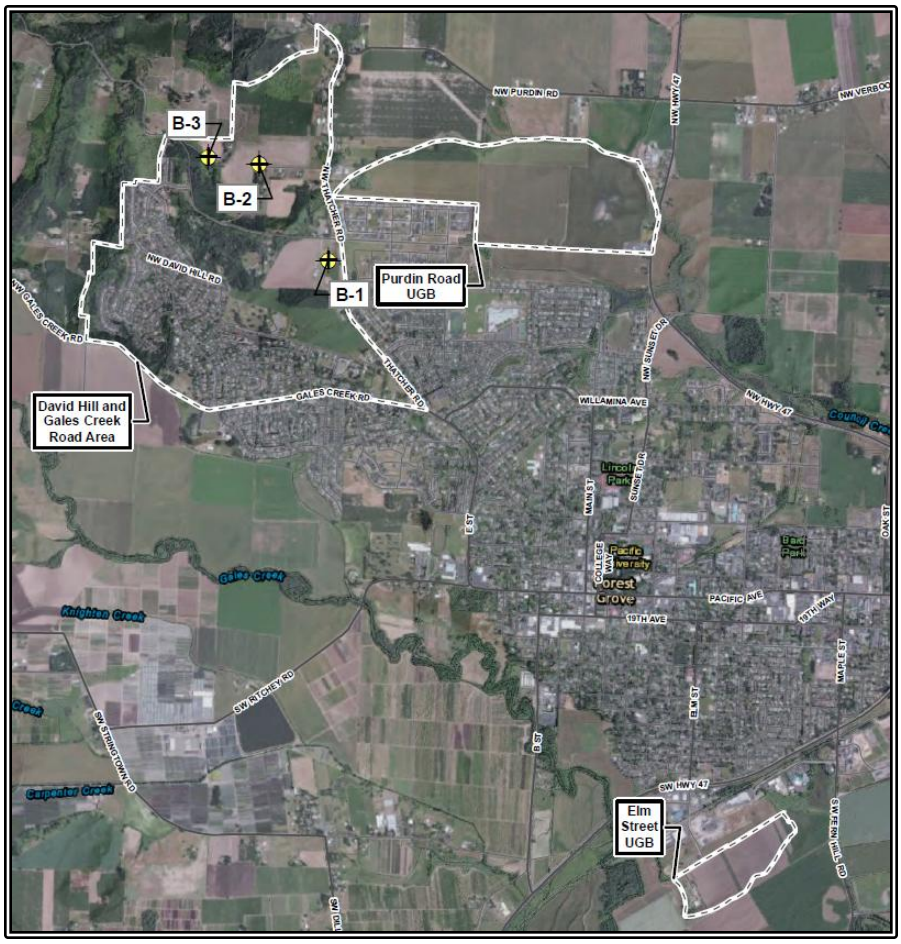
Geological and Geotechnical Assessment Report
Westside Planning Project

David Hill & Gales Creek Road, Purdin Road UGB, and Elm Street UGB
Forest Grove, Oregon



Prepared for:

SCJ Alliance
Vancouver, Washington

February 2015
Project No. 73121.000

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February 2, 2015

SCJ Alliance
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Re: Geological and Geotechnical Assessment Report
David Hill & Gales Creek Road, Purdin Road UGB, and Elm Street UGB
City of Forest Grove – Westside Planning Project, Forest Grove, Oregon
PBS Project No. 73121.000

INTRODUCTION AND BACKGROUND

This report presents the results of the PBS Engineering and Environmental Inc. (PBS) geological and geotechnical assessment for the David Hill & Gales Creek Road, Purdin Road UGB, and Elm Street UGB in Forest Grove, Oregon (site). The following paragraphs outline the Westside Planning Project for the City of Forest Grove (City).

The City is experiencing a significant increase in development activity, which is rapidly depleting the supply of approved single-family residential parcels. The Westside Planning Project is intended to address and resolve the land use and infrastructure issues in the David Hill and Gales Creek Road (DH&GCR), Purdin Road, and Elm Street planning areas (Figure 1, Vicinity Map; Figure 2, Study Area Map; and Figure 3, David Hill Urban Reserve Concept Plan). Specific issues and objectives for these areas are as follows.

David Hill and Gales Creek Road Area – The City's recent Transportation System Plan (TSP) update, noted that a street network in this area could not be identified due to unresolved land use and natural resource issues. The David Hill area plan will include a land-use element, a sustainability framework, geotechnical analysis, including the recommendations for revising development standards in steeply sloped areas (provided in this report), a conceptual transportation network that documents TPR compliance, an infrastructure concept that can be broadly costed, and a general financing approach. It should be noted that the primary focus of this planning area is on David Hill in the area north of Watercrest Road. The Gales Creek area is included primarily to address issues realted to contect and connectivity.

Purdin Road Urban Growth Boundary (UGB) – Purdin Road has recently been added to the City's UGB. The TSP update identified future street extensions that could ultimately serve the Purdin Road area. Comprehensive planning for this area will help to assure that it develops in a way that is coordinated with existing and planned street, water, sewer, and stormwater infrastructure.

Elm Street UGB – The City is interested in maximizing the development potential and is promoting sustainable development practices. It will be critical for the refinement plan to support development that is coordinated with existing and planned street, water, sewer, and stormwater infrastructure, and to accommodate future property annexation efforts. It will also be important to acknowledge the context of

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the property, which is largely industrial, with its southern boundary located along the current Tualatin River 100-year floodplain mapped by Federal Emergency Management Agency (FEMA).

The primary project goals for the geotechnical-related aspects of the Westside Planning Project are to evaluate slope stability, soil constraints, and seismic issues potentially affecting development and to prepare guidance for the City's use in updating development code provisions. This work also includes preparing Geographic Information System (GIS) mapping for the project study areas to illustrate development constraints and planning recommendations.

As part of this multi-discipline effort, PBS has documented several geotechnical-related conditions for the Westside Planning Project that may constrain and influence future land and infrastructure development. To the extent possible, PBS has obtained readily available and applicable information of the DH&GCR, Purdin Road UGB, and Elm Street UGB study areas. These data have included aerial photographs and light detection and ranging (LiDAR) imagery, geologic and geohazard maps, and soil surveys.

In addition to the desktop studies, PBS completed three geotechnical borings in the DH&GCR study area to provide more specific information in regards to potential slope stability issues, depth to groundwater, and characterize soil erosion potential.

The information obtained from the geotechnical work is included in this report and has been used to provide conceptual recommendations for slope setbacks related to slope heights and inclinations. The information has been compiled in the attached figures and in a geographic information system (GIS [ArcGIS 9.3™]) data file for use by the project team and the City.

Several data sources were used to provide information for this report. These sources are provided at the end of this report.

GOAL 5: NATURAL RESOURCES, SCENIC AND HISTORIC AREAS, AND OPEN SPACES

The State of Oregon has established guidelines under Oregon Administrative Rule (OAR) 660-015-0000(5), named GOAL 5, to protect natural resources and conserve scenic and historic areas and open spaces. Based on the guidelines, local governments need to adopt programs that will protect these features to promote a healthy environment and natural landscape that contributes to Oregon's livability. The resources that shall be included:

- Riparian Corridors
- Wetlands
- State Scenic Waterways
- Federal Wild and Scenic Rivers
- Groundwater Resources
- Natural Areas
- Wilderness Areas
- Mineral/Aggregate Resources
- Cultural areas
- Energy Sources
- Approved Oregon Recreation Trails

In addition, local governments and state agencies are encouraged to maintain current inventories for:

- Historic Resources
- Open Spaces
- Scenic Views and Sites

PBS has included the information in the GIS as a Goal 5 layer and a compilation of the features is presented on Figure 4, Oregon Goal 5 Resources. Of these resources, PBS has identified wetland and recreation areas in the DH&GCR study area using the METRO RLIS data bank. A wetland is also

shown along the edge of the Purdin Road UGB study area. Only those resources identified within the project boundary are shown.

GOAL 7: AREAS SUBJECT TO NATURAL HAZARDS

The State of Oregon has established guidelines under Oregon Administrative Rule (OAR) 660-015-0000(7), named GOAL 7, to protect people and property from natural hazards by adopting comprehensive plans (inventories, policies and implementing measures). Natural hazards for purposes of this goal are:

- Floods (coastal and riverine)
- Landslides[a]
- Earthquakes and related hazards
- Coastal erosion
- Tsunamis
- Wildfires

[a] For "rapidly moving landslides," the requirements of ORS 195.250-195.275 (1999 edition) apply.

As part of this GOAL 7, the City should consider: a) the benefits of maintaining natural hazard areas as open space, recreation and other low density uses; b) the beneficial effects that natural hazards can have on natural resources and the environment; and c) the effects of development and mitigation measures in identified hazard areas on the management of natural resources. The City should also coordinate their land use plans and decisions with emergency preparedness, response, recovery and mitigation programs.

For development purposes under GOAL 7:

1. The City should give special attention to emergency access when considering development in identified hazard areas.
2. The City should consider programs to manage stormwater runoff as a means to help address flood and landslide hazards.
3. The City should consider non-regulatory approaches to help implement this goal, including but not limited to:
    a. providing financial incentives and disincentives;
    b. providing public information and education materials;
    c. establishing or making use of existing programs to retrofit, relocate, or acquire existing dwellings and structures at risk from natural disasters.
4. When reviewing development requests in high hazard areas, local governments should require site-specific reports, appropriate for the level and type of hazard (e.g., hydrologic reports, geotechnical reports or other scientific or engineering reports) prepared by a licensed professional. Such reports should evaluate the risk to the site as well as the risk the proposed development may pose to other properties.
5. The City should consider measures that exceed the National Flood Insurance Program (NFIP) such as:
    a. limiting placement of fill in floodplains;
    b. prohibiting the storage of hazardous materials in floodplains or providing for safe storage of such materials; and
    c. elevating structures to a level higher than that required by the NFIP and the state building code.
6. Flood insurance policy holders may be eligible for reduced insurance rates through the NFIP's Community Rating System Program when local governments adopt these and other flood protection measures.

In order to conform to these guidelines, new hazard inventory information provided by federal and state agencies will be reviewed by the Department of Land Conservation and Development (Department) in consultation with affected state and local government representatives. After consultation, the Department will notify local governments if the new hazard information requires a local response. Local governments will then respond to new inventory information on natural hazards within 36 months after being notified by the Department, unless extended by the Department.

To the extent possible, this study documents the applicable natural hazards listed above using the most recent information at the time the analyses were performed. Hazards such as coastal flooding, tsunamis, and coastal erosion will not impact the study areas and, therefore, were excluded.

GEOLOGIC SETTING

The three project areas included in this study lie within two geologic provinces in Oregon. The DH&GCR study area is located on the northeastern flank of the Oregon Coast Range geomorphic province while the Purdin Road UGB and Elm Street UGB study areas are within the Tualatin Basin portion of the Willamette Lowland geomorphic province.

The Oregon Coast Range generally consists of a long, narrow belt of moderately high mountains and coastal headlands. The province extends from approximately the Columbia River to the north to the Coquille River (near Bandon) to the south – a distance of approximately 200 miles. Width of the province varies from approximately 30 to 60 miles and extends from the western edge of the Willamette Valley to the offshore continental shelf and slope.

Formation of the province began in the early Eocene age when a volcanic island chain was accreted to the North American plate. These volcanic rocks form the basement complex of the province. It is estimated the volcanic rocks are up to two miles thick (Orr and others 1992). The convergence of large tectonic plates resulted in the formation of a forearc basin that began filling with Eocene to Miocene marine sediments. Intrusive rocks derived from magma chamber(s) below the forearc were emplaced in the marine sediments. Exposed by uplift and erosion, these intrusive rocks form the major peaks of the Oregon Coast Range that exist today. Uplift of the range was nearly complete by the late Oligocene and early Miocene (Orr and others, 1992). Erosion by rainfall, mass wasting processes (e.g., landslides), and major rivers cutting their drainage courses through the range to the Pacific Ocean, modified the geomorphology of the range created the topographic features characteristic of the current range.

Locally, the DH&GCR study area is mapped as lower Miocene to Eocene Marine sedimentary rocks (Tm) on the south side of NW David Hill Road and Miocene Columbia River Basalt Group (Tcr) on the north side (Gannett and Caldwell, 1998) (Figure 5, Geologic Map). The Tm Unit generally consists of sandstone, siltstone, shale, and claystone with lesser conglomerate that can be locally tuffaceous. The Tcr Unit consists of layered flows of dark gray to black basalt that includes tuffaceous sedimentary beds, and is typically deeply weathered near the surface. In addition to the mapped bedrock units by the U.S. Geological Survey (USGS), the Natural Resources Conservation Service (NRCS) soil survey indicates that some of the soils are derived from loess parent materials. Based on the PBS borings, we interpret the loess deposits are overlying the residual bedrock soil.

Four separate basins are generally recognized in the Willamette Lowland; 1) the southern Willamette Valley; 2) the central Willamette Valley; 3) the Tualatin Basin; and 4) the Portland Basin (Gannett and Caldwell, 1998). Narrow ridges underlain by the Columbia River Basalt Group separate the basins.

Basins and tributary valleys, such as those in the Forest Grove area from the Tualatin River, are generally filled with over 1,600 feet of unconsolidated alluvial deposits derived from surrounding highland areas and the Columbia River Basin (Gannett and Caldwell, 1998; O'Connor and others, 2001). The Missoula Floods from approximately 12,000 to 15,000 years ago, caused widespread inundation of the valley with up to 250 feet of silt, sand, and gravel being deposited in the eastern adjacent Portland Basin, and up to 130 feet of silt, known as the Willamette Silt, were deposited elsewhere in the valley (Woodward and others, 1998).

Locally, the Elm Street UGB is mapped as Holocene Alluvial deposits (Qal) and the Purdin UGB study area as Pleistocene Alluvium and glacial-outburst flood sediment (Qs) (refer, Figure 5). The Qal unit consists of sand, gravel, and silt deposits along channels and flood plains of present-day drainage systems. The Qs Unit consists of silt, sand, and gravel deposited primarily during late Pleistocene glacial-outburst floods.

No faults are mapped as underlying the study areas. The northwest striking Gales Creek fault zone is mapped approximately 1 ½ miles south of the project areas. The fault zone has no unequivocal evidence of deformation of Quaternary deposits, but a thick sequence of silty sediment deposited by the Missoula floods covers much of the southern part of the fault trace. The fault zone is considered capable of generating a Mw 6.8 (moment magnitude) earthquake. Other examples of significant faults capable of strong ground shaking include the Cascadia Subduction Zone (Mw 9.3) and the Portland Hills fault (Mw 6.8).

GEOLOGIC AND SEISMIC HAZARDS

Geologic and seismic hazards are defined as those conditions associated with the geologic and seismic environment that could influence existing and/or proposed improvements. In general, the geologic and seismic hazards most commonly associated with the physical and chemical characteristics of near surface soil, rock, and groundwater include:

- **Slope stability**
- **Adverse soils**
- Land subsidence
- Subsurface voids
- **Hydrology and drainage**
- Hazardous Minerals and gases
- **Erosion and sedimentation**
- **Hydrogeology and groundwater**
- Volcanic hazards
- Permafrost and freeze-thaw
- Seismic hazards (**liquefaction, lateral spreading, earthquake-induced landslides,** fault ground rupture)

Those shown in **bold** above are possible hazards that could impact the study areas' development and should be considered in the planning process. Specific discussions of readily recognized hazards are presented for the individual study areas below and in the conclusions and recommendations section. The "Level of Concern" in Tables 2 through 4 is a qualitative assessment based on our engineering judgment. Where noted with footnotes in the tables, the terminology is taken from a specific source (i.e. HazVu). Figures 6 through 9 present the published geologic, flood, and seismic hazards for the areas.

DH&GCR

This study area has residential developments in its southern portion and has the greatest relief within the UGB of the three study areas. We understand that part of the impetus for this geotechnical-related planning assessment is due to unanticipated hazards encountered during the earlier residential developments that primarily included slope failures. The primary geologic and seismic hazards to

consider in planning are the slopes and associated stability (static and earthquake-induced), adverse soil conditions, hydrology and drainage, and erosion and sedimentation.

Slopes and Slope Instabilities

This study area has high relief, particularly the slopes descending toward NW David Hill Road. Table 1 presents the generalized slopes in the study area taken from profiles created through Google Earth. These profiles were compared to the slope values generated using the LiDAR data in the GIS. Figure 10 – DH&GCR Generalized Slope Areas shows these locations.

Table 1: Generalized Slopes in the DH&GCR Study Area

Location	Location No. on Figure 10	Approximate Slope Trend	Slope Ratio	Slope Percent	Slope Instabilities (Y/N)[a]
Forest Gale Drive to NW Antler Road on south side of NW David Hill Road	1	North	Max: 1.5H:1V General: 3H:1V to 6H:1V	Max: 67 General: 33.5 to 17	Y
NW Antler Road to Thatcher Road on south side of NW David Hill Road	2	North	Max: 6H:1V General: 6H:1V to 20H:1V	Max: 17 General: 17 to 5	N
Unnamed Road at top of NW David Hill Road to Thatcher Road on north side of NW David Hill Road	3	East	Max: 4H:1V General: 6H:1V to 8H:1V	Max: 25 General: 17 to 12	N
North portion of the study area to Thatcher Road	4	East	Max: 4H:1V General: 6H:1V to 20H:1V	Max: 25 General: 17 to 5	N
Wismer Property to NW David Hill Road	5	South	Max: 2H:1V General: 6H:1V to 10H:1V	Max: 50 General: 17 to 10	Y
NW Plum Hill Lane to NW David Hill Road	6	South	Max: 2.5H:1V General: 4H:1V to 8H:1V	Max: 40 General: 25 to 12	Y
Previously Developed Area[b]	7	Southwest and South			Y

[a] Mapped by DOGAMI or readily observable in LiDAR imagery
[b] Two slope failures were noted prior to or during construction of the earlier David Hill Estates, Phase 1 development

In general, the study area should be considered prone to slope instabilities, and landslides have historically occurred within both of the two mapped geologic units Tms and Tcr. In particular, the location between Forest Drive and NW Antler Road is mapped by DOGAMI as a landslide complex that is further supported by surface expressions in the LiDAR imagery (Figure 6, Landslide Inventory). No other landslides are mapped by DOGAMI within the study area though several are immediately adjacent on the north and west sides of the boundary line.

Other areas to consider include apparent shallow debris flow-type failures in the portions identified in the table above as the Wismer Property to NW David Hill Road and NW Plum Hill Lane to NW David Hill Road. These areas should be field verified prior to development. Slopes adjacent to and within steep drainages also show indications of ancient or historical instabilities throughout.

Additional discussion of LiDAR and its interpretation is provided in the LiDAR Section below.

Earthquake-induced landslide hazard maps are not available for the Forest Grove area. However, landslides generated under dynamic conditions are a potential hazard during a significant earthquake.

Other Potential Hazards

In addition to the primary slope stability hazard, adverse soil conditions, hydrology and drainage, erosion and sedimentation, and seismic hazards (Figure 7, Earthquake Liquefaction and Figure 8, Earthquake Ground Shaking) should also be considered in this study area. Additional information and soil parameters about adverse soil conditions, hydrology and drainage, and hydrogeology and groundwater information are provided in Tables 5 through 7 in the following NRCS Soil Description Section. The study area is not mapped within the FEMA 100-year flood zone (Figure 9, FEMA 100-Year Flood Hazard). Table 2 below summarizes these other potential hazards

Table 2: Summary of Other Potential Geologic and Seismic Hazards in the DH&GCR Study Area

Geologic and Seismic Hazard	Possible Examples	Level of Concern
Adverse Soils	Artificial Fill	Low
	Expansive Soil	Low to Moderate
	Compressible Soil	Low
	Organic-Rich Soil	Moderate
	Sensitive Clay	Low
Hydrology and Drainage	Flooding[a]	None[b]
	Standing Water	Low
Hydrogeology and Groundwater	Shallow Groundwater	Low to Moderate
	Seepage and Piping	Moderate
	Permeability and Percolation	High
Erosion and Sedimentation		Low to Moderate
Seismic Hazards	Liquefaction and Lateral Spread[c]	None[d]
	Seismically-Induced Settlement	Low
	Earthquake Shaking[c]	Strong

[a] FEMA 100-year flood zone from METRO RLIS. Zone effective date September 30, 1982.

[b] Not mapped within the DH&GCR study area

[c] Information and nomenclature from the Department of Geology and Mineral Industries (DOGMAI), Oregon HazVu: Statewide Geohazards Viewer, http://www.oregongeology.org/hazvu/

[d] Area map is blank indicating liquefaction or lateral spreading is not significant. Minimal amounts may occur during strong ground shaking

Purdin Road UGB

The Purdin Road UGB has relatively low relief with a gentle slope to the east and is currently cultivated farmland. The primary geologic and seismic hazards to consider in this study area, in order of potential significance, include seismic hazards, adverse soils, hydrogeology and groundwater, and hydrology and drainage.

Seismic Hazards

Based on the Oregon HazVu by DOGAMI, approximately 75 percent of the area is mapped as having a high potential risk of liquefaction and the remaining 25 percent is considered low to moderate (refer, Figure 7). Potential lateral spreading may occur adjacent to open drainages and stream channels. All of the study area will be susceptible to severe ground shaking during a large earthquake (refer, Figure 8).

Other Potential Hazards

Additional information and soil parameters about adverse soil conditions, hydrology and drainage, and hydrogeology and groundwater information are provided in Tables 5 through 7 in the following NRCS Soil Description Section. Only the eastern edge of this study area adjacent to Council Creek is mapped within the FEMA 100-year flood zone (refer, Figure 9). Table 3 summarizes the other potential geological and seismic hazards in the study area.

Table 3: Summary of Other Potential Geologic and Seismic Hazards in the Purdin Road UGB Study Area

Geologic and Seismic Hazard	Possible Examples	Level of Concern
Slope Stability	Landslides and Existing Slope Movements	Low
Adverse Soils	Artificial Fill Expansive Soil Compressible Soil Organic-Rich Soil Sensitive Clay	Low Low to Moderate Low Moderate Low
Hydrology and Drainage	Flooding[a] Standing Water	None to Frequent[b] Low
Hydrogeology and Groundwater	Shallow Groundwater Seepage and Piping Permeability and Percolation	Moderate to High Low High
Erosion and Sedimentation		Low

[a] FEMA 100-year flood zone from METRO RLIS. Zone effective date September 30, 1982.

[b] Mapped on the eastern boundary of the property

Elm Street UGB

The Elm Street UGB has relatively low relief with a gentle slope to the east and south with the exception of the portion of the property with existing structures, which slopes steeply down to the west. The area is primarily cultivated farmland. The primary geologic and seismic hazards to consider in this study area, in order of potential significance, include seismic hazards, adverse soils, hydrogeology and groundwater, and hydrology and drainage. Slope stability should be considered on the western portion of the property near the existing structures.

Seismic Hazards

Based on the Oregon Geohazards Viewer (HazVu) by Oregon Department of Geology and Mineral Industries (DOGAMI), approximately 75 percent of the area is mapped as having a high potential risk of liquefaction, and the remaining 25 percent is considered low (refer, Figure 7). Potential lateral spreading may occur adjacent to open drainages and stream channels and significant ground shaking may result in seismically-induced settlement. All of the study area will be susceptible to severe ground shaking during a large earthquake (refer, Figure 8).

Other Potential Hazards

Additional information and soil parameters about adverse soil conditions, hydrology and drainage, and hydrogeology and groundwater information are provided in Tables 5 through 7 in the following NRCS Soil Description Section. The southern portion of the study area is mapped within the Preliminary FEMA 100-year flood zone and less so within the current FEMA 100-year flood zone (refer, Figure 9). FEMA is

currently updating data for several counties, which is shown as preliminary data in HazVu. However, HazVu states these data should not currently be used for regulatory purposes. Table 4 summarizes the other potential geological and seismic hazards in the study area.

Table 4: Summary of Other Potential Geologic and Seismic Hazards in the Elm Street UGB Study Area

Geologic and Seismic Hazard	Possible Examples	Level of Concern
Slope Stability	Landslides and Existing Slope Movements	Low
Adverse Soils	Artificial Fill Expansive Soil Compressible Soil Organic-Rich Soil Sensitive Clay	Low Low to Moderate Low Moderate Low
Hydrology and Drainage	Flooding[a] Standing Water	None to Frequent[b] Low
Hydrogeology and Groundwater	Shallow Groundwater Seepage and Piping Permeability and Percolation	Low to High Low High
Erosion and Sedimentation		Low

[a] FEMA 100-year flood zone from METRO RLIS. Zone effective date September 30, 1982.

[b] Mapped on the eastern boundary of the property

NRCS SOIL DESCRIPTIONS

The NRCS provides information from local soil surveys through the U.S. Department of Agriculture (USDA) Web Soil Survey portal. The soil surveys provide the mapped soil unit that includes soil type, soil profiles, soil quality, and soil engineering characteristics. In addition, the soil survey also has suitabilities and limitations for various land use purposes based on the mapped soil units. Figures 11 through 17 present several of the soil unit layers that are applicable to the project's goals. Please note the NRCS soil descriptions are generalizations of the soil characteristics and do not always provide site specific information for features, such as the depth to groundwater, since the soil units may cover a larger area than that being studied.

The following Tables 5 through 7 provide the soil units mapped within the study areas and applicable information to assist in determining the suitability and limitations of development to consider in planning. In general, soils with **more than** 5 percent of the total area are included. The DH&GCR study area has several mapped soil units with less than 5 percent. However, most of these units can be grouped under the same map soil name with the difference being the percent slopes. Therefore, the soils with the same soil map unit name have been combined if in total, these exceed 5 percent of the area.

The NRCS uses a rating system that combines soil characteristics (i.e. soil type and slope) to determine the suitability or limitations of a soil unit. Definitions of the ratings and criteria for the soil characteristics, or suitability/limitations, are provided in Attachment A.

Table 5: Summary of Applicable Soil Information for the DH&GCR Study Area

Soil Unit	Cornelius and Kinton silt loams	Helvetia silt loam	Laurelwood silt loam	Verboort silty clay loam	Woodburn silt loam
Soil Number	11B, 11C, 11D, 11E	19B, 19C, 19D	28B, 28C, 28D, 29Fa	42	45A, 45B, 45C
Percentage of Area	3, 12, 12, 8, total 35	5, 5, 2, total 12	9, 1, 27, 4, total 41	5	4, 1, 2, total 7
Parent Material	Loess over fine-silty Old Alluvium	Old Alluvium	Loess	Alluvium	Old Alluvium
Typical Profile (inches)	0 to 17: silt loam 17 to 38: silty clay loam 38 to 60: silt loam	0 to 5: silt loam 5 to 10: silty clay loam 10 to 48: silty clay 48 to 60: silty clay loam	0 to 11: silt loam 11 to 52: silty clay loam 52 to 72: silty clay	0 to 19: silty clay loam 19 to 33: clay 33 to 60: silty clay loam	0 to 16: silt loam 16 to 31: silty clay loam 31 to 60: silt loam
Unified Soil Classification (Surface)	ML	ML	ML	ML	ML
AASHTO[a] Group Classification (Surface)	A-4	A-4	A-4	A-6	A-4
Slope (percentage)	B: 2 to 7 C: 7 to 12 D: 12 to 20 E: 20 to 30	B: 2 to 7 C: 7 to 12 D: 12 to 20	B: 3 to 7 C: 7 to 12 D: 12 to 20 29F: 30 to 60	0 to 3	A: 0 to 3 B: 3 to 7 C: 7 to 12
Depth to Restrictive Layer	30 to 40 inches to fragipan	More than 80 inches	More than 80 inches	16 to 26 inches to abrupt textural change	More than 80 inches
Natural Drainage Class	Moderately well drained	Moderately well drained	Well drained	Poorly drained	Moderately well drained
Capacity of Most Limiting Layer to transmit Water	Moderately low to moderately high (0.06 to 0.20 in/hr)	Moderately high (0.20 to 0.57 in/hr)	Moderately high (0.20 to 0.57 in/hr)	Very low to moderately low (0.00 to 0.06 in/hr	Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to Water Table	About 27 to 37 inches	About 36 to 72 inches	More than 80 inches	About 0 to 24 inches	About 25 to 32 inches
Frequency of Flooding	None	None	None	Frequent	None
Frequency of Ponding	None	None	None	None	None
Linear Extensibility (Shrink-Swell)	2.5 percent	4.0 percent	4.0 percent	5.2 percent	2.3 percent
Hydrologic Soil Group	C	C	B	D	C

Soil Unit	Cornelius and Kinton silt loams	Helvetia silt loam	Laurelwood silt loam	Verboort silty clay loam	Woodburn silt loam
Corrosion to Steel	High	High	Moderate	High	High
Corrosion to Concrete	Moderate	Moderate	Moderate	Moderate	Low
Farmland Classification	B: Prime C, D, E: Statewide importance	B: Prime C, D: Statewide importance	B: Prime C, D: Statewide importance 29F: Not prime	Statewide importance	A, B:Prime C: Statewide importance
Erosion Hazard (Road, Trail)	B: Moderate C, D, E: Severe	B: Moderate C, D: Severe	B: Moderate C, D, 29F: Severe	Slight	A: Slight B: Moderate C: Severe
Mechanical Site Preparation (Surface)	B, C: Well suited D, E: Poorly suited	B, C: Well suited D: Poorly suited	B, C: Well suited D: Poorly suited 29F: Unsuited	Well suited	Well suited
Mechanical Site Preparation (Deep)	B, C: Well suited D, E: Poorly suited	B, C: Well suited D: Poorly suited	B, C: Well suited D: Poorly Suited 29F: Unsuited	Well suited	Well suited
Soil Rutting Hazard	Severe	Severe	Severe	Severe	Severe
Suitability for Roads (Natural Surface) (Oregon)	B, C, D: Moderately suited E: Poorly suited	Moderately suited	Moderately suited 29F: Poorly suited	Poorly suited	Moderately suited
Local Roads and Streets	Very limited	Very limited	Very limited	Very limited	Very limited

[a] AASHTO = American Association of State Highway and Transportation Officials

Table 6: Summary of Applicable Soil Information for the Purdin Road UGB Study Area

Soil Unit	42 - Verboort silty clay loam	45A - Woodburn silt loam, 0 to 3 percent slopes	45B - Woodburn silt loam, 3 to 7 percent slopes
Percentage of Area	20	70	10
Parent Material	Alluvium	Old Alluvium	Old Alluvium
Typical Profile (inches)	0 to 19: silty clay loam 19 to 33: clay 33 to 60: silty clay loam	0 to 16: silt loam 16 to 31: silty clay loam 31 to 60: silt loam	0 to 16: silt loam 16 to 31: silty clay loam 31 to 60: silt loam
Unified Soil Classification (Surface)	ML	ML	ML
AASHTO Group Classification (Surface)	A-6	A-4	A-4
Slope (percentage)	0 to 3	0 to 3	3 to 7
Depth to Restrictive Layer	16 to 26 inches to abrupt textural change	More than 80 inches	More than 80 inches
Natural Drainage Class	Poorly drained	Moderately well drained	Moderately well drained
Capacity of Most Limiting Layer to transmit Water	Very low to moderately low (0.00 to 0.06 in/hr	Moderately low to moderately high (0.06 to 0.20 in/hr)	Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to Water Table	About 0 to 24 inches	About 25 to 32 inches	About 25 to 32 inches
Frequency of Flooding	Frequent	None	None
Frequency of Ponding	None	None	None
Linear Extensibility (Shrink-Swell)	5.2 percent	2.3 percent	2.3 percent
Hydrologic Soil Group	D	C	C
Corrosion to Steel	High	High	High
Corrosion to Concrete	Moderate	Low	Low
Farmland Classification	Statewide Importance	Prime	Prime
Erosion Hazard (Road, Trail)	Slight	Slight	Moderate
Mechanical Site Preparation (Surface)	Well Suited	Well Suited	Well Suited
Mechanical Site Preparation (Deep)	Well Suited	Well Suited	Well Suited
Soil Rutting Hazard	Severe	Severe	Severe
Suitability for Roads (Natural Surface)(OR)	Poorly Suited	Moderately suited	Moderately suited
Local Roads and Streets	Very Limited	Very Limited	Very Limited

Table 7: Summary of Applicable Soil Information for the Elm Street UGB Study Area

Soil Unit	37A - Quatama loam, 0 to 3 percent slopes	37B - Quatama loam, 3 to 7 percent slopes	30 - McBee silty clay loam	9 - Chehalis silty clay loam, occasional overflow
Percentage of Area	70	15	10	5
Parent Material	Loamy Alluvium	Loamy Alluvium	Alluvium	Mixed Alluvium
Typical Profile (inches)	0 to 15: loam 15 to 30: clay loam 30 to 62: loam	0 to 15: loam 15 to 30: clay loam 30 to 62: loam	0 to 11: silty clay loam 11 to 45: silty clay loam 45 to 65: clay loam	0 to 16: silty clay loam 16 to 45: silty clay loam 45 to 60: silt loam
Unified Soil Classification (Surface)	ML	ML	ML	CL
AASHTO Group Classification (Surface)	A-4	A-4	A-6	A-7
Slope (percentage)	0 to 3	3 to 7	0 to 3	0 to 3
Depth to Restrictive Layer	More than 80 inches	More than 80 inches	More than 80 inches	More than 80 inches
Natural Drainage Class	Moderately well drained	Moderately well drained	Moderately well drained	Well drained
Capacity of Most Limiting Layer to transmit Water	Moderately high (0.20 to 0.57 in/hr)	Moderately high (0.20 to 0.57 in/hr)	Moderately high (0.20 to 0.57 in/hr)	Moderately high to high (0.57 to 1.98 in/hr)
Depth to Water Table	About 24 to 36 inches	About 24 to 36 inches	About 24 to 36 inches	More than 80 inches
Frequency of Flooding	None	None	Frequent	Occasional
Frequency of Ponding	None	None	None	None
Linear Extensibility (Shrink-Swell)	1.5 percent	1.5 percent	4.5 percent	4.5 percent
Hydrologic Soil Group	C	C	C	B
Corrosion to Steel	High	High	High	Moderate
Corrosion to Concrete	Moderate	Moderate	Low	Low
Farmland Classification	Prime	Prime	Prime	Prime
Erosion Hazard (Road, Trail)	Slight	Moderate	Slight	Slight
Mechanical Site Preparation (Surface)	Well Suited	Well Suited	Well Suited	Well Suited
Mechanical Site Preparation (Deep)	Well Suited	Well Suited	Well Suited	Well Suited
Soil Rutting Hazard	Severe	Severe	Severe	Severe
Suitability for Roads (Natural Surface)(OR)	Moderately suited	Moderately suited	Poorly Suited	Moderately suited
Local Roads and Streets	Very Limited	Very Limited	Very Limited	Very Limited

LIDAR

LiDAR imagery was obtained from DOGAMI covering the Gales Creek and Forest Grove quadrangles (refer, Figures 18 through 20). LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the earth. These light pulses, combined with other data recorded by an airborne system, generate precise three-dimensional information about the shape of the earth and its surface characteristics. Over the past decade, DOGAMI has been collecting and analyzing these data to generate landslide maps, including for the two quadrangles that encompass the study areas. The information is presented by DOGAMI through several venues such as the Statewide Landslide Information Database for Oregon (SLIDO), DOGAMI LiDAR data viewer, HazVu, and the interpretive map series IMS-39 (Forest Grove quadrangle) and IMS-46 (Gales Creek quadrangle) maps. PBS obtained the data disks for this planning project to incorporate the files into the GIS and perform our own analyses.

Several slope instabilities were identified within the DH&GCR study area, which are also shown in Table 2 of this report. We focused our evaluation on the undeveloped portion of the DH&GCR and **did not** include the previously developed areas. In particular, the location between Forest Drive and NW Antler Road is mapped by DOGAMI as a landslide complex encompassing approximately 38 acres, occurring at a depth of about 25 feet within the Tms Unit. This landslide area is further supported by surface expressions in the LiDAR imagery presented on Figure 18, David Hill & Gales Creek Road Area LiDAR that shows hummocky terrain typical of recent slope movements. No other landslides are mapped by DOGAMI within the study area, though several are immediately adjacent to the north and west sides of the UGB line.

Based on the LiDAR imagery, other areas to consider include apparent shallow debris flow-type instabilities in the portions identified in the Table 2 of this report as the Wismer Property to NW David Hill Road and NW Plum Hill Lane to NW David Hill Road. Slopes adjacent to, and within steep drainages, also show indications of instabilities throughout the area.

Please note that construction grading can remove surface indictors (e.g., scarps and hummocky terrain) that are used to assist in identifying slope instability features. This is most apparent in the southern portion of the DH&GCR study area where slope instabilities were known to exist prior to the residential developments.

The Purdin Road UGB and Elm Street UGB do not show distinct ground surface disturbance from the LiDAR that would suggest slope instabilities.

DH&GCR GEOTECHNICAL BORINGS

On November 14, 2014, three borings (designated as B-1, B-2, and B-3) were drilled within the DH&GCR study area (refer, Figure 2 and Figure 18). The borings were advanced to depths between 21.5 and 31.5 feet below ground surface (bgs) using mud-rotary drilling techniques by Western States Soil Conservation, Inc. of Hubbard, Oregon. A PBS engineering geologist observed the general soil conditions that were then used to estimate geotechnical parameters for planning purposes. Soil laboratory testing was not included in this scope of work and the soil types are based on field visual-manual classifications using ASTM International (ASTM) D 2488-09a guidelines. Boring logs are presented in Attachment B. The following Table 8 summarizes the boring data.

Table 8: Summary of Geotechnical Borings in the DH&GCR Study Area

Boring	Location	Depth (feet bgs)	Approximate Ground Elevation (feet msl)[a]	Groundwater (feet bgs)	Bedrock (feet bgs)
B-1	Thatcher Park	21.5	273	n/e[b]	n/e
B-2	NW Plum Hill Lane	31.5	385	n/e	n/e
B-3	Wismer Property	31.5	505	n/e	n/e

[a] msl = mean sea level, based on Google Earth
[b] n/e = not encountered during drilling

In general, the three borings encountered similar soil materials from the ground surface to the total depths explored. Fine-grained, light brown to reddish brown silt (MH) and clay (CH) soil with medium stiff to stiff consistencies, N-values between 4 and 16 blows per foot, were observed. The soil samples had low to high plasticity and were generally moist.

PRELIMINARY SLOPE STABILITY ANALYSIS

Previous geotechnical reports in the developed portion of the DH&GCR study area identified two slope failures on the southwestern hillslope. Based on the information provided by GRI (2000) and GeoPacific Engineering, Inc. (2001) in their reports, these landslides are characteristic of rotational and shallow slump-type failures.

PBS has performed preliminary slope stability analyses at the three boring locations. Slope stability is influenced by various factors including, the geometry of the soil mass and subsurface materials, weight of soils overlying the failure surface, the shear strength of soils and/or rock along the failure surface, and the hydrostatic pressure (groundwater levels) along the failure surface. We have used information developed from our field explorations and our experience with similar earth materials to develop the stability analysis model. Our analyses are based upon the assumption that subsurface conditions everywhere within the landslide mass are not significantly different from those encountered by the field explorations. In addition, the exploration depths limit possible failures to 21.5 feet to 31.5 feet bgs. Possible deeper-seated slope instabilities are not addressed and should be considered during development-specific geotechnical evaluations. The slope profiles are based on Google Earth elevation data and are shown on Figure 18. The results of the very limited slope stability analyses are presented on Attachment C. These results should not be considered to be definitive indications of current or future slope stability. They merely suggest current apparent relative slope conditions for planning purposes.

Soil and Material Parameters – Information from our subsurface explorations and our previous experience on similar projects were utilized to estimate material strengths and unit weight parameters for the various geologic units. Table 9 presents the soil layer designations and the physical material parameters used in our stability analyses.

Table 9: Material Properties for Slope Stability Analysis

Boring	Soil Unit	Total Density, γ_m (pcf)	Friction Angle (degrees)	Cohesion, c (psf)
B-1	Med Stiff CL	110	0	600
	Med Stiff CH	110	0	800
	Med Stiff ML	115	30	0
	Very Stiff CL	110	0	1800
	Very Stiff CH	110	0	2000
B-2	Med Stiff ML	115	30	50
	Stiff CL	110	0	2000
B-3	Med Stiff CL	110	0	1100
	Med Stiff CH	110	0	1500

The unit weights of all soils were based on the soil classifications and our experience. The values for shear strength (i.e., internal angle of friction, ϕ, and cohesion, c), were based on soil types and index properties, and our experience.

Table 10 summarizes the results of the three slope stability profiles.

Table 10: Summary of Slope Stability Analysis

Location	Factor of Safety	
	Static	Pseudo-Static
B-1	3.84	1.47
B-2	1.79	1.01
B-3	2.25	1.10

The preliminary slope stability analysis indicates the B-2 area near NW Plum Hill Lane with a slope descending to the south has the lowest static and pseudo-static FOS based on the generalized parameters used in the analysis. The stability of a slope is expressed in terms of factor of safety (FS), which is defined as the ratio of resisting forces to driving forces. At equilibrium, the FS is equal to 1.0 and the driving forces are balanced by the resisting forces. Failure occurs when the driving forces exceed the resisting forces (i.e., FS less than 1.0). An increase in the FS above 1.0, whether by increasing the resisting forces and/or decreasing the driving forces, reflects a corresponding increase in the stability of the mass. The actual FS may differ from the calculated FS due to uncertainty in soil strengths, subsurface geometry, failure surface location and orientation, groundwater levels, and other factors that are not completely known or understood.

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Wetlands and recreational areas have been identified within the DH&GCR study area. In addition, a wetland is mapped along the eastern edge of the Purdin Road UGB. No Goal 5 resources have been identified in the Elm Street UGB study area.

The City owns most of the properties that are recreation areas within the DH&GCR study area. The wetlands should be considered during development and either avoided or balanced in both the DH&GCR and Purdin Road UGB areas.

The primary geotechnical-related aspects to consider in the planning and development of the study areas include:

- weak surface soils
- slope stability
- soil liquefaction during a seismic event
- poorly draining soils
- seismic ground shaking
- shallow groundwater
- potentially expansive soils
- highly disturbed ground surface soil due to past farming practices

In general, the impacts these issues may pose can be mitigated or avoided through implementing proper guidelines following current Federal, State, and local codes, and performing appropriate geotechnical studies at the time of development. Geotechnical approaches to resolve most of these issues would be at the discretion of the Geotechnical Engineer of Record for the development and may include, but not limited to, surface soil ground improvements such as cement treating to strengthen weak or potentially expansive soils, over-excavation to remove poor soil conditions, and deep foundations or ground improvements, as applicable. The areas and associated development should include a liquefaction analysis based on the relevant Oregon Structural Specialty Code (OSSC) at the time of development. Impacts of liquefaction and the appropriate method to mitigate would be at the discretion of the Geotechnical Engineer of Record.

The International Building Code (IBC) (2012) provides guidelines for foundations on, or adjacent to, slopes in IBC Section 1808. In general, buildings should be placed at least the smaller of Height (H)/2 or 15 feet from the toe of the slope and at least the smaller of H/3 or 40 feet from the top of slope. IBC Section 1808.7 provides additional details that should be considered in development planning. We recommend following these codes for all areas of development, if not already implemented by the City.

Modifications to the City of Forest Grove Code, Section 10.8.310 HAZARD AREAS may be considered by the City and include additional, specific information for performing slope stability studies in a designated Landslide Study Zone (LSZ) and / or areas of steeper than a specified slope. The City requested PBS to use greater than 10 percent slope as the determiner for areas that would require slope stability studies. To remove ambiguity interpreting the code for undulating topography in the DH&GCR, PBS has created a LSZ to be considered by the City. In areas like the DH&GCR, slopes flatter than 10 percent can still be prone to or affected by slope instabilities because, for example, it lies within the body of or landslide, may be impacted by landslide movement upslope, or could be impacted by landslide movement down slope.

The presented LSZ only includes the DH&GCR due to the scope of this project but could be extended to other areas with similar characteristics within the City bounds. The LSZ is based on:

1) The relatively steep and pervasive slopes in the area (greater than 10 percent was used to depict these slopes in Figures 21 and 22),
2) Known, existing slope instabilities throughout the study area, and
3) Past developments in the area where construction grading and excavations resulted in slope instabilities.

Furthermore, based on GOAL 7 requirements and guidelines and pertinent case studies, we **do not** recommend permitting further development of structures or infrastructure within the DOGAMI mapped landslide between Forest Gale Drive to NW Antler Road south of David Hill Road (Area 1 on Figure 10)

unless the landslide and its impacts are clearly addressed in the design of the project. Even with these measures, the City should consider alternative uses (i.e. open space) as a potential plan for the area.

Based on conversations with the City, the properties within the NW Antler Road to Thatcher Road south of David Hill Road location are primarily owned by the City of Forest Grove School District and the City of Forest Grove Parks and Recreation Department. We understand the City of Forest Grove School District property may eventually be selected for private development. Although this land is currently shown as an ORCA from the METRO RLIS database on Figure 4, it does not preclude its future development.

Figures 21 and 22, Study Areas Slope Percentages and DH&GCR Slope Percentages, generated by analyzing the LIDAR data through the GIS shows the steep slopes (4:1; ≥ 25 percent), slopes greater than 10 percent, and a potential Landslide Study Zone (around the DH&GCR) for the three study areas. The revised code would result in portions of the Purdin UGB and Elm Street UGB requiring slope stability studies based on these areas having slopes greater than 10 percent (refer, Figure 21).

The current code and potential modifications (in *red italics*) is shown below.

A. Information and studies for hazards shall be provided as follows:
   1. (pertains to flood plains and is omitted)
   2. For development sites within *a Landslide Study Zone (LSZ) or* having slopes of *10%* or more, the following requirements shall be met. To ensure compliance with the provisions of this ordinance, prior to the issuance of a building permit for the construction of any new building within the city, and prior to any grading, excavation or filling or other site modification within *a LSZ or* areas having a slope of *10%* or greater, there shall be submitted to the Community Development Department for review and approval, or approval with modifications:
      a. a site plan (showing any grading, excavating or filling) drawn to scale of the entire property developed and of the proposed construction;
      b. the submission of a geological assessment and geotechnical report prepared and stamped by a Certified Engineering Geologist who is a registered geologist certified in the specialty of Engineering Geology under provisions of ORS 672.505 to 672.705 *and a Geotechnical Engineer under provisions of ORS 672.002 to 672.325*. The assessment and report shall address the entire site and meet the following requirements:
         i. The geological *and engineering* assessment shall include information and data regarding the nature, distribution of underlying geology, and the physical and chemical properties of existing soils; an opinion as to stability of the site, and conclusions regarding the effect of geologic conditions on the proposed development.
         ii. *The study shall include: 1) review of aerial photography including stereo views and LiDAR imagery, 2) review of geologic literature or previous reports, 3) site reconnaissance including mapping of observable geologic features or hazards, 4) field explorations, as necessary, and 5) laboratory testing.*
         iii. The geotechnical report shall include a comprehensive description of the site topography and geology; an opinion as to the adequacy of the proposed development from an engineering standpoint; and opinion as to the extent that instability on adjacent properties may adversely affect the

project; a description of the field investigation and findings; conclusions regarding the effect of geologic conditions on the proposed development; and specific requirements for plan modification, corrective grading and special techniques and systems to facilitate a safe and stable development. The report shall provide other recommendations as necessary, commensurate with the project grading and development.

iv. Address the requirements of Section 10.8.310 B.

B. Through hazard study(ies) required pursuant to Section 10.8.310 A., the applicant shall establish methods to minimize hazards to acceptable risks by:
   1. Site design approaches that avoids development within hazard area;
   2. Grading, erosion control and other site preparation techniques to minimize hazard impacts;
   3. Techniques to minimize impacts from utility installation; and/or
   4. Building and foundation techniques to minimize hazard impacts.

C. Where a hazard area is proposed to be avoided:
   1. For divisions of land, the area shall be placed in an open space tract separate from areas intended for development. The open space tract is subject to the requirements of 10.8.200 et seq.
   2. For development not involved in a division of land, the area shall be held in common for residential condominiums or by the primary land owner for apartment complexes or non-residential development. The area shall be placed within an easement and adequate maintenance provisions shall be provided consistent with the requirements of Section 10.8.200.
   3. The tract or easement area shall be restricted to open space. Utilities may be located within the area provided that the report proposes acceptable measures to minimize hazard impacts. Open space tracts are subject to the provisions of Section 10.8.200.

LIMITATIONS

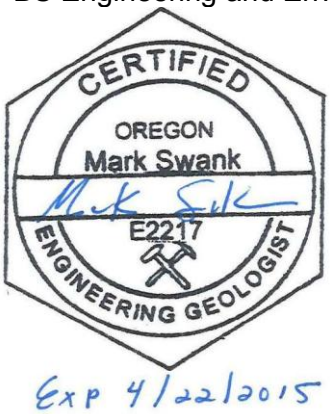
Our conclusions are based upon limited review of the referenced documents and subsurface explorations intended to suggest general conditions of the DH&GCR study area. The guidelines and recommendations provided in this report are for the City's consideration for the Westside Planning Project. Federal, State, and Local codes, guidelines, and statutes should be followed. Subsurface conditions, material types, groundwater, and similar, can change substantially over relative short distances, and from time to time. Consequently, the borings and related information and preliminary slope stability analyses presented herein must not be relied upon for future development plans.

The information provided in this report is for use in feasibility planning associated with the study areas, and PBS is not liable in any regard for decisions related to due diligence, purchase, or design and construction estimating. Site-specific exploration and engineering is required in order to refine the very general discussion of subsurface conditions (based on nearby information) provided in this report.

CLOSING

We trust this Geological and Geotechnical Assessment Report meets your current needs. If you have any questions or wish to further discuss our observations, conclusions, and recommendations, please contact Saiid Behboodi at 503.417.7705 or Mark Swank at 503.417.7738.

Sincerely,
PBS Engineering and Environmental Inc.



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Senior Engineering Geologist

REVIEWED BY:

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Principal Geotechnical Engineer

Arlan H. Rippe, PE, GE, D.GE
Senior Geotechnical Consultant

MWS/SB/AR

ATTACHMENTS

Attachment A – Soil Classification Descriptions
Attachment B – Soil Boring Logs
Attachment C – Slope Stability Analysis

FIGURES

Figure 1 – Vicinity Map
Figure 2 – Study Area Map
Figure 3 – David Hill Urban Reserve Concept Plan
Figure 4 – Oregon GOAL 5 Resources
Figure 5 – Geologic Map
Figure 6 – Landslide Inventory
Figure 7 – Earthquake Liquefaction
Figure 8 – Earthquake Ground Shaking
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Figure 18 – David Hill and Gales Creek Road Area LIDAR
Figure 19 – Purdin Road UBG LIDAR
Figure 20 – Elm Street UGB LIDAR
Figure 21 – Study Areas Slope Percentages
Figure 22 – DH&GCR Slope Percentages

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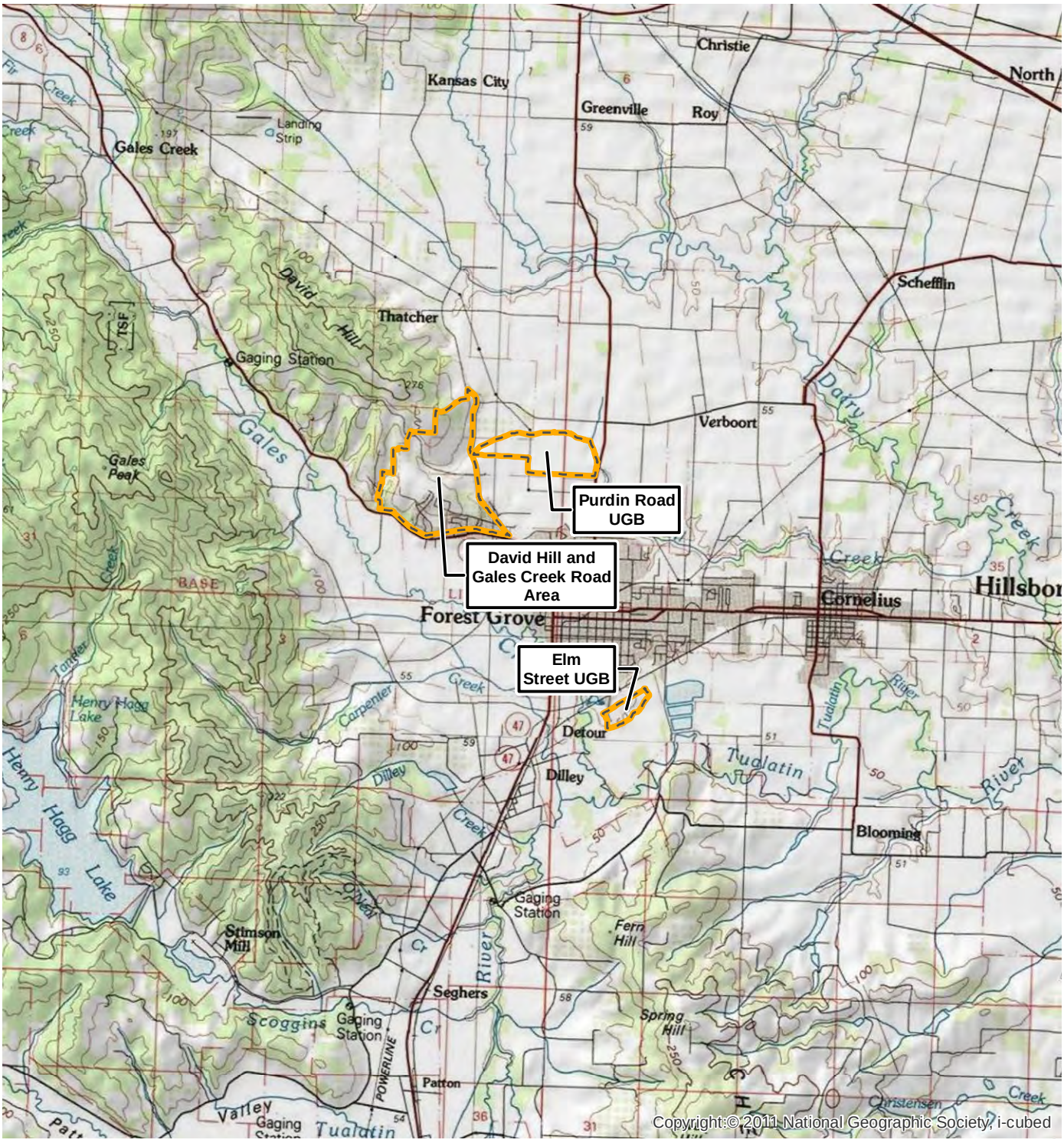
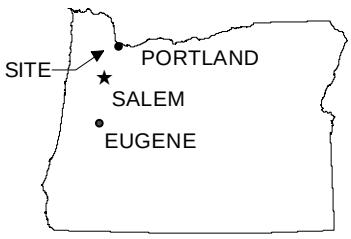
FIGURES





Legend

Westside Planning Study Area

0 4,000 8,000 16,000'

1 inch = 8,000 feet

PREPARED FOR: SCJ Alliance

PBS

PROJECT # 73121.000

DATE JAN 2015

VICINITY MAP

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE 1

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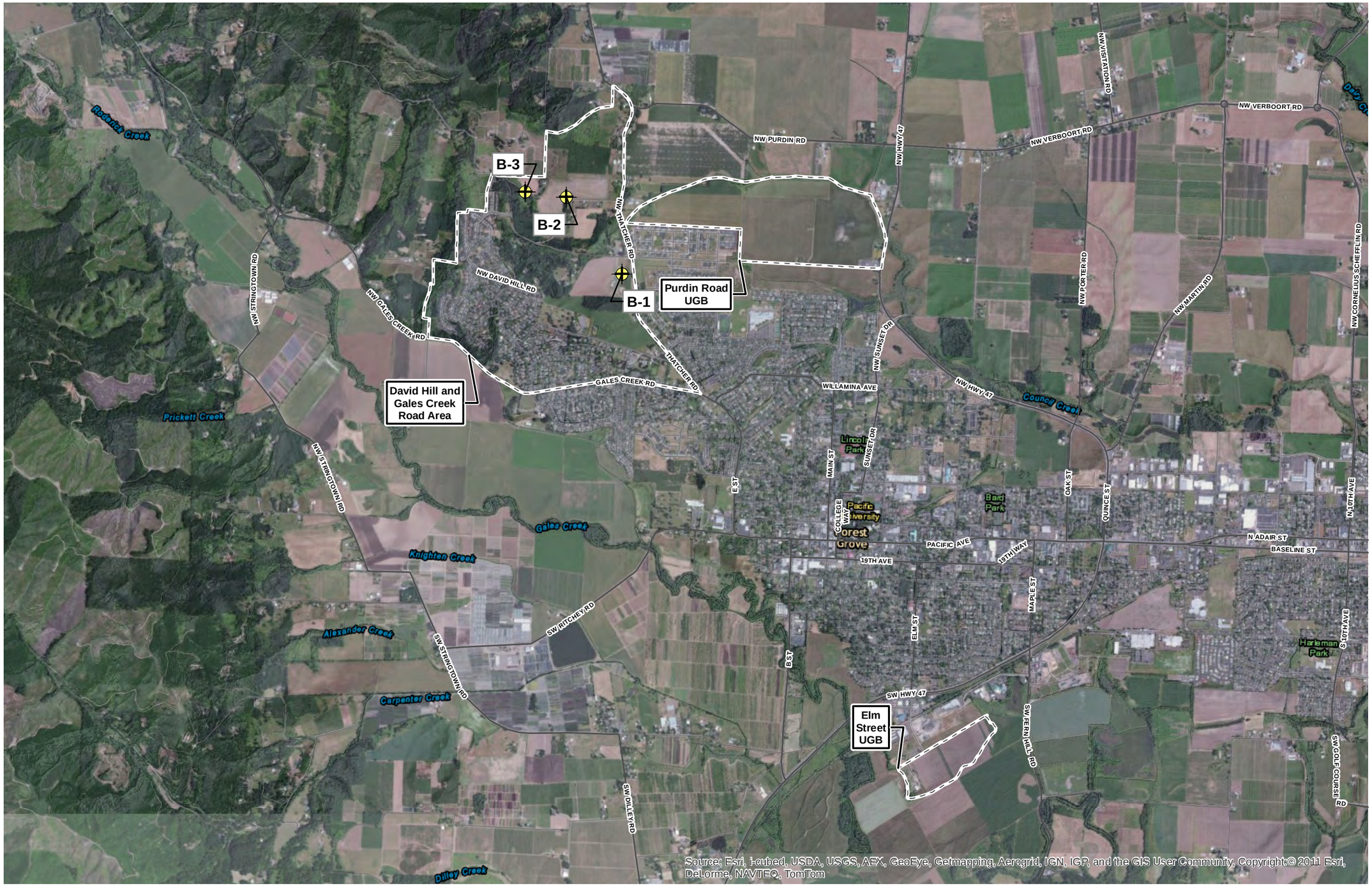

SOURCES: Metro RLIS

PREPARED FOR: SCJ Alliance

LEGEND

- Westside Planning Study Area
- Borings
- Arterial Street
- Street

STUDY AREA

0 1,250 2,500 5,000'

1 inch = 2,500 feet

PBS
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503.248.1939 Main
866.727.0140 Fax
www.pbsenv.com

FOREST GROVE WESTSIDE PLANNING PROJECT

FOREST GROVE, OREGON

PROJECT	73121.000
DATE	JAN 2015
FIGURE	2

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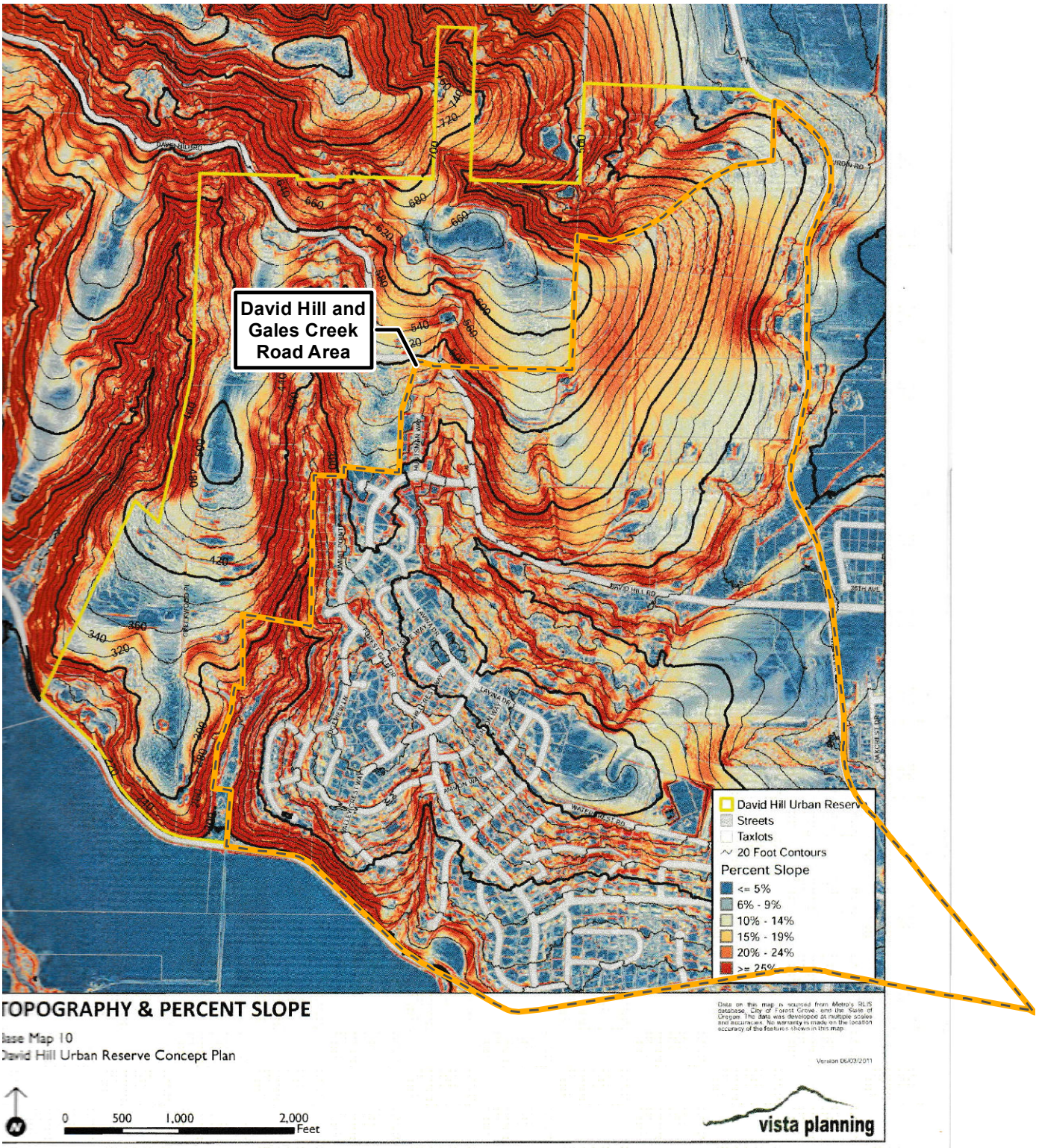

SOURCE: "David Hill Urban Reserve Concept Plan, Appendices", Vista Planning and Portland State University, June 2011

Legend

- Westside Study Areas
- Arterial streets
- Slope 10-20%
- Slope >20%
- Landslide Hazard Zone -Possible

0 625 1,250 2,500 '

1 inch = 1,250 feet

PREPARED FOR: SCJ Alliance

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PBS

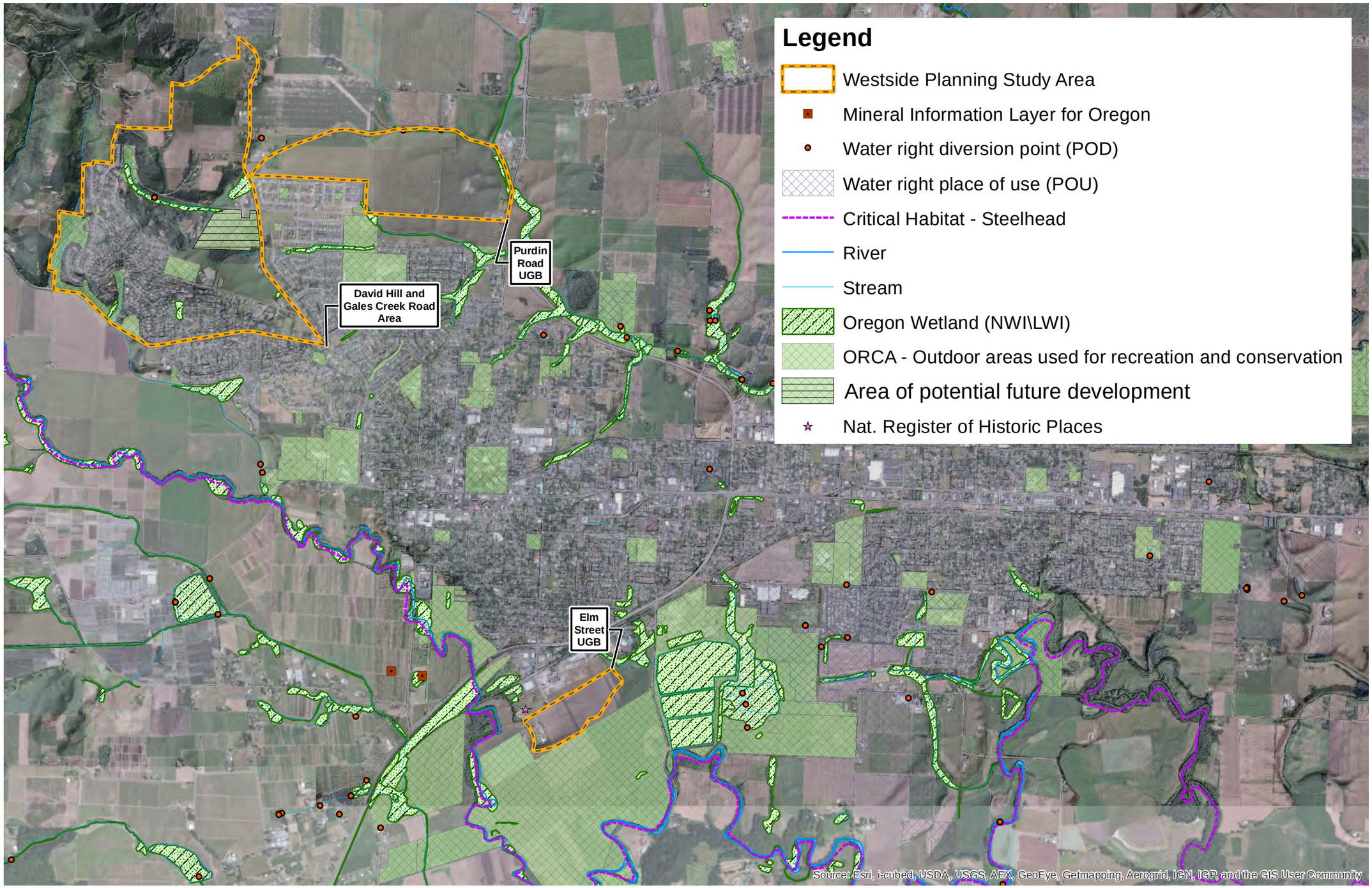
PROJECT # 73121.000

DATE JAN 2015

DAVID HILL URBAN RESERVE CONCEPT PLAN

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE 3



SOURCES: Metro RLIS; Oregon Wetlands Geodatabase,
Oregon Natural Heritage Information Center & The Wetlands Conservancy;
National Park Service, National Register of Historic Places;
Oregon Department of Geology and Mineral Industries;
Oregon Water Resources Dept.

PREPARED FOR: SCJ Alliance

OREGON GOAL 5 RESOURCES

0 1,250 2,500 5,000'

1 inch = 2,500 feet

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FOREST GROVE WESTSITE PLANNING PROJECT

FOREST GROVE, OREGON

PROJECT	73121.000
DATE	JAN 2015
FIGURE	4

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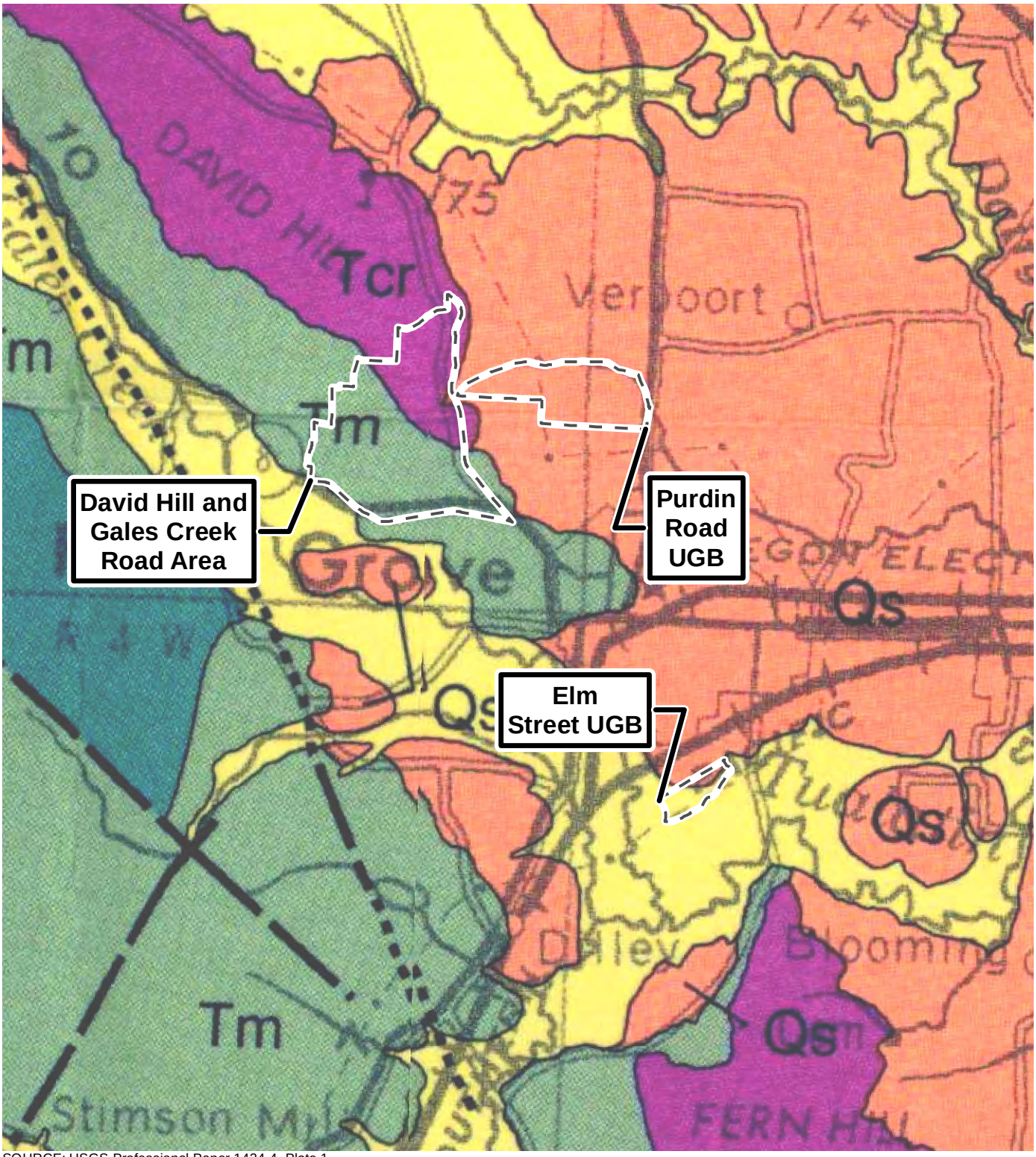

SOURCE: USGS Professional Paper 1424-4, Plate 1

Legend

Westside Planning Study Area

Geologic Features

- Qal: Alluvial deposits (Holocene)
- Qs: Alluviam and glacial-outburst flood sediment (Pleistocene)
- Tcr: Columbia River Basalt Group (Miocene)
- Tm: Marine sedimentary rocks, undivided (lower Miocene to Eocene)
- Tvc: Volcanic rocks of the Coast Range (Eocene)

0 2,500 5,000 10,000'

1 inch = 5,000 feet

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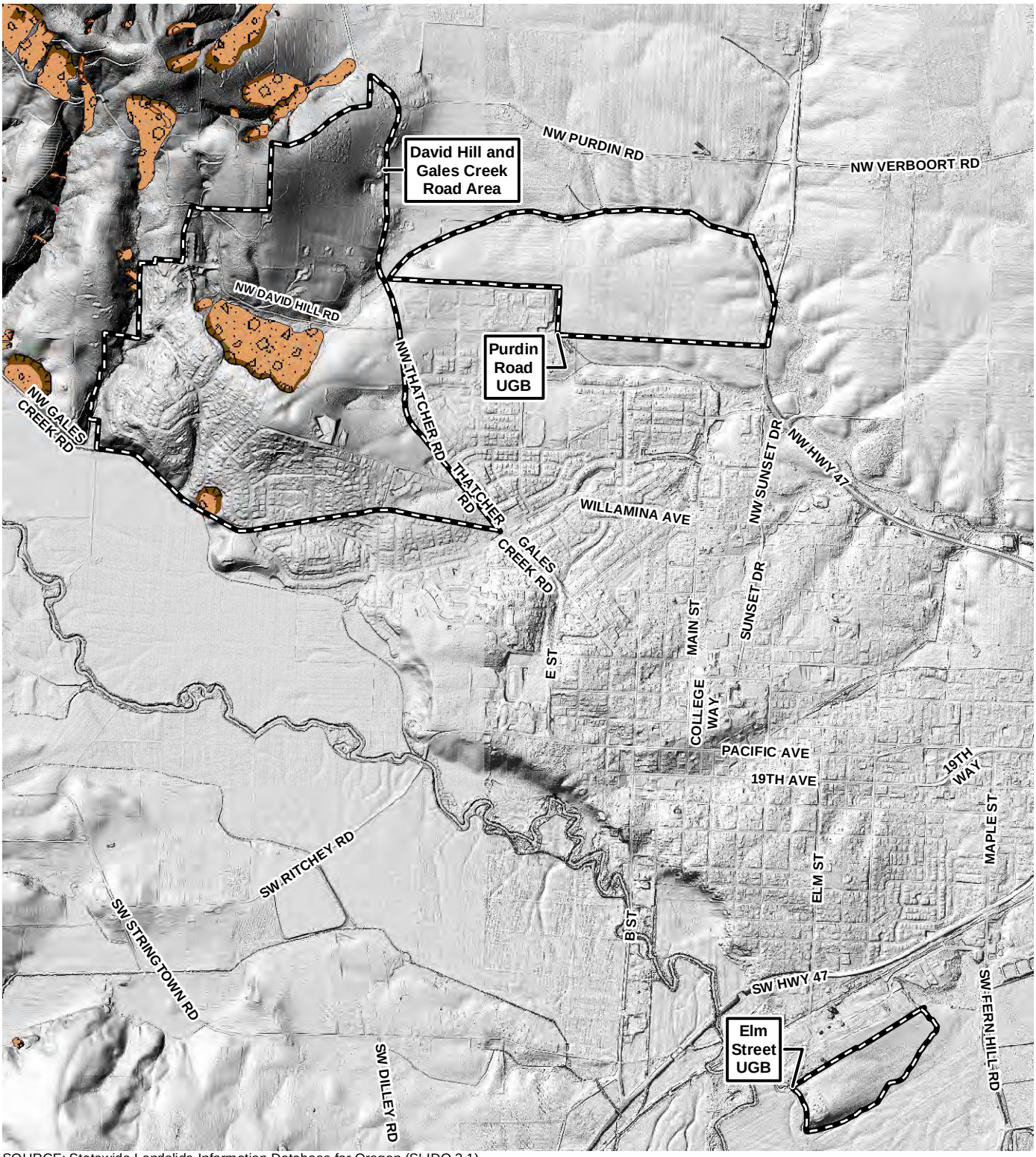
DATE JAN 2015

GEOLOGIC MAP

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **5**

L:\Projects\73000\73100-73199\73121_FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig5_Geology.mxd



SOURCE: Statewide Landslide Information Database for Oregon (SLIDO 3.1)

Legend

- Westside Planning Study Area
- Arterial streets

0 1,250 2,500 5,000'

1 inch = 2,500 feet

PREPARED FOR: SCJ Alliance

L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig6_Landslides.mxd

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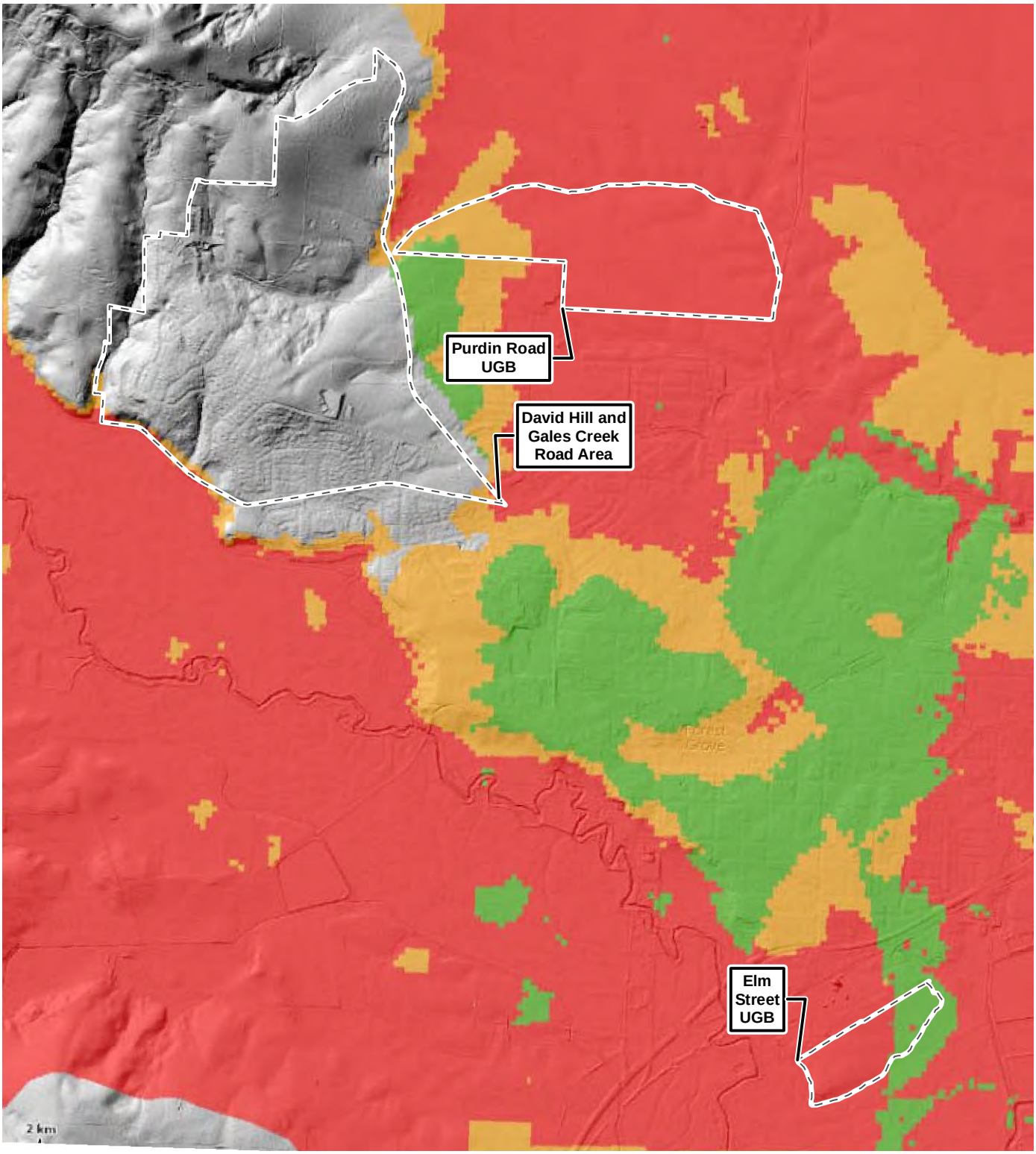
LANDSLIDE INVENTORY

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **6**



SOURCE: Oregon DOGAMI HAZVU Statewide Geohazards Viewer - Earthquake Liquefaction accessed 12/2014

Legend

Westside Planning Study Area

Earthquake Liquefaction Hazard

- High
- Moderate
- Low
- None to Minimal

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

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L:\Projects\73000\73100-73199\73121 FirstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig7_Liquefaction.mxd

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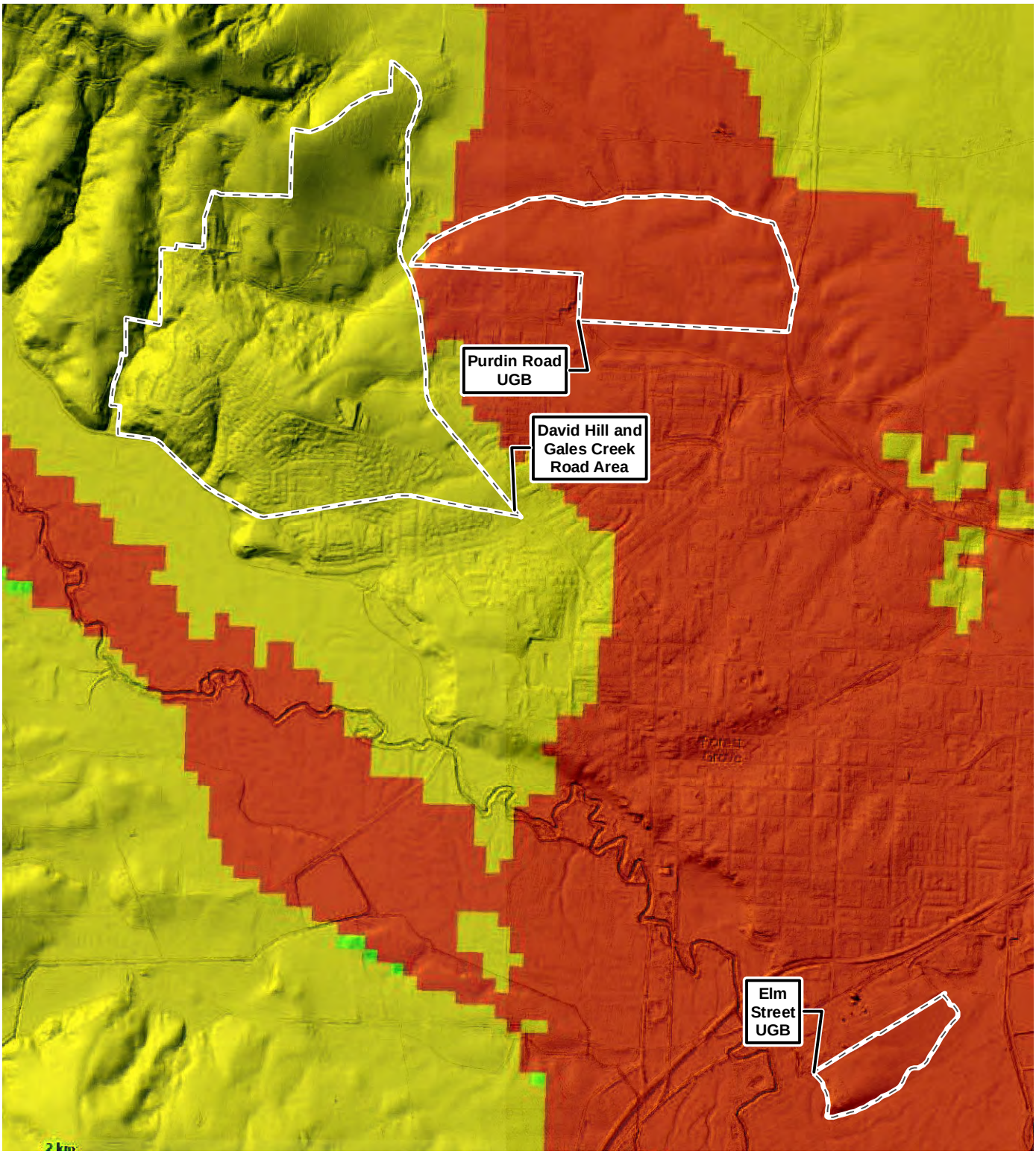
EARTHQUAKE LIQUEFACTION

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **7**



SOURCE: PBS Engineering and Environmental; Oregon DOGAMI HAZVU Statewide Geohazards Viewer - Expected Earthquake Shaking accessed 12/2014

Legend

Westside Planning Study Area

Expected Ground Shaking

- Violent
- Severe
- Very Strong
- Strong
- Moderate
- Light

0 1,250 2,500 5,000'

1 inch = 2,500 feet

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L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig8_GroundShaking.mxd

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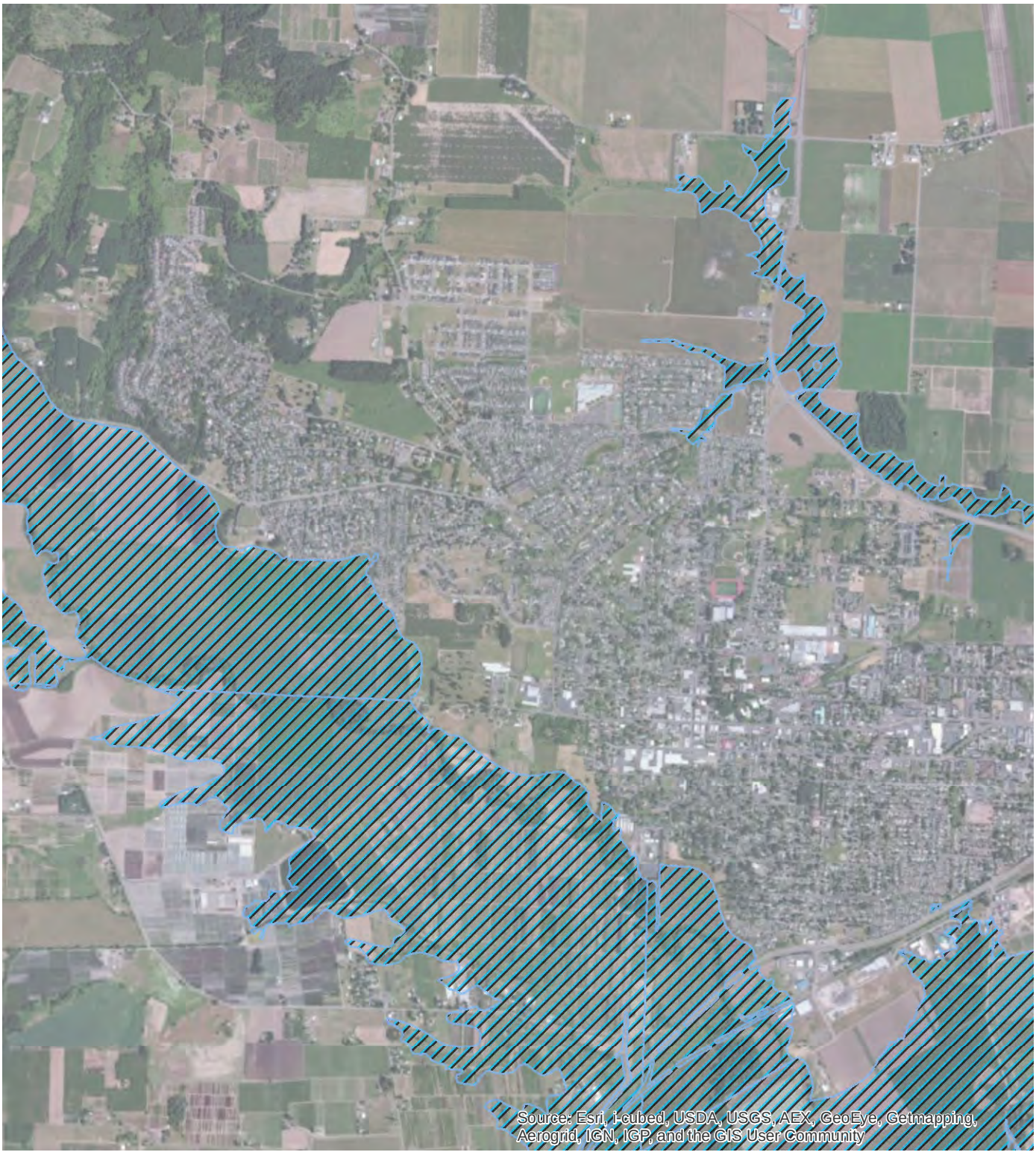
DATE JAN 2015

EARTHQUAKE GROUND SHAKING

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **8**



SOURCE: Oregon Metro RLIS

Legend

- Westside Planning Study Area
- FEMA Floodplain

0 1,250 2,500 5,000'

1 inch = 2,500 feet

PREPARED FOR: SCJ Alliance

L:\Projects\73000\73100-73199\73121_FirstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig9_FEMA 100-Year Flood.mxd

PBS

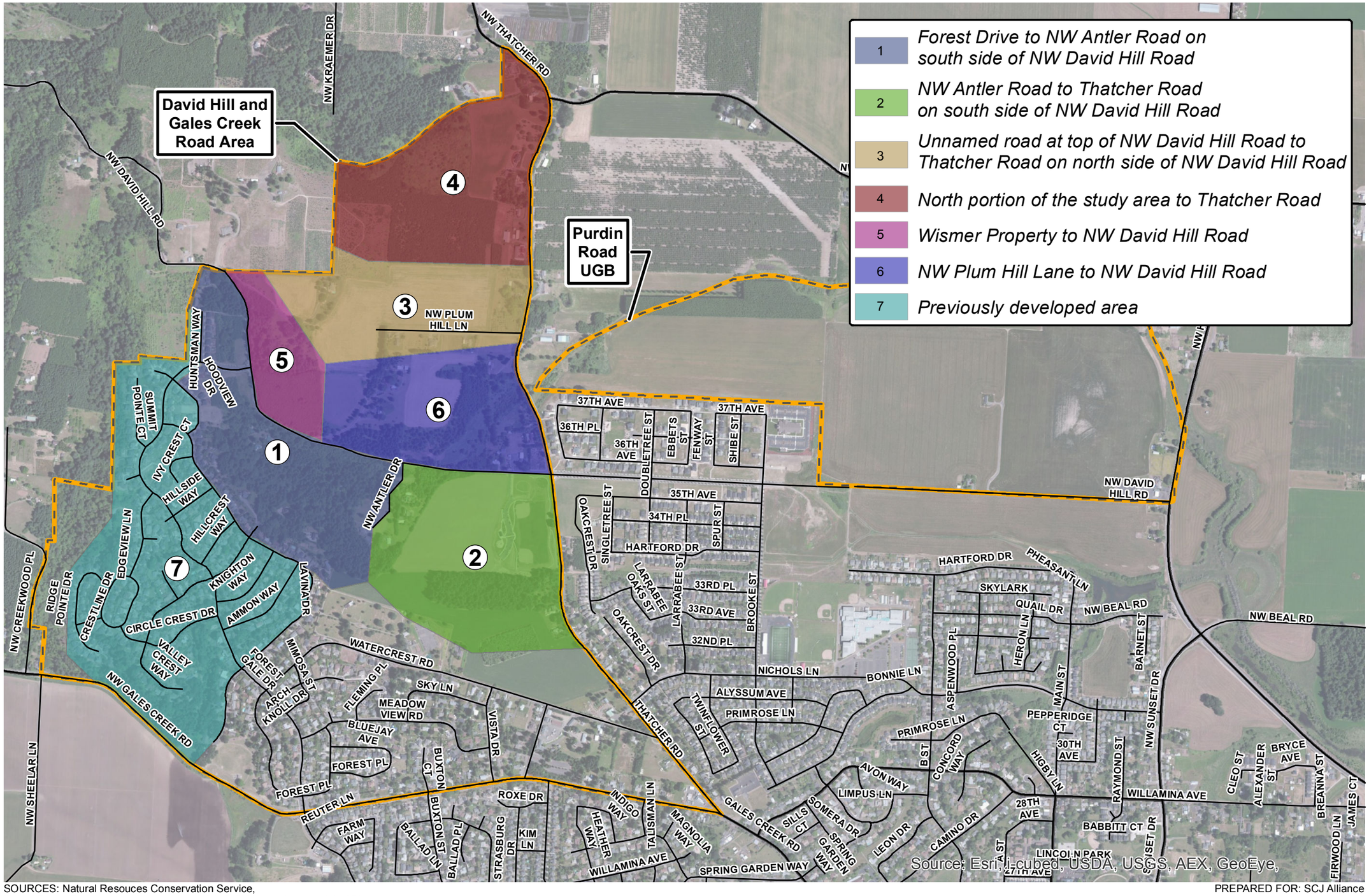
PROJECT # 73121.000

DATE JAN 2015

FEMA 100-YEAR FLOOD HAZARD

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **9**



SOURCES: Natural Resouces Conservation Service,
United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

PREPARED FOR: SCJ Alliance

Legend

Westside Study Areas — Streets — Arterial streets

DH&GCR GENERALIZED SLOPE AREAS

0 500 1,000 2,000
Feet
1 inch = 1,000 feet

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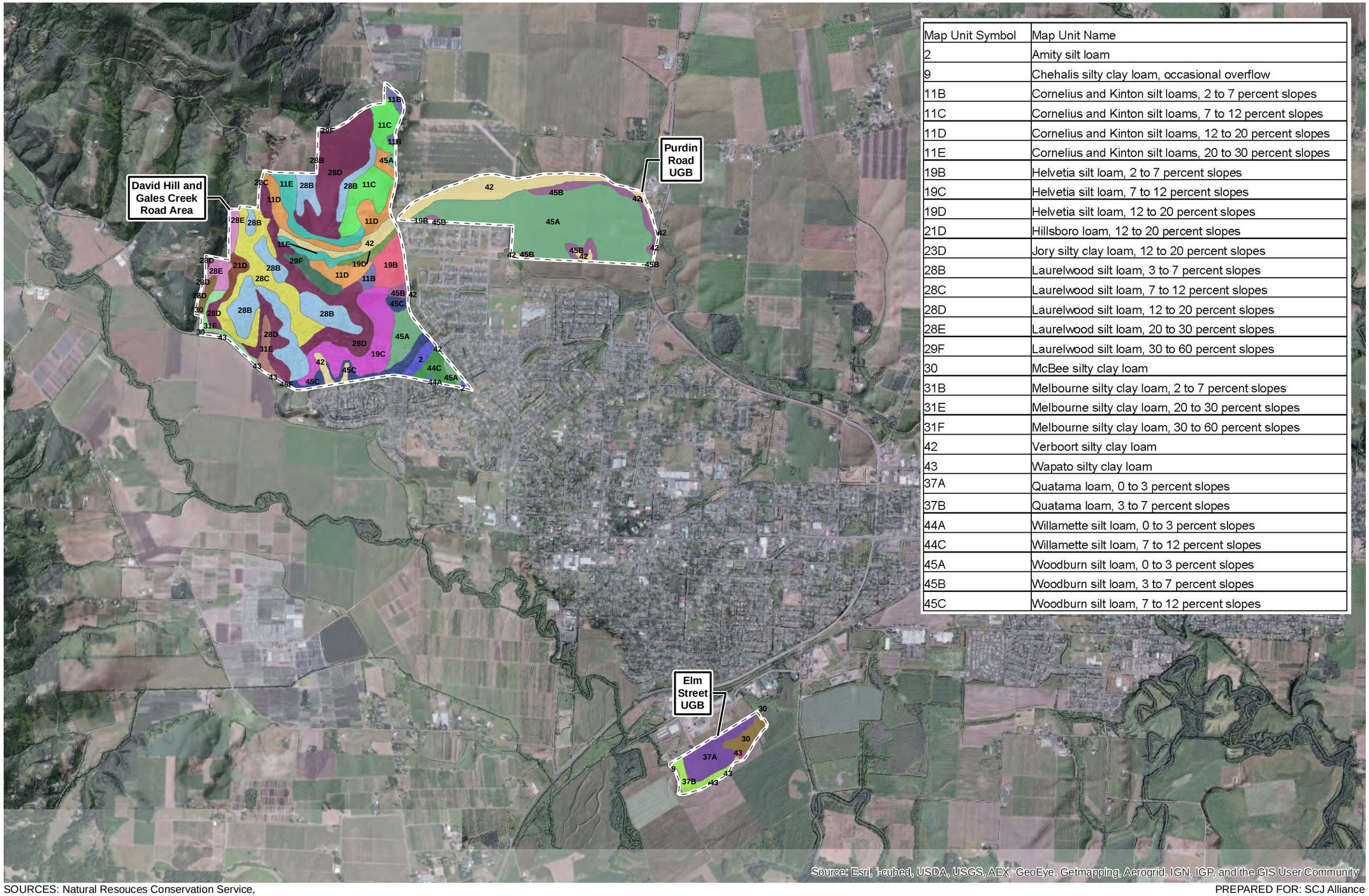
FOREST GROVE WESTSITE PLANNING PROJECT

FOREST GROVE, OREGON

PROJECT	73121.000
DATE	JAN 2015
FIGURE	10

L:\Projects\73000\73100-73199\73121 FstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig10_DHGCR_Areas_11x17.mxd



Map Unit Symbol	Map Unit Name
2	Amity silt loam
9	Chehalis silty clay loam, occasional overflow
11B	Cornelius and Kinton silt loams, 2 to 7 percent slopes
11C	Cornelius and Kinton silt loams, 7 to 12 percent slopes
11D	Cornelius and Kinton silt loams, 12 to 20 percent slopes
11E	Cornelius and Kinton silt loams, 20 to 30 percent slopes
19B	Helvetia silt loam, 2 to 7 percent slopes
19C	Helvetia silt loam, 7 to 12 percent slopes
19D	Helvetia silt loam, 12 to 20 percent slopes
21D	Hillsboro loam, 12 to 20 percent slopes
23D	Jory silty clay loam, 12 to 20 percent slopes
28B	Laurelwood silt loam, 3 to 7 percent slopes
28C	Laurelwood silt loam, 7 to 12 percent slopes
28D	Laurelwood silt loam, 12 to 20 percent slopes
28E	Laurelwood silt loam, 20 to 30 percent slopes
29F	Laurelwood silt loam, 30 to 60 percent slopes
30	McBee silty clay loam
31B	Melbourne silty clay loam, 2 to 7 percent slopes
31E	Melbourne silty clay loam, 20 to 30 percent slopes
31F	Melbourne silty clay loam, 30 to 60 percent slopes
42	Verboort silty clay loam
43	Wapato silty clay loam
37A	Quatama loam, 0 to 3 percent slopes
37B	Quatama loam, 3 to 7 percent slopes
44A	Willamette silt loam, 0 to 3 percent slopes
44C	Willamette silt loam, 7 to 12 percent slopes
45A	Woodburn silt loam, 0 to 3 percent slopes
45B	Woodburn silt loam, 3 to 7 percent slopes
45C	Woodburn silt loam, 7 to 12 percent slopes

SOURCES: Natural Resouces Conservation Service,
United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

PREPARED FOR: SCJ Alliance

Legend

Westside Planning Study Area

NRCS SOILS

0 1,250 2,500 5,000
Feet
1 inch = 2,500 feet

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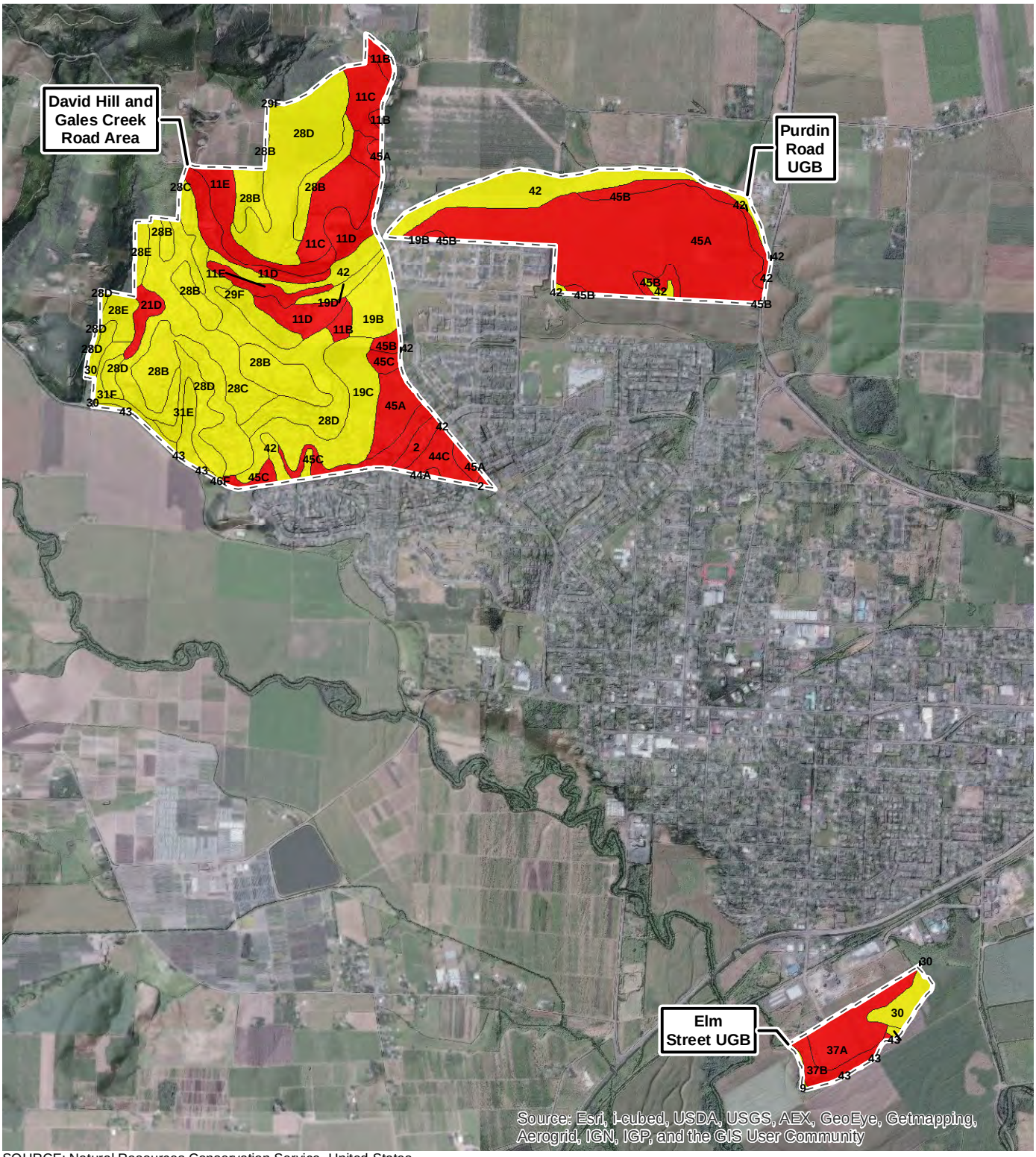
PROJECT	73121.000
DATE	JAN 2015
FIGURE	11

L:\Projects\73000\73100-73199\73121_FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig11_NRCS_Soils 11x17.mxd



SOURCE: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

Legend

Westside Planning Study Area

Linear Extensibility

- Low (0 - 3)
- Moderate (3 - 6)
- High (6 - 9)
- Very High (9 - 30)

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

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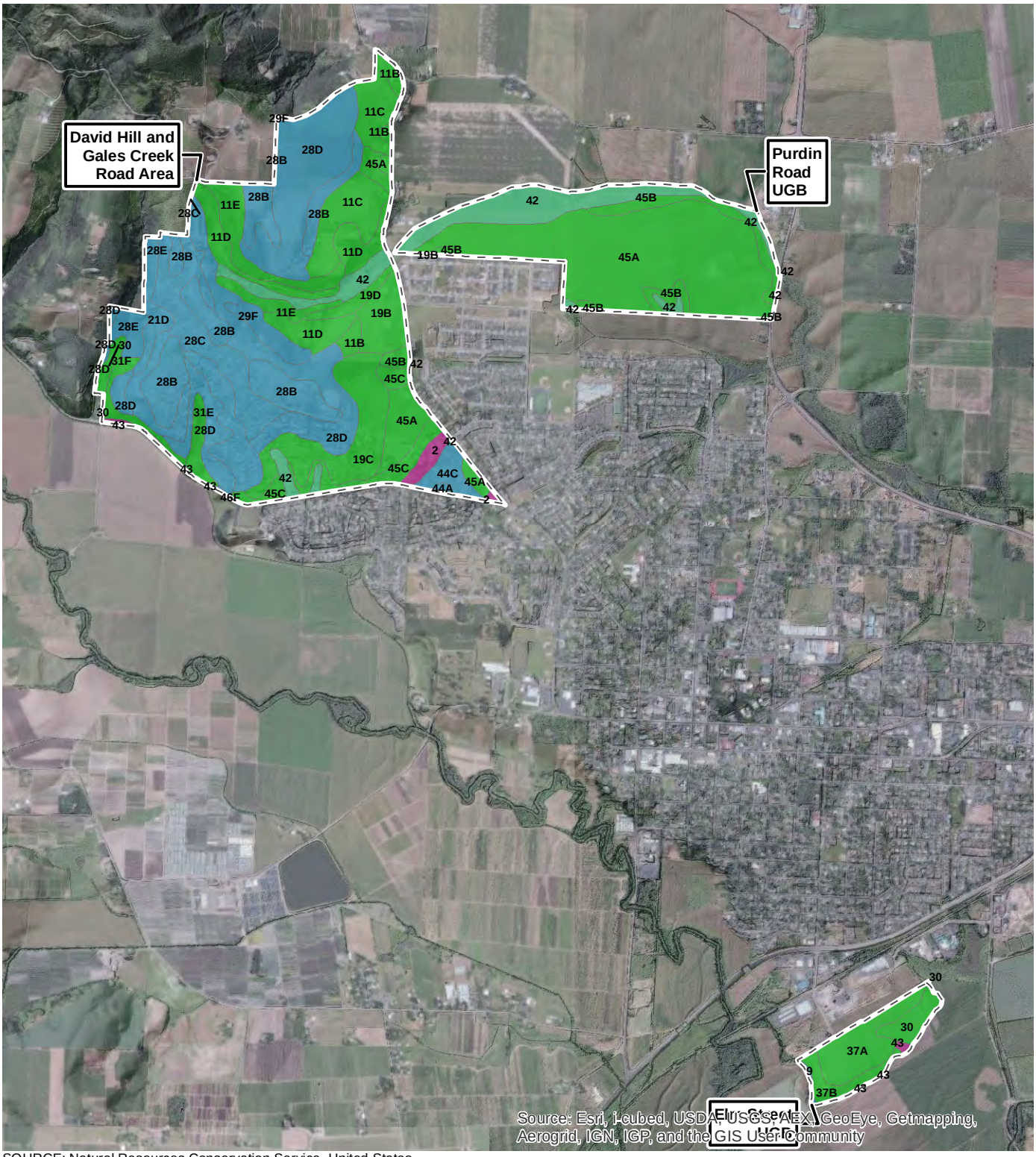
SOILS - LINEAR EXTENSIBILITY

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **12**

L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig12 Soil LinExt.mxd



SOURCE: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

Legend

Westside Planning Study Area

Hydrologic Soil Group

A
A/D
B
B/D
C
C/D
D

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

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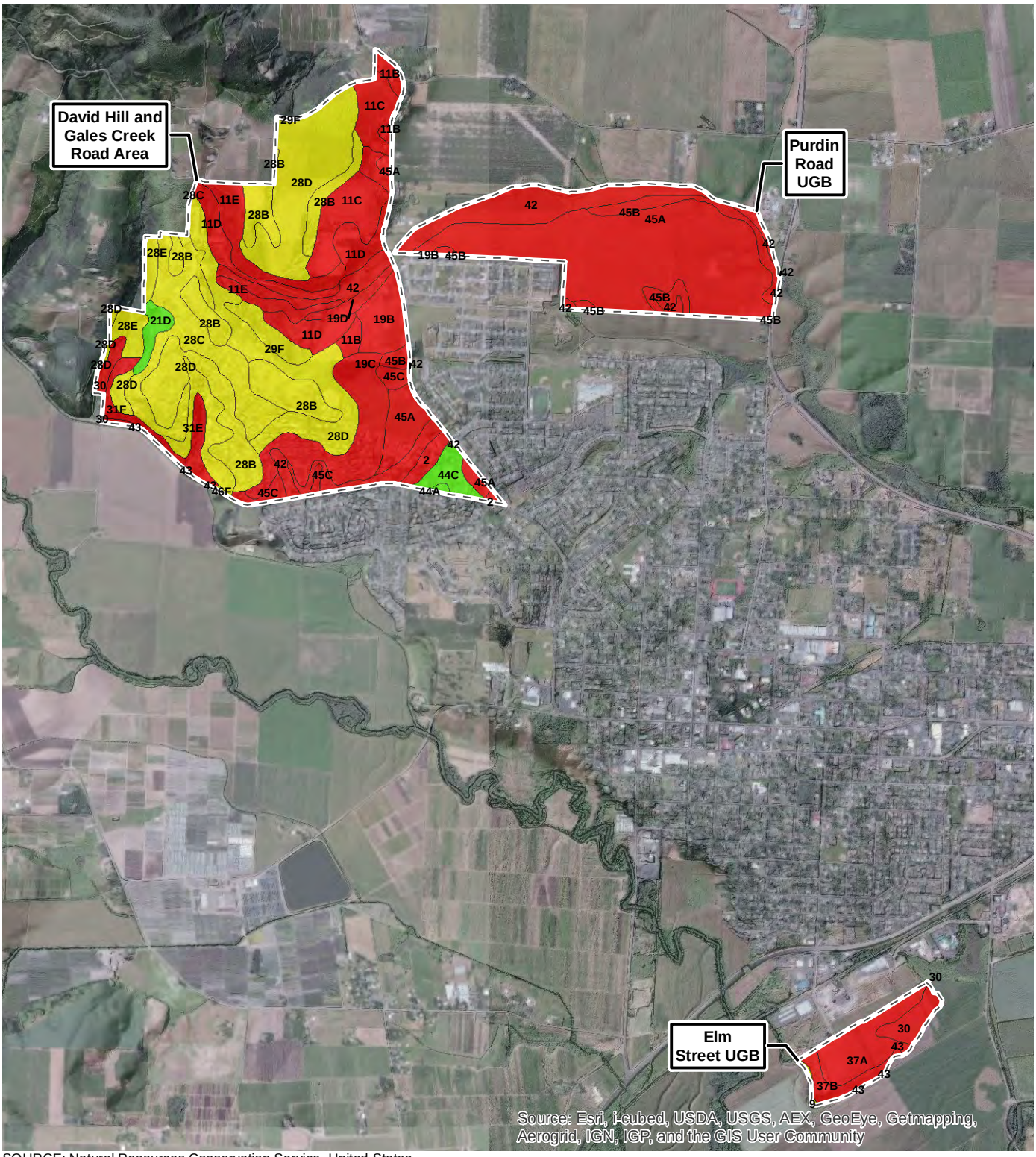
DATE JAN 2015

HYDROLOGIC SOIL GROUP

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **13**

L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig13_Soil_HydGrp.mxd



SOURCE: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

Legend

Westside Planning Study Area

Corrosion of Steel

- Low
- Moderate
- High

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

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L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig14 Steel.mxd

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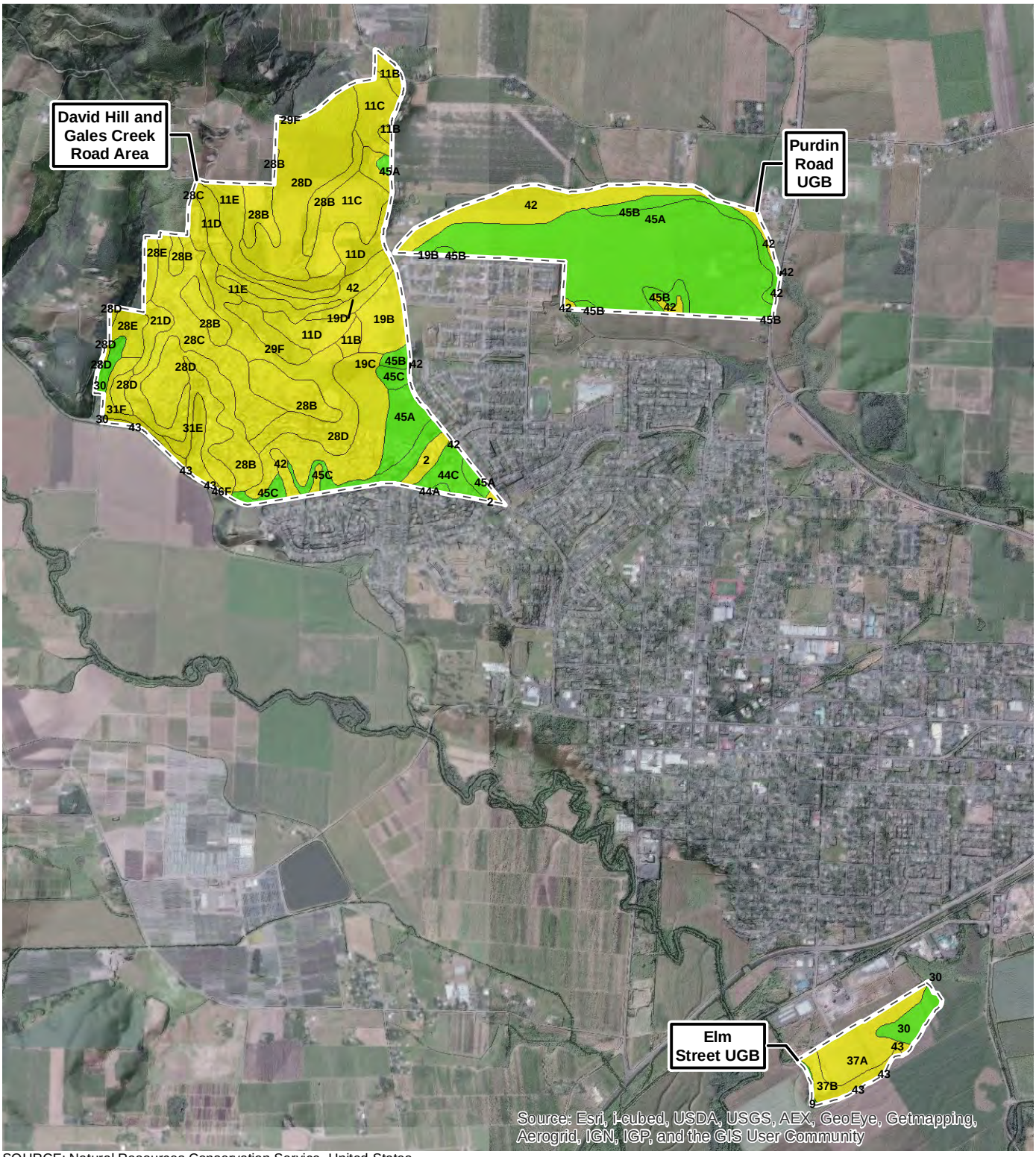
PROJECT # 73121.000

DATE JAN 2015

SOILS - CORROSION OF STEEL

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **14**



SOURCE: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

Legend

Westside Planning Study Area

Corrosion of Concrete

- Low
- Moderate
- High

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

PREPARED FOR: SCJ Alliance

L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig15 Concrete.mxd

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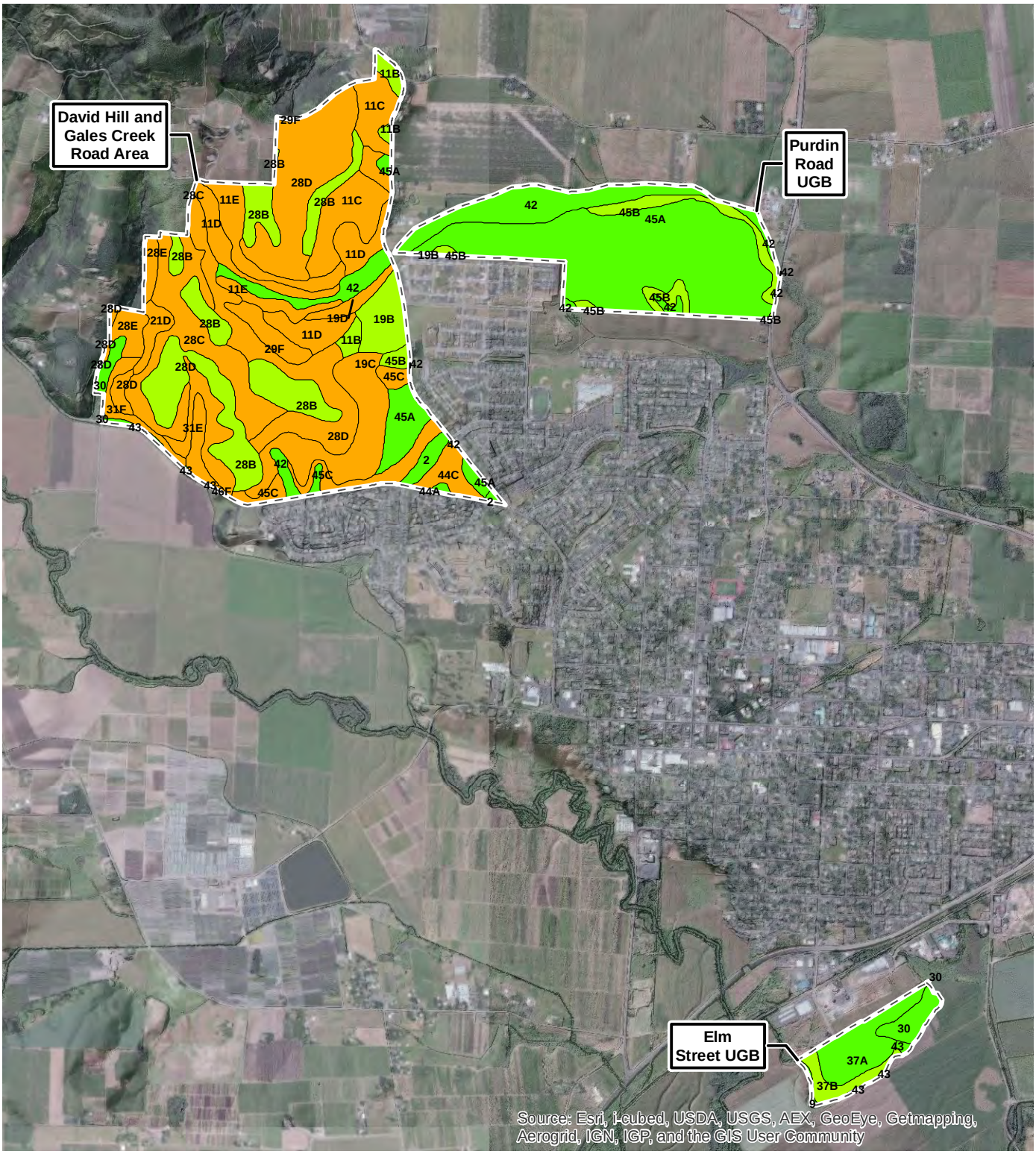
DATE JAN 2015

SOILS - CORROSION OF CONCRETE

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **15**



SOURCE: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

Legend

Westside Planning Study Area

Soil Erosion (Road, Trail)

- Very Severe
- Severe
- Moderate
- Slight

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

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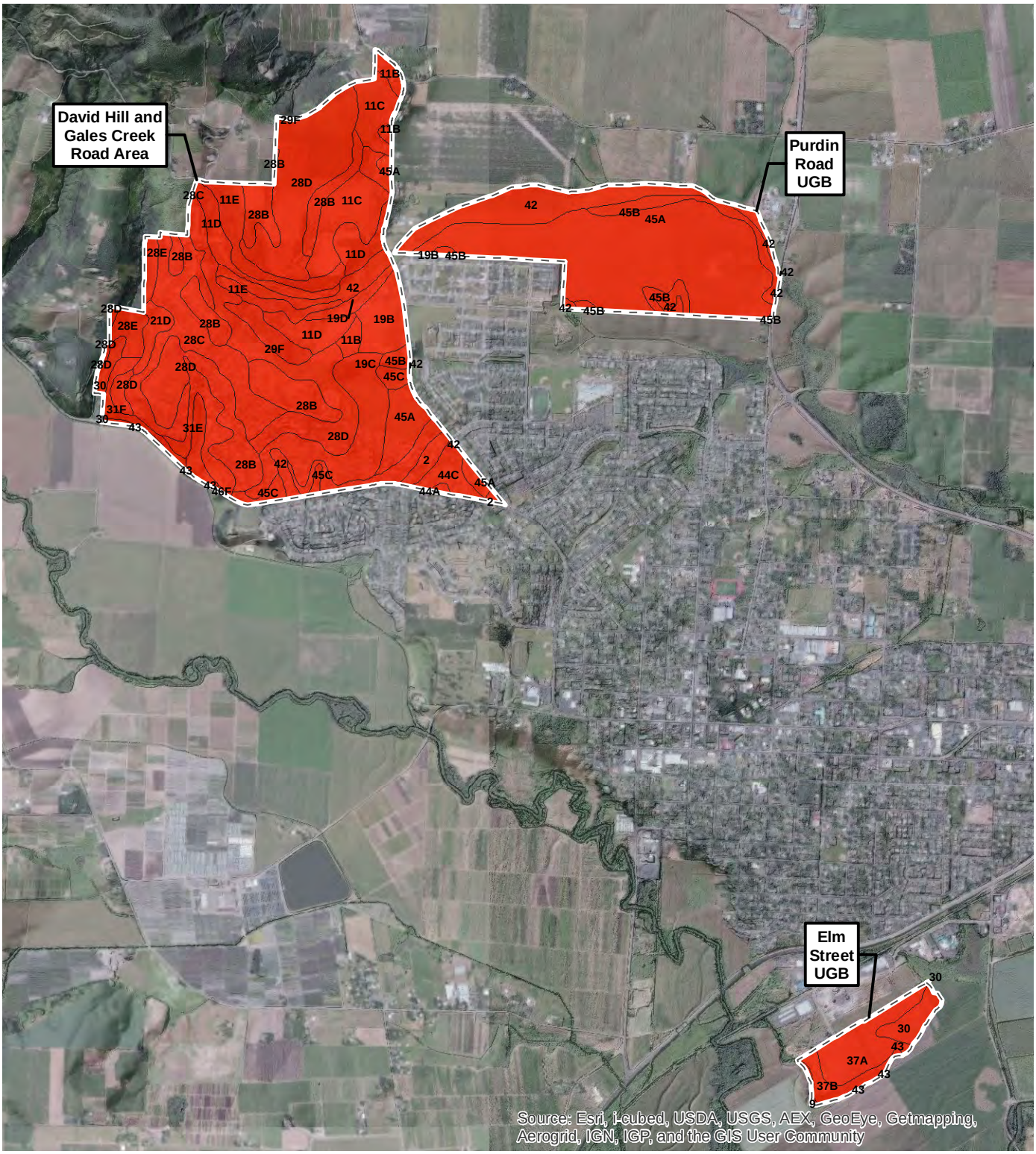
SOILS - EROSION HAZARD (ROADS AND TRAILS)

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **16**



SOURCE: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed 11/07/14

Legend

Westside Planning Study Area

Local Roads and Streets

- Very limited
- Somewhat Limited
- Not Limited

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

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L:\Projects\73000\73100-73199\73121_FirstGroveWestsidePlanning\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig17_RdsStreet.mxd

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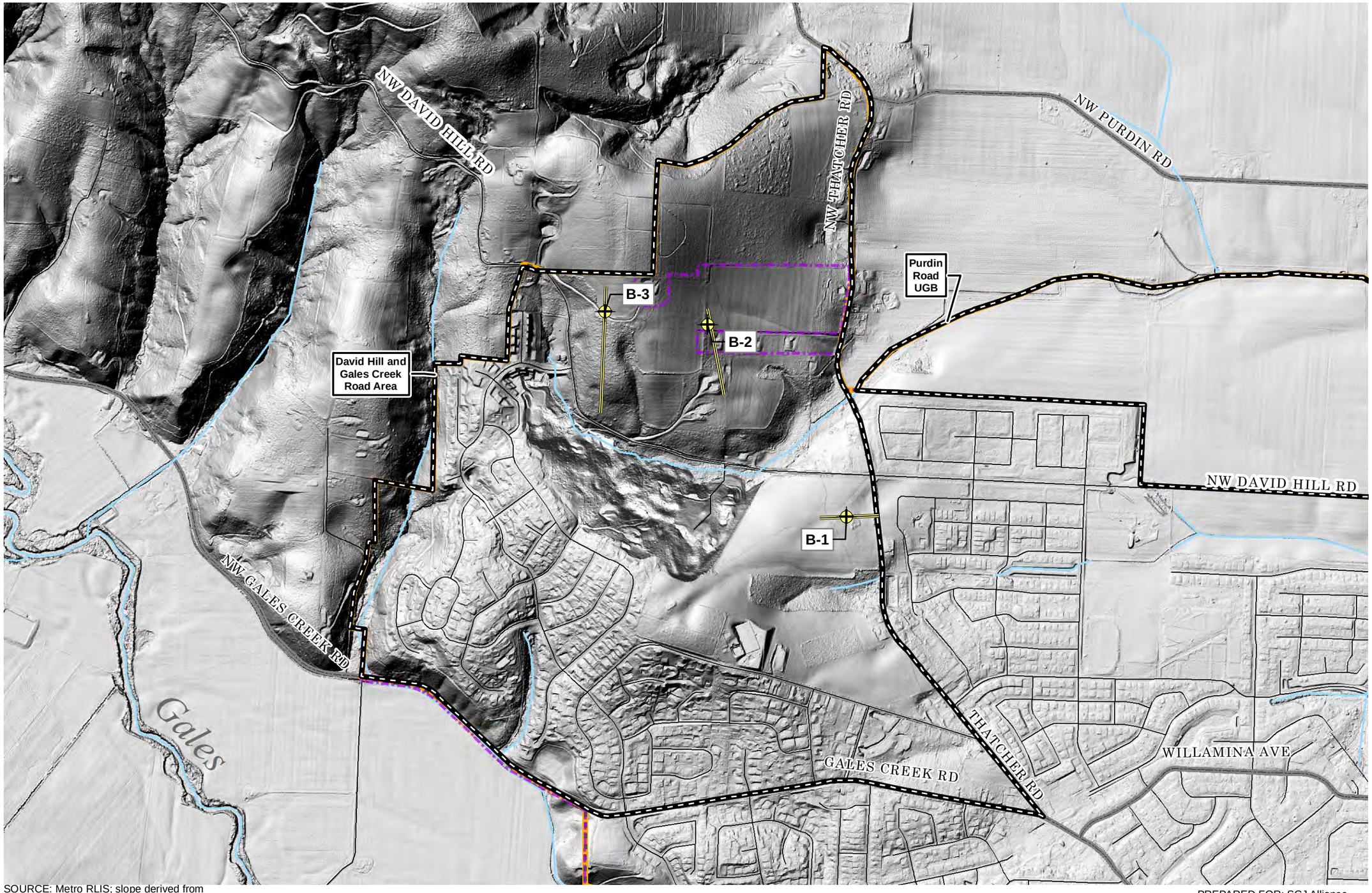
SOILS - LOCAL ROADS AND STREETS

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **17**



SOURCE: Metro RLIS; slope derived from Oregon DOGAMI data and DEM acquired 10/28/2014

LEGEND

- Westside Planning Study Area
- Urban growth boundary
- Forest Grove City Boundary
- Borings
- Profile
- Arterial streets
- Streets
- Streams and water bodies

DAVID HILL & GALES CREEK ROAD AREA LIDAR

PREPARED FOR: SCJ Alliance

0 500 1,000 2,000 '

1 inch = 1,000 feet

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FOREST GROVE WESTSIDE PLANNING PROJECT

FOREST GROVE, OREGON

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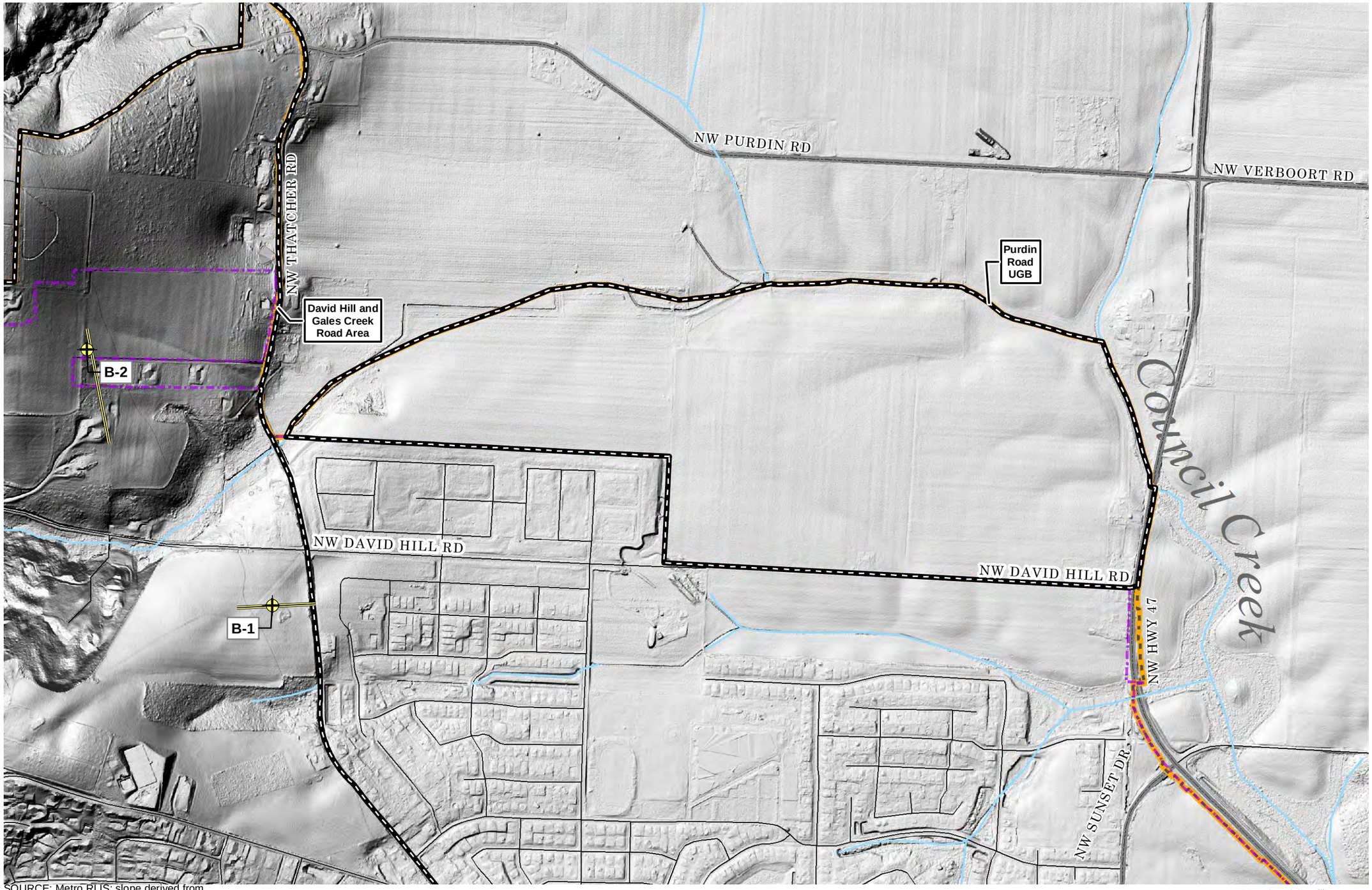
FIGURE	18

L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig18 DHGC LiDAR.mxd



L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig19_Purdin_LiDAR.mxd

SOURCE: Metro RLIS; slope derived from Oregon DOGAMI data and DEM acquired 10/28/2014

LEGEND

- Westside Planning Study Area
- Urban growth boundary
- Forest Grove City Boundary
- Borings
- Profile
- Arterial streets
- Streets
- Streams and water bodies

PURDIN ROAD UGB
LIDAR

PREPARED FOR: SCJ Alliance

0 375 750 1,500 '

1 inch = 750 feet

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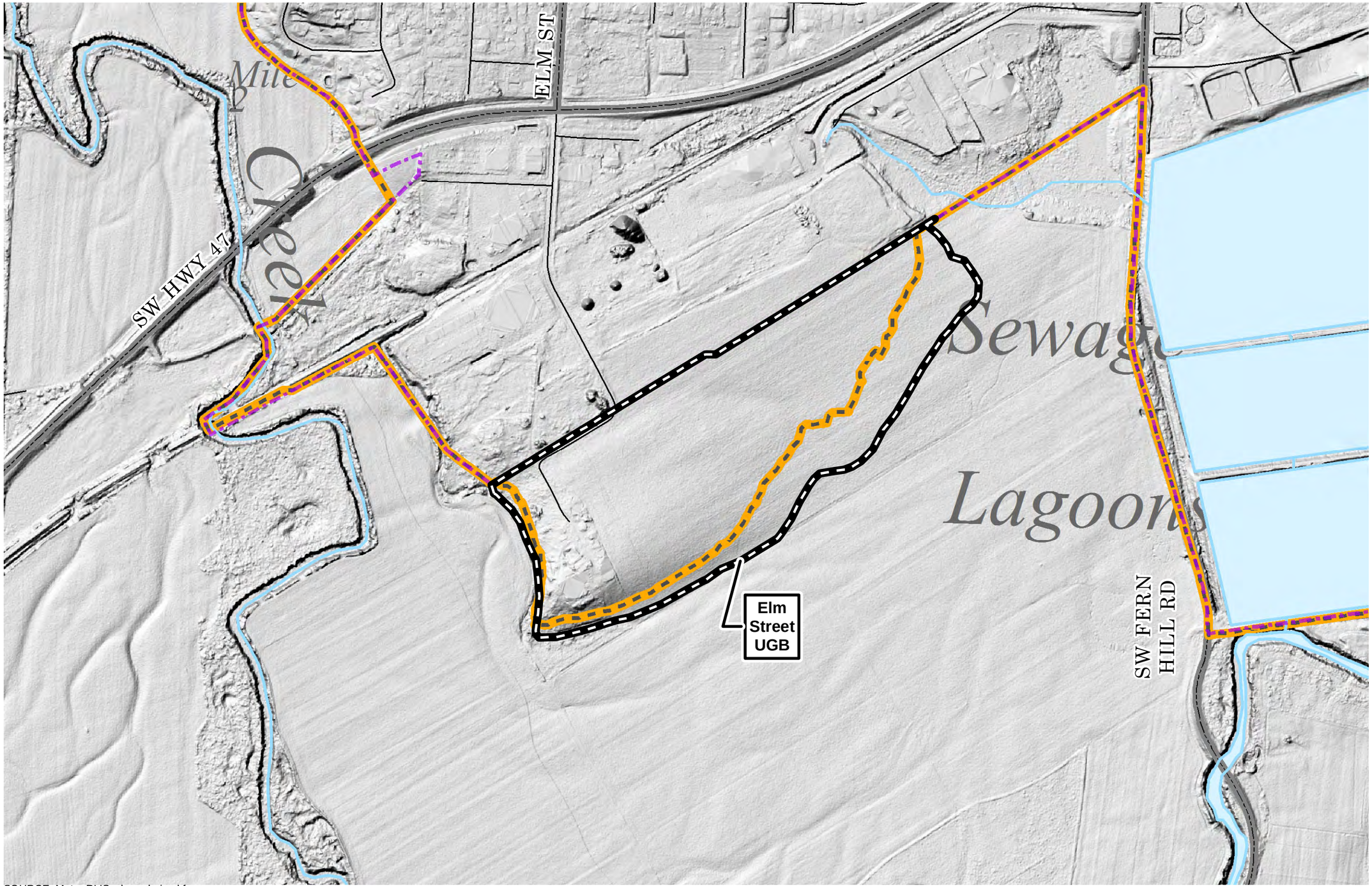
FOREST GROVE WESTSIDE PLANNING PROJECT

FOREST GROVE, OREGON

PROJECT	73121.000
DATE	JAN 2015
FIGURE	19



SOURCE: Metro RLIS; slope derived from Oregon DOGAMI data and DEM acquired 10/28/2014

LEGEND

- Westside Planning Study Area
- Urban growth boundary
- Forest Grove City Boundary
- Arterial streets
- Streets
- Streams and water bodies

ELM STREET UGB
LIDAR

PREPARED FOR: SCJ Alliance

0 250 500 1,000 '

1 inch = 500 feet

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FOREST GROVE WESTSIDE PLANNING PROJECT

FOREST GROVE, OREGON

PROJECT	73121.000
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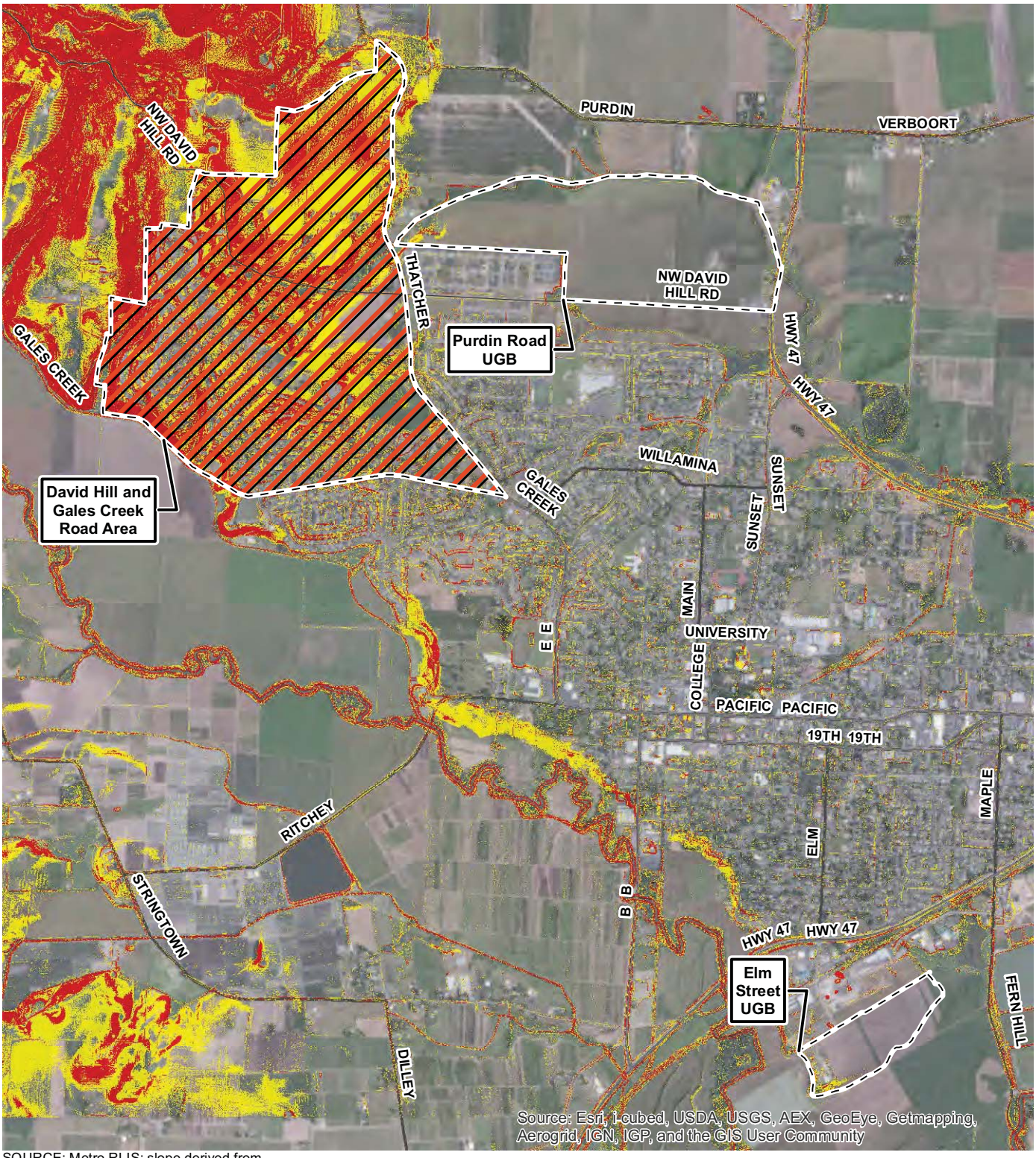
FIGURE	20

L:\Projects\73000\73100-73199\73121 FrstGroveWestsidePlanng\Plans - Maps - Specs\GIS\MXD\Report Figures\Fig20 Elm LiDAR.mxd



SOURCE: Metro RLIS; slope derived from
Oregon DOGAMI data and DEM acquired 10/28/2014

Legend

- Westside Planning Study Area
- Arterial streets
- > 20%
- 10-20%
- Landslide Study Zone - Possible

0 1,250 2,500 5,000 '

1 inch = 2,500 feet

PREPARED FOR: SCJ Alliance

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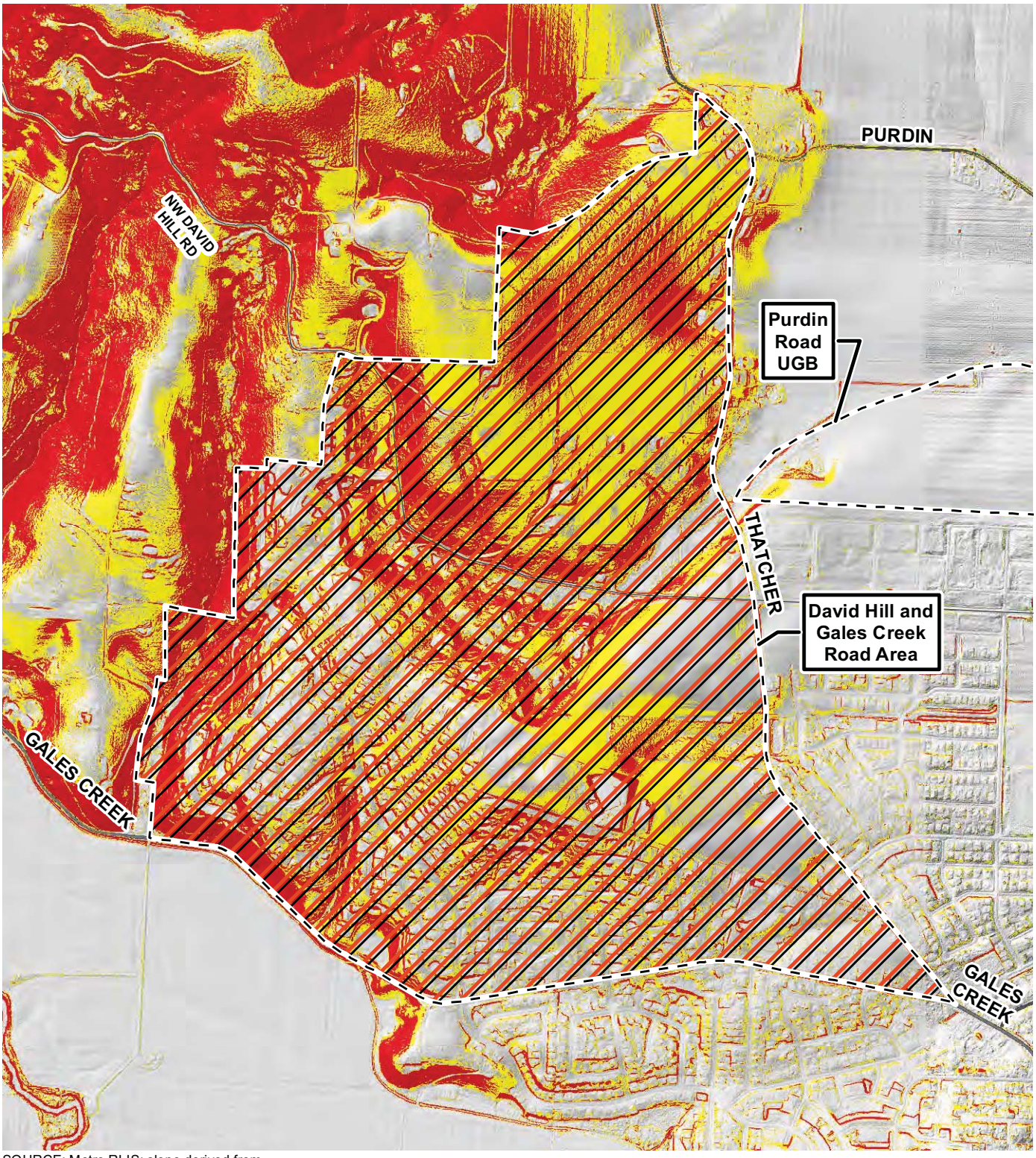
STUDY AREAS SLOPE PERCENTAGES

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **21**



SOURCE: Metro RLIS; slope derived from Oregon DOGAMI data and DEM acquired 10/28/2014

Legend

- Westside Study Areas
- Arterial streets
- Slope 10-20%
- Slope >20%
- Landslide Study Zone -Possible

0 625 1,250 2,500 '

1 inch = 1,250 feet

PREPARED FOR: SCJ Alliance

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DATE JAN 2015

DH&GCR SLOPE PERCENTAGES

WESTSIDE PLANNING PROJECT
FOREST GROVE, OREGON

FIGURE **22**

ATTACHMENT A

Soil Classification Descriptions

ATTACHMENT A – SOIL CLASSIFICATION DESCRIPTIONS

Unified Soil Classification (Surface)

The Unified soil classification system classifies mineral and organic mineral soils for engineering purposes on the basis of particle-size characteristics, liquid limit, and plasticity index. It identifies three major soil divisions: (i) coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074 mm in diameter; (ii) fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter; and (iii) highly organic soils that demonstrate certain organic characteristics. These divisions are further subdivided into a total of 15 basic soil groups. The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM D 2487 shows the criteria chart used for classifying soil in the Unified system and the 15 basic soil groups of the system and the plasticity chart for the Unified system.

The various groupings of this classification correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can serve to make some general interpretations relating to probable performance of the soil for engineering uses.

For each soil horizon in the database one or more Unified soil classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

AASHTO Group Classification

AASHTO group classification is a system that classifies soils specifically for geotechnical engineering purposes that are related to highway and airfield construction. It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index. This classification system is covered in AASHTO Standard No. M 145-82. The classification is based on that portion of the soil that is smaller than 3 inches in diameter.

The AASHTO classification system has two general classifications: (i) granular materials having 35 percent or less, by weight, particles smaller than 0.074 mm in diameter and (ii) silt-clay materials having more than 35 percent, by weight, particles smaller than 0.074 mm in diameter. These two divisions are further subdivided into seven main group classifications, plus eight subgroups, for a total of fifteen for mineral soils. Another class for organic soils is used.

For each soil horizon in the database one or more AASHTO Group Classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

Depth to Restrictive Layer

A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers.

This theme presents the depth to any type of restrictive layer that is described for each map unit. If more than one type of restrictive layer is described for an individual soil type, the depth to

the shallowest one is presented. If no restrictive layer is described in a map unit, it is represented by the "> 200" depth class.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Natural Drainage Class
"Drainage class (natural)" refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Capacity of Most Limiting Layer to transmit Water
Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity is considered in the design of soil drainage systems and septic tank absorption fields.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

The numeric Ksat values have been grouped according to standard Ksat class limits.

Depth to Water Table
"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Frequency of Flooding
Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent.

"None" means that flooding is not probable. The chance of flooding is nearly 0 percent in any year. Flooding occurs less than once in 500 years.

"Very rare" means that flooding is very unlikely but possible under extremely unusual weather conditions. The chance of flooding is less than 1 percent in any year.

"Rare" means that flooding is unlikely but possible under unusual weather conditions. The chance of flooding is 1 to 5 percent in any year.

"Occasional" means that flooding occurs infrequently under normal weather conditions. The chance of flooding is 5 to 50 percent in any year.

"Frequent" means that flooding is likely to occur often under normal weather conditions. The chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year.

"Very frequent" means that flooding is likely to occur very often under normal weather conditions. The chance of flooding is more than 50 percent in all months of any year.

Frequency of Ponding
Ponding is standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes. Ponding frequency classes are based on the number of times that ponding occurs over a given period. Frequency is expressed as none, rare, occasional, and frequent.

"None" means that ponding is not probable. The chance of ponding is nearly 0 percent in any year.

"Rare" means that ponding is unlikely but possible under unusual weather conditions. The chance of ponding is nearly 0 percent to 5 percent in any year.

"Occasional" means that ponding occurs, on the average, once or less in 2 years. The chance of ponding is 5 to 50 percent in any year.

"Frequent" means that ponding occurs, on the average, more than once in 2 years. The chance of ponding is more than 50 percent in any year.

Linear Extensibility (Shrink/Swell) (Figure 12)
Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A

"representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Hydrologic Soil Group (Figure 13)
Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A – Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B – Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C – Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D – Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in Group D are assigned to dual classes.

Corrosion of Steel (Figure 14)
"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Corrosion of Concrete (Figure 15)
"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Farmland Classification
Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Erosion Hazard (Road, Trail) (Figure 16)
The ratings in this interpretation indicate the hazard of soil loss from unsurfaced roads and trails. The ratings are based on soil erosion factor K, slope, and content of rock fragments.

The ratings are both verbal and numerical. The hazard is described as "slight," "moderate," or "severe." A rating of "slight" indicates that little or no erosion is likely; "moderate" indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed; and "severe" indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are needed.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site.

Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Mechanical Site Preparation (Surface)
The ratings in this interpretation indicate the suitability for use of surface-altering soil tillage equipment during site preparation in forested areas. The ratings are based on slope, depth to a restrictive layer, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The part of the soil from the surface to a depth of about 1 foot is considered in the ratings.

The ratings are both verbal and numerical. Rating class terms indicate the degree to which the soils are suited to this aspect of forestland management. The soils are described as "well suited," "poorly suited," or "unsuited" to this management activity. "Well suited" indicates that the soil has features that are favorable for the specified kind of site preparation and has no limitations. Good performance can be expected, and little or no maintenance is needed. "Poorly suited" indicates that the soil has one or more properties that are unfavorable for the specified kind of site preparation. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. "Unsuited" indicates that the expected performance of the soil is unacceptable for the specified kind of site preparation or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Mechanical Site Preparation (Deep)
The ratings in this interpretation indicate the suitability for the use of deep soil tillage equipment during site preparation in forested areas. The ratings are based on slope, depth to a restrictive layer, rock fragments on or below the surface, depth to a water table, and ponding. The part of the soil from the surface to a depth of about 3 feet is considered in the ratings.

The ratings are both verbal and numerical. Rating class terms indicate the degree to which the soils are suited to this aspect of forestland management. The soils are described as "well

suited," "poorly suited," or "unsuited" to this management activity. "Well suited" indicates that the soil has features that are favorable for the specified kind of site preparation and has no limitations. Good performance can be expected, and little or no maintenance is needed. "Poorly suited" indicates that the soil has one or more properties that are unfavorable for the specified kind of site preparation. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. "Unsuited" indicates that the expected performance of the soil is unacceptable for the specified kind of site preparation or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Soil Rutting Hazard

The ratings in this interpretation indicate the hazard of surface rut formation through the operation of forestland equipment. Soil displacement and puddling (soil deformation and compaction) may occur simultaneously with rutting.

Ratings are based on depth to a water table, rock fragments on or below the surface, the Unified classification of the soil, depth to a restrictive layer, and slope. The hazard is described as slight, moderate, or severe. A rating of "slight" indicates that the soil is subject to little or no rutting. "Moderate" indicates that rutting is likely. "Severe" indicates that ruts form readily.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented

to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Suitability for Roads (Natural Surface)(OR)
The ratings in this interpretation indicate the suitability for using the natural surface of the soil for roads. The ratings are based on slope, rock fragments on the surface, plasticity index, content of sand, the Unified classification of the soil, depth to a water table, ponding, flooding, and the hazard of soil slippage.

The ratings are both verbal and numerical. The soils are described as "well suited," "moderately suited," or "poorly suited" to this use. "Well suited" indicates that the soil has features that are favorable for the specified kind of roads and has no limitations. Good performance can be expected, and little or no maintenance is needed. "Moderately suited" indicates that the soil has features that are moderately favorable for the specified kind of roads. One or more soil properties are less than desirable, and fair performance can be expected. Some maintenance is needed. "Poorly suited" indicates that the soil has one or more properties that are unfavorable for the specified kind of roads. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen, which is displayed on the report. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the Selected Soil Interpretations report with this interpretation included from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Local Roads and Streets (Figure 17)
Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material

(concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

ATTACHMENT B

Soil Boring Logs

PBS Engineering + Environmental
4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

WEST SIDE PLANNING PROJECT
FOREST GROVE, OREGON

PBS PROJECT NUMBER:
73121.000

BORING B-1

APPROX. BORING B-1 LOCATION:
(See Site Plan)

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	BLOW COUNT / DYNAMIC CONE PENETROMETER / MOISTURE CONTENT % / RQD% / CORE REC%	INSTALLATION AND COMMENTS
0.0		Topsoil (6 inches)	0.5				Surface Conditions: Grass lawn
		Medium stiff light brown LEAN CLAY (CL); medium plasticity; moist.			S-1	8	
5.0		Medium stiff red brown FAT CLAY (CL); high plasticity; moist.	4.0		S-2	7	
		Medium stiff to very stiff red brown SILT (ML); low plasticity; moist.	7.0		S-3	8	
10.0					S-4	15	
15.0		Very stiff red LEAN CLAY (CL); medium plasticity; moist.	14.0		S-5	15	
		Very stiff red FAT CLAY (CH); high plasticity; moist.	18.0		S-6	18	
20.0		Boring complete at 21.5 ft bgs Groundwater not observed at time of exploration	21.5				
25.0							
30.0							

0 50 100

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: B. Portwood

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT:
LOGGING COMPLETED: 11/14/14

FIGURE B1

BORING LOG 73121 BORINGS B1 THRU B3.GPJ PBS DATATMPL.GEO.GDT PRINT DATE: 12/5/14:MS

PBS Engineering + Environmental
4412 SW Corbett Avenue
Portland, Oregon 97239
Phone: 503.248.1939
Fax: 866.727.0140

WEST SIDE PLANNING PROJECT
FOREST GROVE, OREGON

PBS PROJECT NUMBER:
73121.000

BORING B-2

APPROX. BORING B-2 LOCATION:
(See Site Plan)

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	BLOW COUNT / DYNAMIC CONE PENETROMETER / MOISTURE CONTENT % / RQD% / CORE REC%	INSTALLATION AND COMMENTS
0.0		NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.				0 50 100	Surface Conditions: Gravel driveway
		3/4"-0 crushed rock	0.3				
		Medium stiff light brown SILT (ML); low plasticity; moist.			S-1	8	
5.0					S-2	10	
					S-3	4	
		Very stiff light red brown spotted dark brown SILT (ML); low plasticity; moist.	9.0				
10.0					SH-4		
				PP	S-5	16	PP = 4.5 Tsf tsf
15.0					S-6	15	
		Stiff red LEAN CLAY (CL); medium plasticity; moist.	18.0				
20.0					S-7	14	
25.0					S-8	12	
30.0					S-9	12	
		Boring complete at 31.5 ft bgs Groundwater not observed at time of drilling	31.5			0 50 100	

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: B. Portwood

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT:
LOGGING COMPLETED: 11/14/14

FIGURE B2

PBS Engineering + Environmental
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WEST SIDE PLANNING PROJECT
FOREST GROVE, OREGON

PBS PROJECT NUMBER:
73121.000

BORING B-3

APPROX. BORING B-3 LOCATION:
(See Site Plan)

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	BLOW COUNT / DYNAMIC CONE PENETROMETER / MOISTURE CONTENT % / RQD% / CORE REC%	INSTALLATION AND COMMENTS
0.0		NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.				0 50 100	Surface Conditions: AC driveway
		Asphalt (2 inches)	0.3				
		3/4"-0 Crushed rock FILL	1.0				
		Medium stiff to stiff light brown LEAN CLAY (CL); medium plasticity; dry to moist.			S-1	12	
5.0					S-2	10	
					S-3	7	
		Stiff red brown LEAN CLAY (CL); medium plasticity; moist.	9.0				
10.0					S-4	14	
		Stiff red FAT CLAY (CH); high plasticity; moist.	14.0				
15.0					S-5	13	
20.0					S-6	12	
25.0					S-7	9	
		Stiff light yellow brown with red-brown and white streaks FAT CLAY (CH); high plasticity; moist to wet.	28.0				
30.0					S-8	11	
		Boring complete at 31.5 ft bgs Groundwater not observed at time of drilling	31.5				
						0 50 100	

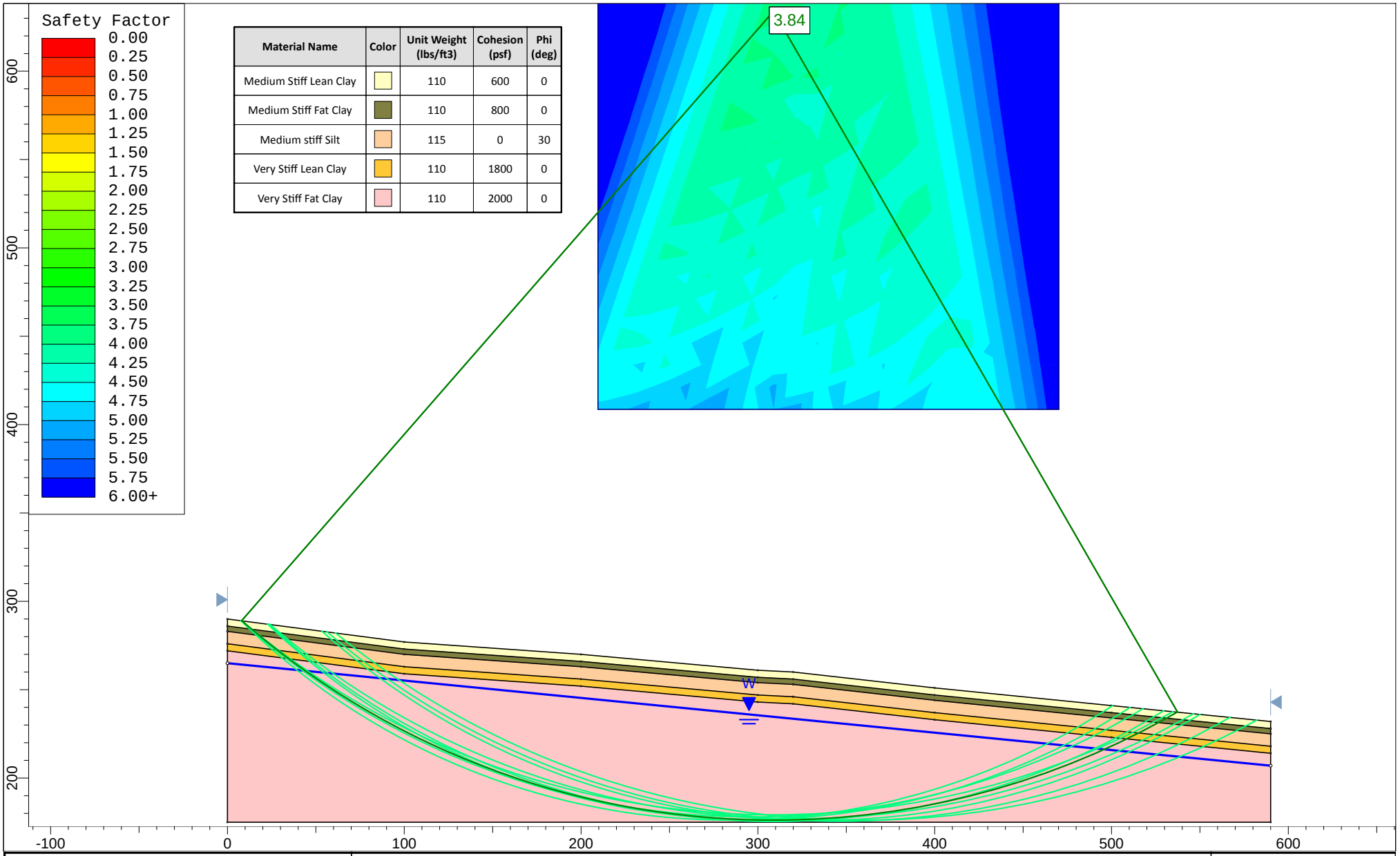
DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: B. Portwood

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT:
LOGGING COMPLETED: 11/14/14

FIGURE B3

ATTACHMENT C

Preliminary Slope Stability Analyses

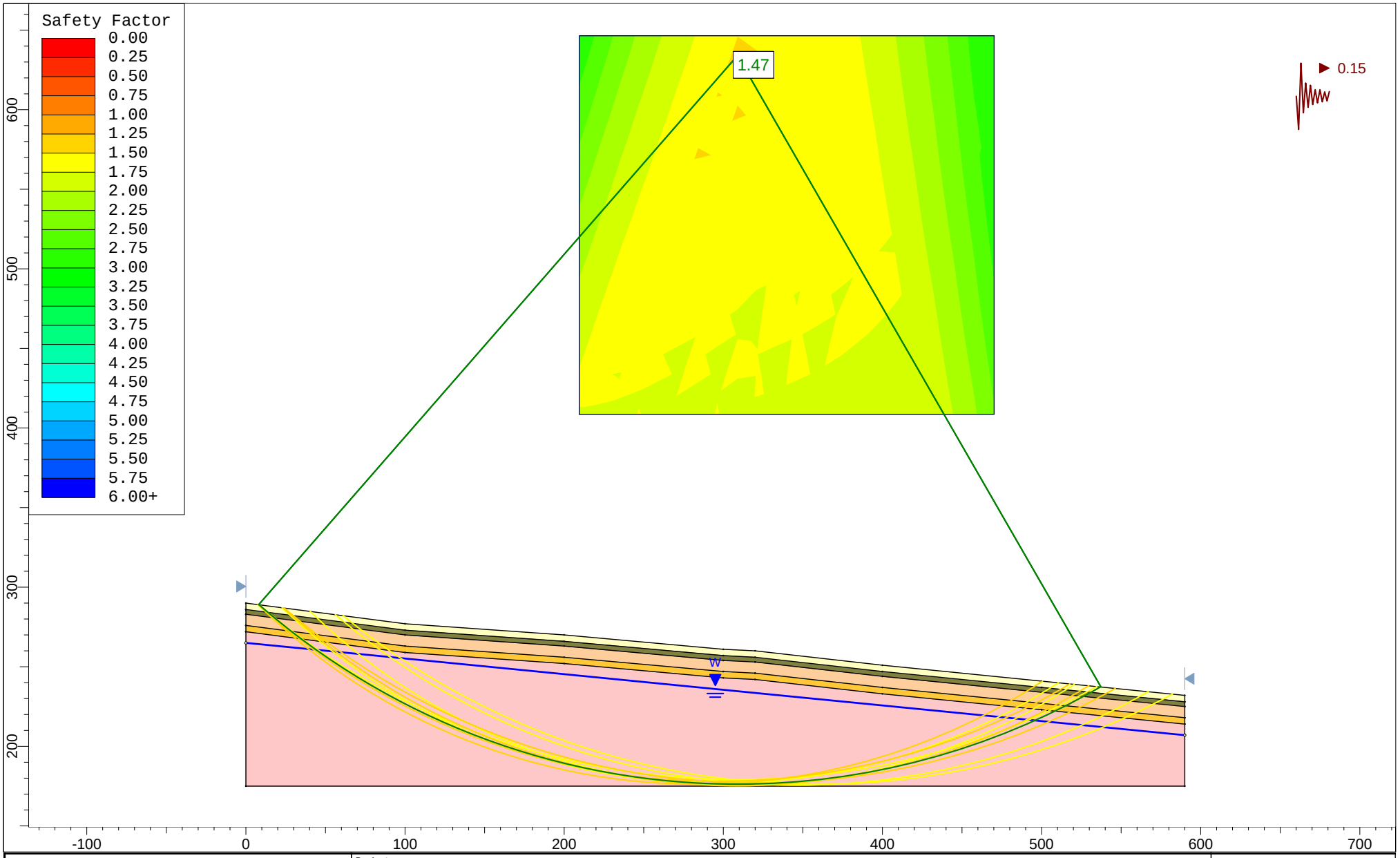


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Medium Stiff Lean Clay		110	600	0
Medium Stiff Fat Clay		110	800	0
Medium stiff Silt		115	0	30
Very Stiff Lean Clay		110	1800	0
Very Stiff Fat Clay		110	2000	0

PBS Engineering + Environmental

SLIDEINTERPRET 6.025

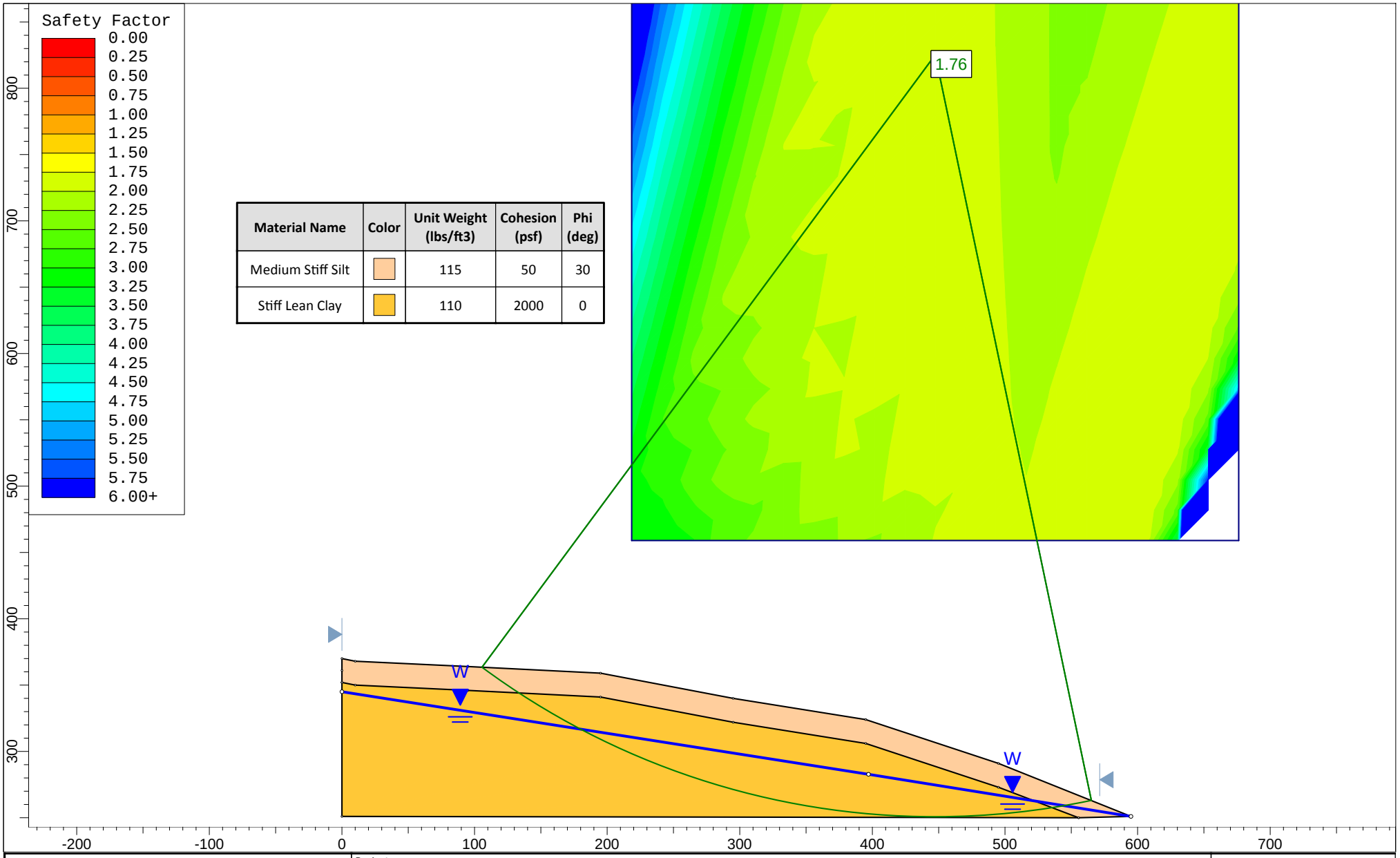
Project	73121.000 Westside Planning - Forest Grove		FIGURE: C1
Analysis Description	B-1 Static		
Drawn By	R. White	*Company*	
Date	12/3/2014, 10:20:23 AM	*File Name*	B1.slim



PBS Engineering + Environmental

SLIDEINTERPRET 6.025

Project	73121.000 Westside Planning - Forest Grove		FIGURE: C2
Analysis Description	B-1 Seismic		
Drawn By	R. White	*Company*	
Date	12/3/2014, 10:20:23 AM	*File Name*	B1_seismic.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Medium Stiff Silt		115	50	30
Stiff Lean Clay		110	2000	0

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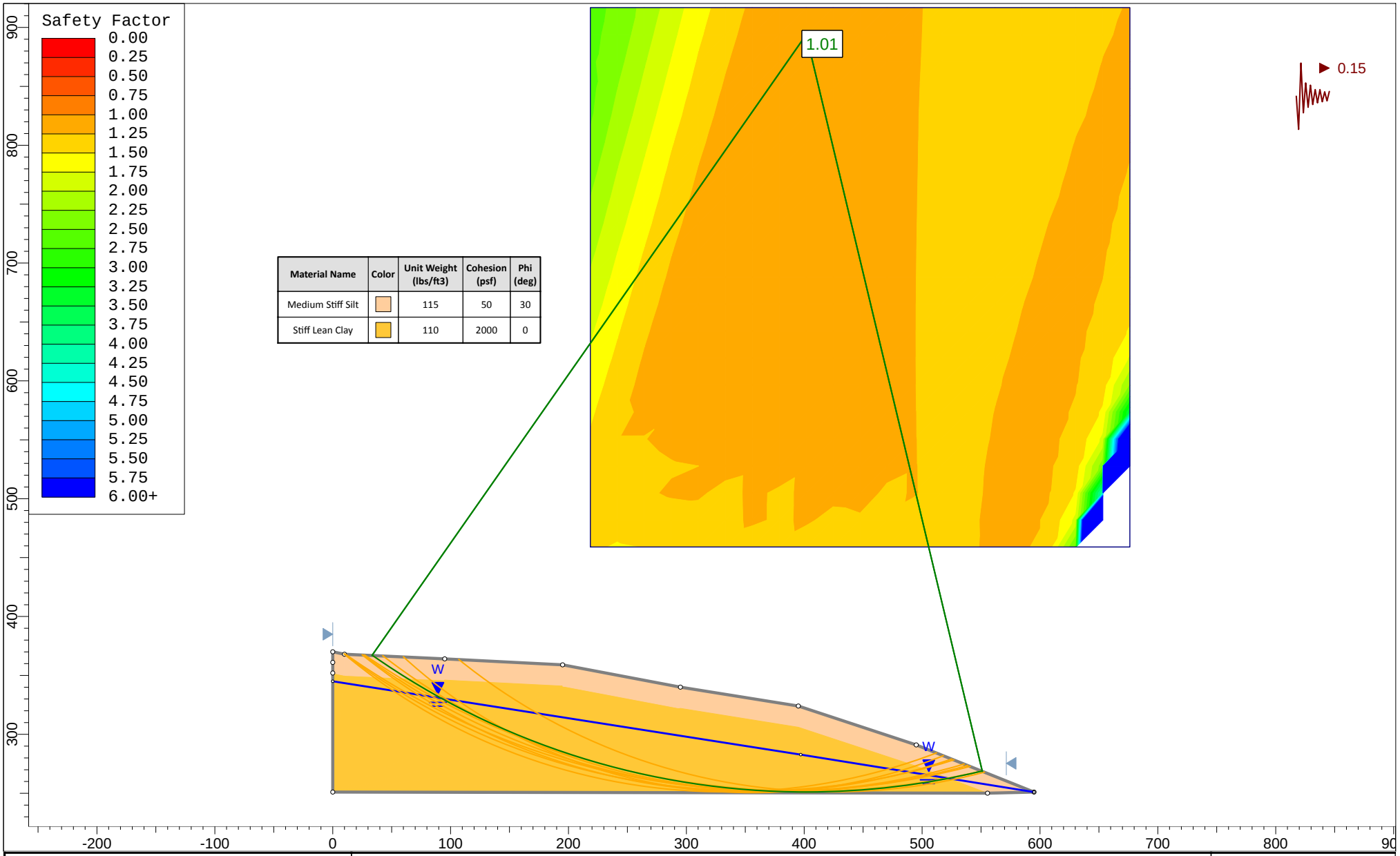
SLIDEINTERPRET 6.025

Project	73121.000 Westside Planning - Forest Grove		FIGURE: C3
Analysis Description	B-2 Static		
Drawn By	R. White	Company	
Date	12/3/2014, 10:55:33 AM	File Name	B2.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Medium Stiff Silt		115	50	30
Stiff Lean Clay		110	2000	0

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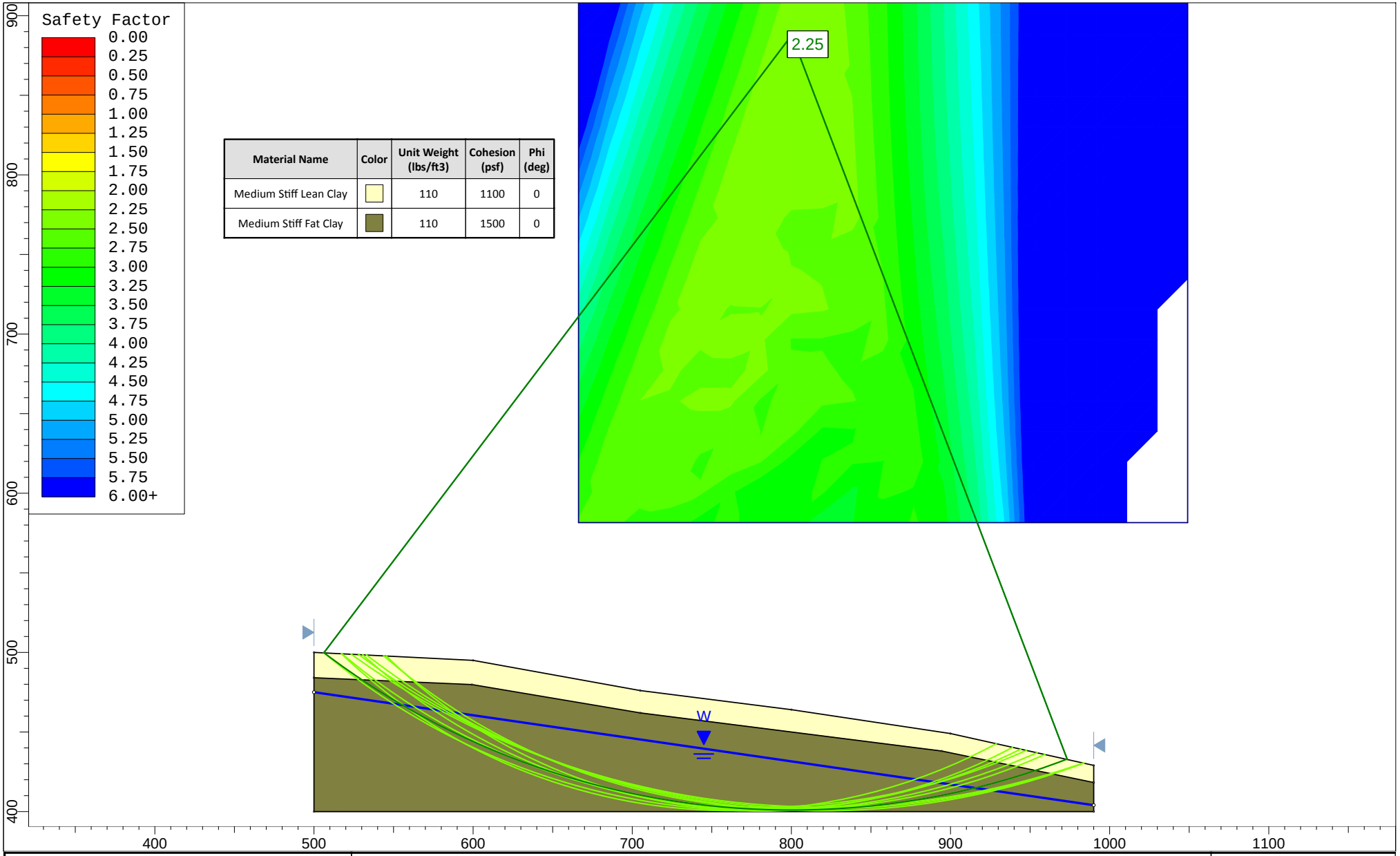
SLIDEINTERPRET 6.025

Project	73121.000 Westside Planning - Forest Grove		FIGURE:
Analysis Description	B-2 Seismic		C4
Drawn By	R. White	*Company*	
Date	12/3/2014, 10:55:33 AM	*File Name*	B2_seismic.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Medium Stiff Lean Clay		110	1100	0
Medium Stiff Fat Clay		110	1500	0

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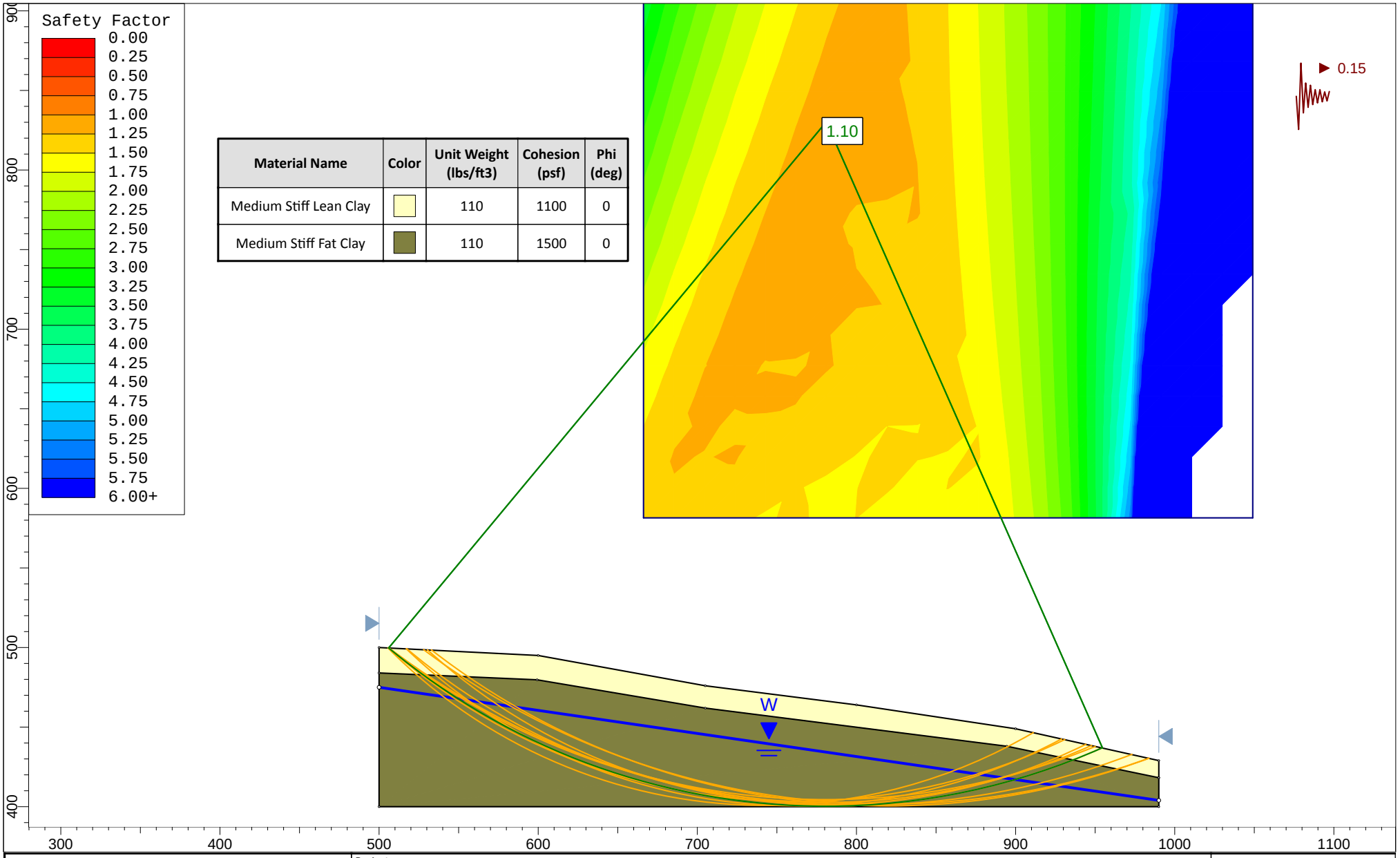
SLIDEINTERPRET 6.025

Project	73121.000 Westside Planning - Forest Grove
Analysis Description	B-3 Static
Drawn By	R. White
Company	
Date	12/3/2014, 9:53:35 AM
File Name	B3.slim

FIGURE:

C5



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Medium Stiff Lean Clay		110	1100	0
Medium Stiff Fat Clay		110	1500	0

PBS Engineering + Environmental

SLIDEINTERPRET 6.025

Project	73121.000 Westside Planning - Forest Grove
Analysis Description	B-3 Seismic
Drawn By	R. White
Company	
Date	12/3/2014, 9:53:35 AM
File Name	B3_seismic.slim

FIGURE:

C6