## Appendix C Map Portfolio

This appendix includes the following figures:

<table>
<thead>
<tr>
<th>Reach-scale Attribute</th>
<th>Description</th>
<th>Map Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Shoreline Jurisdiction</td>
<td>Approximate extent of SMP jurisdiction (current), approximate extent of SMP jurisdiction (predesignation), approximate extent of landslide hazard areas considered for optional jurisdiction.</td>
<td>1</td>
</tr>
</tbody>
</table>

### Physical Environment

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Map Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cover</td>
<td>USGS gap analysis program (GAP) data showing forested, shrub-covered, grass-covered, non-vegetated, and water areas. Includes tabular summary of vegetation/land cover.</td>
<td>2</td>
</tr>
<tr>
<td>Soil</td>
<td>USGS Soil Survey Geographic Database (SSURGO) and US Forest Service data.</td>
<td>3</td>
</tr>
<tr>
<td>Contours</td>
<td>LiDAR-derived 10- and 100-foot contours provided by Skamania County GIS.</td>
<td>4</td>
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<tr>
<td>Liquefaction Hazards</td>
<td>Displays hazard categories for land movement during earthquakes.</td>
<td>5</td>
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<tr>
<td>Geologic Hazards</td>
<td>Stevenson Critical Areas Hazard Map showing potentially unstable slopes, landslide hazard areas, scarps, and unstable soils. Includes memo from PBS Engineering, 2007.</td>
<td>5A</td>
</tr>
<tr>
<td>Floodplains</td>
<td>FEMA FIRM, Zone A on Map S30161 A, Panels 01-02 (Red) and Map S30160, Panel 425 (Yellow).</td>
<td>6</td>
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<tr>
<td>Channel Migration Zones</td>
<td>Department of Ecology Map and coarse-scale analysis of likely Channel Migration Zones (CMZs) in Skamania County. Includes memo.</td>
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<tr>
<td>Flowage Easements</td>
<td>Based on County easements records and shows vertical elevation of all flowage easements maintained by the Corps of Engineers for the Bonneville Dam Project.</td>
<td>6B</td>
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</table>

### Biological Resources

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Map Number</th>
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</thead>
<tbody>
<tr>
<td>PHS Data</td>
<td>WDFW Priority Habitat and Species (PHS) Wildlife GIS data. Includes species list by reach.</td>
<td>7</td>
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<tr>
<td>Wetlands</td>
<td>USFWS National Wetlands Inventory and Stevenson Critical Areas Wetland Map showing potential wetlands as identified by JD White and Associates in 2007. Includes acreage of wetlands.</td>
<td>8</td>
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</tbody>
</table>

### Land Use & Altered Conditions

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Map Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Land Use</td>
<td>County parcel data using Department of Revenue (DOR) codes (derived and categorized from Skamania County Assessor’s database).</td>
<td>9</td>
</tr>
<tr>
<td>Future Land Use</td>
<td>Map from 2013 Stevenson Comprehensive Plan designating areas for different types of residential and trade uses.</td>
<td>9A</td>
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<tr>
<td>Zoning</td>
<td>Map developed by Skamania County GIS using County and City maps.</td>
<td>10</td>
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<tr>
<td>Archeology/Historic Resources</td>
<td>Washington State Department of Archaeology and Historic Preservation (DAHP), includes publicly available information, excludes sensitive information.</td>
<td>14</td>
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### Public Access

<table>
<thead>
<tr>
<th>Attribute</th>
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<tr>
<td>Public Ownership</td>
<td>Public land includes all land owned by federal, state, or local government agencies. &quot;Rights-of-way&quot; were not classified as &quot;Public&quot;. Areas not covered by parcel dataset (i.e., large portion of the Columbia River) were classified as &quot;Public&quot;. Data for length and area in public ownership included and specific recreation areas also noted.</td>
<td>11</td>
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</table>

### Restoration Opportunities

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Map Number</th>
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</thead>
<tbody>
<tr>
<td>Impervious Surfaces</td>
<td>County data was used to calculate impervious area (square feet) and linear distance of impervious surface (feet). Includes tabular data for impervious surface types.</td>
<td>12</td>
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<tr>
<td>Rooftops</td>
<td>County data on rooftops within shoreline area and measuring rooftop distance to OHWM. Includes tabular data for building number and size.</td>
<td>13</td>
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<tr>
<td>Shoreline Modifications</td>
<td>Aerial photo-derived data by Skamania County GIS. Includes tabular data on armoring length, island dimensions, and size of docks/piers.</td>
<td>15</td>
</tr>
<tr>
<td>Fish Passage Barriers</td>
<td>WDFW Fish Passage and Diversion Screening Inventory Database. Includes reports for identified barriers.</td>
<td>16</td>
</tr>
</tbody>
</table>
Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally delineated or surveyed and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm or modify the information shown on this map. Shoreline jurisdiction will be determined at time of project review using the best available site-specific information.
Quantities by type*:

<table>
<thead>
<tr>
<th>Type</th>
<th>Acres</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>89.7</td>
<td>43.9%</td>
</tr>
<tr>
<td>Shrub</td>
<td>25.0</td>
<td>12.3%</td>
</tr>
<tr>
<td>Grass</td>
<td>39.5</td>
<td>19.4%</td>
</tr>
<tr>
<td>NonVeg</td>
<td>49.8</td>
<td>24.4%</td>
</tr>
<tr>
<td>Total:</td>
<td>204.0</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

* Water area is not included in the above quantities and percentages. The total acreage of water in the preliminary jurisdiction area is 858.2 acres, which is 80.8% of the total area.

Heritage tree note:
A review of WA Natural Heritage Program public GIS data (Feb, 2015) did not indicate the presence of any heritage species in the shoreline jurisdiction area.

FIGURE 2: Land Cover
FIGURE 3: Soils

LEGEND

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple</td>
<td>Stevenson City Limits</td>
</tr>
<tr>
<td>Orange</td>
<td>Public Roads</td>
</tr>
<tr>
<td>Green</td>
<td>State Boundary</td>
</tr>
<tr>
<td>Yellow</td>
<td>Road</td>
</tr>
<tr>
<td>Gray</td>
<td>Parcel</td>
</tr>
</tbody>
</table>

Skamania / Stevenson Soils

- AAE NT S
- BEN EV I LLE
- STE E VE R
- STE VEN S
- SKAMANIA

Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally defined or surveyed and are intended for planning purposes only. Additional site-specific evaluation may be necessary to confirm or modify the information shown on the map. Shoreline jurisdiction will be determined at the time of project review using the best available site-specific information.
**FIGURE 4: Contours**

**LEGEND**

- Shoreline
- Shoreline Jurisdiction Boundaries
- Private Property Boundaries
- Public Roads
- Railroads
- Water Bodies
- Contours
  - 100 Foot Contours
  - 10 Foot Contours

**Absolute Scale**: 1:15,000

**Relative Scale**: 1 inch = 1,250 feet

Shoreline jurisdiction boundaries depicted on the map are approximate. These have not been formally delineated or surveyed and are for general planning purposes only. Additional specific evaluation and boundary clarification may be required to confirm or modify the information shown on the map. Shoreline jurisdiction will be determined at time of project review using the best available site-specific information.
Stevenson, Washington
Critical Areas &
Geologic Hazards Map

FIGURE 5A
Geologic Hazards
Although our landslide hazard map is a significant contribution and an improvement to the map currently used by the City, the level of certainty is relatively lower than is typical for this type of effort. This is mainly because ground-based confirmation of interpreted landslides was not possible due to the scope and budget of the project.

However, this memorandum includes recommendations to improve the map and ordnance for future updates. Further, due to budget constraints, no subsurface boring information was made available to us and thus was not incorporated as part of this effort.

**LANDSLIDE AND LANDSLIDE HAZARD DEFINITIONS**

**Landslide Definition and Types in the Stevenson Area**

Landslides is a general term covering a wide variety of mass movement landforms and processes involving the downslope transport of soil and rock material en masse. The downslope movement of geologic materials may be triggered by a number of natural factors including intense rainfall, rapid snowmelt, wave or stream erosion, earthquake shaking, and volcanic eruptions. Human actions such as the removal or concentration of water on a slope, placement of nonengineered fill material on the head of a slope, and cutting into the toe of a slope can all increase the likelihood future landslide activity.

Landslides are broadly characterized as deep-seated or shallow. Deep-seated landslides fall below the rooting depth of vegetation within or below colluvial materials and into stable, in-place sediments or bedrock. They are often large in extent, complex, and once reactivated, by other natural causes or land management practices, are expensive and difficult to mitigate. In many cases mitigation of deep-seated landslides may not be financially possible. Because deep-seated landslides typically move relatively slow the threat of injury or death to humans is normally low. Several terms have been applied to the types of deep-seated landslides based upon their mechanism of failure and type of materials and include: earth and rock falls, topples, slides, and flows (see for example Varnes and Crumon, 1996). Shallow landslides typically have a shallow depth of failure within the soil and/or colluvium layer above bedrock. These are generally smaller in size than deep-seated landslides but may also be large in surface area. Shallow landslides include debris flows, shallow slumps, and soil creep. Initiation sites of debris flows are at the heads or on the side slopes of creeks and river valleys. Debris flows are commonly caused by the buildup of pore water pressures in the soil mantle during periods of heavy rainfall or rapid snowmelt whereby the water saturated materials partially or fully liquefy, fail and move downslope typically into a confined stream channel or swale. Debris flows typically built up, increasing in size during transport as sediments in the pathway are entrained. Deposition of the materials occur when the velocity decreases at the outlet where the channel becomes unconfined and the gradient decreases. The risk is to structures, roads, and people within the pathway or deposition area. There is evidence of shallow, debris flow failures at the heads and side slopes of smaller drainages as well as the larger creeks (Rock Creek and Kanaka Creek). We recommend that a detailed evaluation of the debris flow hazards be completed to better quantify the risk levels.

Soil creep is a slow process that is normally limited to the topsoil zone. Creep is typically a slow process, and its impact can usually be mitigated during development.
Landslide Hazards

It must be emphasized that the City of Stevenson region is characterized as a landslide prone area with widespread and commonly large landslides that may be ancient or historically active as well as steep slopes at risk to rock fall and debris flow. The landslides include both deep-seated and shallow, rapidly moving landslides (debris flows). The most recent landslide occurred in Rock Creek this year and resulted in condemnation of a home and significant deposition of sediment at the creek outlet that had to be dredged. For example the southwestern corner of the City overlaps the lower portion and toe of two very large ancient landslides that are part of an even larger landslide complex known as the Bonneville slide. A portion of the Kanaka Creek landslide formed the Maple Hill slide with the toe being about one mile north of the city limit was reactivated in 1996 resulting in significant damage to homes and roads from deep-seated slides and debris flows. Numerous debris flows were triggered by the 1996 rains that affected Highway 14 in the region.

Landslides pose a threat to the health and safety of citizens and infrastructure when incompatible development is sited in areas of significant hazard. Because Stevenson includes significant landslide prone areas it is incumbent upon the City to recognize and control development of those hazards. A good hazard map and ordinance can achieve that purpose. The ordinance establishes a framework to facilitate sound land use decisions in hazardous areas that is largely based on 1) avoidance of landslides (no building), 2) setbacks from landslides, or 3) mitigation of landslide risk through adequate site investigations and engineering.

SOURCES OF INFORMATION AND METHODS

In accordance with our proposal, PFS utilized information provided to us by J.D. White that we understanding was obtained from the City. Additionally PFS utilized readily available published geologic and landslide hazards maps for the Stevenson area. Each of these sources of information are discussed in the following subsections:

Geologic Mapping and Summary of Geologic Conditions

Our research indicates that only regional-scale published geologic mapping is currently available for the Stevenson area. The most useful map we found is contained in the previously referenced consultants report (Squier Associates, 1989) containing the results of investigations of the Maple Hill Landslide as prepared for Skamania County (PFS had a copy of this report as a result of work completed for property within the landslide). The geologic map indicates it is based on the regional geologic map by Hammond (1980) but was not reviewed by Hammond map. The Squier Associates map indicates two Tertiary-aged bedrock geologic units and two Quaternary-aged units in Stevenson. The bedrock units are the Ohanapecosh formation and the overlying (younger) Eagle Creek Formation. Quaternary units are the Mosley Lake and Red Bluff landslides, mapped in the southwestern portion of the Maple Hill Landslide and "debris flow deposits" from the Kanaka Creek Landslide located along Kanaka Creek. The Ohanapecosh formation covers the eastern third of the city and is mapped in the area to the east of Frank John's Road. The Eagle Creek Formation is mapped in the adjacent area to the west up to the boundary with the Red Bluff and Mosley Lake landslides extending past the city limits on the west side. This area excludes area of debris flows proximal to Kanaka Creek.

The Ohanapecosh Formation formed in the ancient western Cascades volcanic province and is generally consists of bedded mudstone, siltstone, sandstone, and conglomerate with significant volcanic components and andesite lava flows. The overlying Eagle Creek Formation consists of a series of anastomosis debris flow deposits and fluvioglacial sediments composed of volcanic conglomerates, sandstones, and tuffs. An angular unconformity separates the units. The Eagle Creek Formation is locally overlain by Middle Miocene age basalt lava flows of the Columbia River Basalt Group. These rock units are south dipping towards the Columbia River, contain weak, clay rich layers, and are generally prone to landslides. The Kanaka Creek landslide occurs in these geologic units. According to the Squier Associates report, the Maple Hill landslide is the southwestern portion of the Kanaka Creek landslide that was reactivated in 1996 as a result of the high rainfall and snowmelt in February 1996. The Maple Hill landslide is characterized by deep-seated movements as well as debris flows that originated on steep slump scarps and flowed downslope caused damage to Loop Road.

We transposed the limits of the Mosley Lake and Red Bluffs landslides from the Squier Associates map to our map (Attachment 1). As noted below, landslide topography is clearly indicated by the LIDAR data for this area. The head scarps of these large, complex landslides coincide with the high cliffs and bluffs to the northwest. These landslides involve the Ohanapecosh and Eagle Creek Formations as well as the younger Columbia River Basalt Group lava flows and other units. It is widely interpreted that these landslides were triggered as a result of rapid drawdown (water level change) associated with the Late Pleistocene glacial outburst floods (also known as the "Missoula Floods") that flowed through the Columbia River about 12,000 years ago. The Skamania Lodge property is entirely located on these landslides. The Bonneville Dam is also located on the landslide complex that is sometimes referred to as the Bonneville Landslide.

Reactivated portions of the landslides within the Columbia River Gorge are known and represent a continued risk to major facilities, particularly transportation routes. The margins of ancient landslides are typically at higher risk for renewed activity. We assume that geotechnical investigations were completed for the Skamania Lodge development addressed mitigation of landslide risks however we did not receive copies of these reports. Additionally, the U.S. Corps of Engineers, possibly the Washington State Department of Transportation and the railroad owner have undertaken studies of landslides with regard to their facilities. Those reports could provide useful information but were not available for this project.

Steep Slopes and Slide Areas, Stevenson Washington (City ID # PL 905 D)

PFS received a copy of the map that is referred to in the existing Stevenson CAO. This map is from the previously referenced 1977 published map by Mackey Smith of the DNR. Accompanying explanatory text for this publication, if it existed, was not received. This large-scale map shows the following categories of geologic hazards:

- "Steep slopes generally greater than 15 percent. May become unstable if existing land use is modified."
- "Unstable areas: displays recently active landsliding"
- "Scars of old landslides"
- "Scars of recently active landslides"

These features include areas that extend outside of the current city limits to the north and east. We note however that this map did not identify the area of the Mosley Lake or Red Bluffs landslides.

PFS transposed the scarps and the "unstable areas" from the 1977 map to the map in Attachment 1. The "scars of recently active landslides" and "unstable areas" is limited to the Rock Creek area. The Rock Creek area is high risk area for future slope failures and debris flows in which a large portion failed in February of this year. Landslide features are clearly evident from LIDAR data and the limit of the 2007 failure was delineated by DNR in the referenced 2007 publication.
The "scars of older currently inactive landslides" shown on the 1977 map does not indicate the extent of landslide masses that occur downstream of the scarps. Landslide features from LIDAR data are associated with the scarps in the area centered on Iman Cemetery Road between Ryan Allen Road and Loop Road in the southwest part of the city. However, landslide features are not clearly evident below the scarp shown in the developed area in the northeastern corner of Stevenson exist of Bone road and south of El Paso Lane. The only other scarp feature within the City Limits on the 1977 map occurs nearby to the northwest. Our LIDAR mapping indicates a landslide scarp at that location.

Geotechnical Reports

PBS received a limited number of geotechnical reports (three) that we reviewed. However, none of these reports included subsurface explorations. Thus interpretations of geology, landslides, and slope stability were based on reconnaissance combined with literature review and aerial photo analysis in one of the reports. Two reports pertained to a recent developments south and east of Iman Loop Road one of which is bordered by Rock Creek on the northeast side. Landslides were recognized on the steep slopes bordering Rock Creek and setbacks were recommended. According to geographic information systems (GIS) data showing the location of homes, one of the new homes is located less than 50 feet from the top of the slope break. Fresh slumps on the slope and the recent 2007 failure adjacent to the steep slopes on the other side of the creek indicate that the 50-foot setback is inadequate without further stabilization.

Another report is for property located within the area east of Iman Cemetery Road below the 1977-mapped scarp mentioned above. That report included review of aerial photographs that identified landslide features in the area. It included recommendations for subsurface explorations.

A higher level of certainty regarding evaluation of landslide conditions and slope stability are from geotechnical investigations that include subsurface explorations (test pits, borings, borings instrumented with piezometers and inclinometers, laboratory testing, and slope stability modeling) as well as detailed mapping. We suspect that other geotechnical reports with this type of information exist however we did not receive any. We are particularly interested in geotechnical reports associated with the Skamania Lodge development because it occurs on the large ancient landslide complex that may be unstable.

Light Detection and Ranging (LIDAR) Data, Topographic Map and Aerial Photograph

Our landslide mapping relied heavily on digital elevation models (DEMs) derived from LIDAR data we received for this project along with the record (2007) topographic map and aerial photograph. According to a representative of Minister & Glaseker Surveying, the topographic map was derived from traditional photogrammetric methods using ortho-rectified aerial photos flown in March 2007; a two-foot contour interval is used. We understand that the LIDAR data was obtained from Washington DNR and was flown in February – March 2005. In addition, J.D. White provided GIS information showing roads and buildings. This data was used to delineate apparent landslide scarps, debris flow hazard zones, and steeper slopes (equal to or greater than 25 percent) at generally greater risk for slope movements.

DEMs created from LIDAR are a powerful tool used to evaluate landslide hazards as it provides a much more accurate representation of the ground surface in forested areas than is possible by photogrammetric methods. For this project we utilized shaded relief maps/images at a scale of 1 inch = 500 feet with two different virtual sunlight orientations. In particular we utilized a constant sun angle of 45 degrees with sun azimuths (direction) of 45 and 315 degrees. The shaded relief maps were analyzed alone and with the topography, roads and buildings superimposed. Additionally we evaluated the topographic map combined with the aerial photograph.

LANDSLIDE HAZARD MAPPING BY AREA

The LIDAR shaded relief images and images combined with the topographic map accurately depict the ground surface and allow overall interpretation of landslides associated with landslides. Landslide related landforms that were observed include scarps, hummocky (irregular) topography, disrupted drainageways, and fan deposits associated with debris flows. The images also allow significant fill areas to be recognized. Typically when landslide mapping is performed using LIDAR DEM's, or other methods such as traditional topographic maps or aerial photographs, field reconnaissance of selected features is conducted to evaluate the general age of the landslide. State of activity can be evaluated based on geomorphology.

In order to improve the accuracy of the attached landslide hazard map by PBS, site reconnaissance of the suspected landslides is recommended as well as review of geotechnical reports that include subsurface explorations (if available). Because our scope of work did not include reconnaissance to evaluate the apparent landslide features, the level of certainty of some of the less obvious mapped landslide features is low. During reconnaissance, the age and state of activity should be estimated based on where features associated with active movement are present (e.g. sharp appearing scarps, ground cracks, leaning or pistol butted trees) or whether the landslide features are subdued due to erosion and possible inactive. A commonly used classification of the age and activity of landslides based on geomorphology indicators includes the following categories (Varnes and Cruden, 1989): 1) Active, reactivated, suspended; 2) Dormant – young; 3) Dormant – mature; 4) Dormant – old or relict. Old landslides are often termed ancient that formed hundreds to thousands of years ago. In some cases these ancient landslides are judged to be inactive and stable. However, ancient landslides or portions of large ancient landslide complexes may reactivated and periodic movement may have occurred for very long periods of time.

The landslide hazards map shows areas where the slope is 25 percent or higher (4:1:1V or 14 degrees delineated as a potentially unstable slope in Attachment 1). Steep sloped areas typically include the scarp areas and side slopes to drainage ways.

Northeastern Stevenson:

This area encompasses the northeastern portion of Stevenson extending from the north city limits down to the Columbia River on the southeast. We delineated two landslides and scarps in this area based on LIDAR. The northern-most landslide extends outside of the city limits in an undeveloped area. As shown on Attachment 1, the northern portion includes a landslide head scarp mapped by the Department of Natural Resources (DNR) in 1977 and is designated as "scars of older inactive landslides". The LIDAR images are inconclusive with respect to features associated with a landslide below the 1977 mapped scarp although it is possible this is a landslide. Other steeper slope areas are delineated in the northern and southern portions of the area including a south-trending drainage way and undeveloped area above the Columbia River.

Rock Creek:

Rock Creek has cut a steep sided canyon through the north-central portion of Stevenson. This area includes "scars of recently active landslides" and "unstable areas with recently active landslides" mapped by DNR in 1977. That area approximately coincides with landslides and steep slopes we mapped using LIDAR images. The limit of the large landslide that occurred in February 2007 is also shown and is based on the limit shown in the previously referenced DNR paper publication from this year. The LIDAR images clearly show landslide scarps and associated landforms which appear sharp and recent or youthful indicating that this is a high-risk area for future landslide activity. The Rock Creek area is also subject to debris flows originating from slumps into the creek that are then transported downstream.
Central Stevenson:
Two areas west of Rock Creek in central Stevenson contain landslides based on LIDAR as well as delineated steep slopes. The southeastern slide was also mapped by DNR in 1977. This area appears to be prone to landslides and debris flows that originate from the head and sidewalls of the surface water drainages. Aerial photo analysis (performed for one of the geotechnical reports we reviewed) similarly interpreted landslides in this area.

Southwestern Stevenson (Red Bluff and Mosley Lake Landslides):
The southwestern Stevenson area is defined by the approximate limit of the Red Bluff and Mosley Lake Landslides, taken from the referenced geologic map in the Squier Associates report, as shown on Attachment 1. The Red Bluff Landslide that comprises the northeastern portion of the area includes individual landslides that are interpreted from LIDAR images as well as adjacent steep slopes. This area also includes a scarp identified by DNR as "scarps of older currently inactive landslides".

The LIDAR images for the area to the southwest (that coincides with the Mosley Lake landslide and includes the Skamania Lodge Resort and golf course property) clearly show landforms characteristic of a large landslide complex. Local areas with steep slopes are delineated.

CONCLUSIONS AND RECOMMENDATIONS
The Landslide Hazard Map is based on the information compiled in the Attachment 1 map and is thus largely based on interpretation of slope hazards from LIDAR images in combination with previous hazard mapping. In order to improve the accuracy of the mapping, site reconnaissance of the mapped landslide features, steep slopes and geologic conditions is strongly recommended. Additionally review of geotechnical reports from the Skamania Lodge development and other developments that include subsurface explorations, should be completed. This could be done for future updates of the geologic hazard map. It is possible that landslide features exist that could become evident with field reconnaissance or further study.

On the basis of the available information used for this report and our professional judgment we have characterized the risk of the identified areas as follows:

HIGH HAZARD:
Rock Creek area, - Landslides and Debris Flows
Delineated Landslides

MEDIUM HAZARD:
Mosley Lake and Red Bluff Landslides
Steep slopes
Debris flows

LOW HAZARD:
None

The draft ordinance includes requirements for detailed geotechnical investigations for these areas.
Red areas are designated via FEMA FIRMs Map 530161 A Panels 01-02.

Yellow areas are designated via FEMA FIRMs Map 530160, Panel 425.
MEMORANDUM

To: Skamania County SMP Update Team
From: Jay Cook, Hydrogeologist, WA Department of Ecology
Date: May 19, 2016
Subject: Channel migration zone analysis for SMA streams in Skamania County

Provided with this memo is a collection of digital data files (ArcGIS map package) that show the results of a planning-level assessment of channel migration zones completed on behalf of the County for the Shoreline Master Program (SMP) Update.

The GIS map data provided by Ecology include two layers. The first is a line layer of the Planning Level Channel Migration Zone (pCMZ) boundaries. The second is a point layer with comments of notable observations, which is not required for the SMP update but hopefully will provide some useful information.

Please note that the pCMZs within the map package are currently drafts. Skamania County, upon review of the pCMZ map data and this document, may contact Ecology to discuss the delineations and the possibility and protocol for adjustments prior to finalizing.

Understanding the low development pressure in the federally owned lands within Skamania County and to expedite the process of generating pCMZs, the county was divided into two parts – low development potential (federally owned land) and higher development potential (privately held land within the National Forest and privately owned land within the rest of the county). In low-development areas, the pCMZ was auto-generated based on channel confinement and valley width. In the higher-development areas, a standard pCMZ analysis was performed.

Low Potential Development Areas

In GIS, the SMA-jurisdiction streams layer was compared to the CHAMP (Channel Migration Potential) layer. CHAMP layer streams segments, which are present upstream of the 20 cubic feet per second (cfs) regulatory threshold, were trimmed to match the SMA jurisdictional extent. CHAMP data are described in Ecology Publication No. 15-06-003, “Screening Tools for Identifying Migrating Stream Channels in Western Washington” and are available for public use at the Department of Ecology website.

The relative degree of channel confinement, found in the CHAMP dataset, was selected as the most suitable attribute to categorize stream segments for auto-generating pCMZs. Stream segments were divided into two categories: 1) unconfined, and 2) confined and moderately confined. The Screening Tools publication suggests that in confined and moderately confined stream settings, the valley bottom is a reasonable and conservative approximation of the planning level CMZ. The publication does not offer similar guidance for unconfined settings. Thus, the standard pCMZ methodology, outlined in Ecology’s publication No. 14-05-025, “Methodology for Delineating Planning Level Channel Migration Zones”, was consulted to aid in appropriately locating pCMZs. The auto-generated pCMZs were assigned as follows:

- Confined and moderately confined segments: pCMZ = Valley Bottom Width (attribute within CHAMP data layer).
- Unconfined segments: pCMZ = Valley Bottom Width plus 500 feet. Rationale for this approach is as follows: Ecology’s pCMZ publication prescribes first delineating the “Modern Valley Bottom” (MVB), followed by situating the pCMZ at some distance relative to the MVB. In settings with very wide valleys relative to the stream, the pCMZ may be placed streamward of the MVB. In settings where the stream is likely to impinge on the valley wall, the pCMZ may be placed outside of the MVB to recognize potential erosion due to undercutting of valley walls. The placement of the pCMZ when outside of the MVB for any segment is controlled by several factors, including the probability of impingement against valley walls, erodibility of valley wall materials, and height of the valley wall. In settings with low erodibility and high valley walls, as generally expected in northern Skamania County, the methodology suggests the pCMZ be placed up to one channel width outside the MVB. In order to assign a common, protective “buffer” distance outside of the valley bottom for all streams in the low-development area, the area stream with the widest active channel, Muddy River, was evaluated. The active channel for Muddy River reaches more than 1,000 feet in width in a few places. While this appears to be atypically wide for streams in the general area, it was a consideration in determining the common pCMZ placement for unconfined stream segments. Considering the Muddy River channel, the hydrologic and geologic setting, and that no migration analysis was performed, it was determined that a reasonable and protective pCMZ for all unconfined stream segments is 500 feet outside of the valley bottom defined in the CHAMP dataset.

- In GIS, the SMA-jurisdiction streams layer was compared to the CHAMP (Channel Migration Potential) layer. CHAMP layer streams segments, which are present upstream of the 20 cubic feet per second (cfs) regulatory threshold, were trimmed to match the SMA jurisdictional extent. CHAMP data are described in Ecology Publication No. 15-06-003, “Screening Tools for Identifying Migrating Stream Channels in Western Washington” and are available for public use at the Department of Ecology website.

- The relative degree of channel confinement, found in the CHAMP dataset, was selected as the most suitable attribute to categorize stream segments for auto-generating pCMZs. Stream segments were divided into two categories: 1) unconfined, and 2) confined and moderately confined. The Screening Tools publication suggests that in confined and moderately confined stream settings, the valley bottom is a reasonable and conservative approximation of the planning level CMZ. The publication does not offer similar guidance for unconfined settings. Thus, the standard pCMZ methodology, outlined in Ecology’s publication No. 14-05-025, “Methodology for Delineating Planning Level Channel Migration Zones”, was consulted to aid in appropriately locating pCMZs. The auto-generated pCMZs were assigned as follows:

- Confined and moderately confined segments: pCMZ = Valley Bottom Width (attribute within CHAMP data layer).
- Unconfined segments: pCMZ = Valley Bottom Width plus 500 feet. Rationale for this approach is as follows: Ecology’s pCMZ publication prescribes first delineating the “Modern Valley Bottom” (MVB), followed by situating the pCMZ at some distance relative to the MVB. In settings with very wide valleys relative to the stream, the pCMZ may be placed streamward of the MVB. In settings where the stream is likely to impinge on the valley wall, the pCMZ may be placed outside of the MVB to recognize potential erosion due to undercutting of valley walls. The placement of the pCMZ when outside of the MVB for any segment is controlled by several factors, including the probability of impingement against valley walls, erodibility of valley wall materials, and height of the valley wall. In settings with low erodibility and high valley walls, as generally expected in northern Skamania County, the methodology suggests the pCMZ be placed up to one channel width outside the MVB. In order to assign a common, protective “buffer” distance outside of the valley bottom for all streams in the low-development area, the area stream with the widest active channel, Muddy River, was evaluated. The active channel for Muddy River reaches more than 1,000 feet in width in a few places. While this appears to be atypically wide for streams in the general area, it was a consideration in determining the common pCMZ placement for unconfined stream segments. Considering the Muddy River channel, the hydrologic and geologic setting, and that no migration analysis was performed, it was determined that a reasonable and protective pCMZ for all unconfined stream segments is 500 feet outside of the valley bottom defined in the CHAMP dataset.

- It should be noted that pCMZ areas delineated in this fashion are very coarse, and depending on actual stream location versus stream-location data in GIS, the delineated pCMZ area could be significantly misaligned. Skamania County should narratively explain in their SMP update that...
proposed development near (inside or outside of) these auto-generated pCMZs should first be analyzed on the ground to determine if the project is actually within the valley bottom for confined stream segments or within about 500 feet of the valley bottom for unconfined stream segments. Additionally, the SMP update should note that proposed developments within the physical, on-the-ground boundaries will require a site-specific, detailed CMZ analysis. Ecology Publication #03-06-027 “A Framework for Delineating Channel Migration Zones” provides a methodology for such a detailed analysis that should be conducted by a qualified professional.

- There are 5 streams/stream segments within the Low Development Areas that fall under SMA jurisdiction but are not in the CHAMP stream dataset. Three are in the northwest corner of the county – South Coldwater Creek headwaters, North Fork Toutle River, and Studebaker Creek. Two are in the eastern portion of the county – Trout Lake Creek and the upper White Salmon River. Absent CHAMP data, valley width and confinement information, the valley bottom was hand-digitized using available data (USGS Topographic Information from ESRI, 10-m DEM, and Aerial Photos), and the pCMZ was set back 500 feet from the mapped valley bottom.
  - The upstream portion of South Coldwater Creek is the outfall of Spirit Lake and appears to travel through a tunnel, thus no pCMZ was generated for that section.

- The pCMZ delineation lines within the GIS package overlap at many stream confluences. Where this occurs, the most protective (i.e., farthest from the stream) should be used.

Higher Potential Development Areas

- Note, the unnamed stream in red in the map above was not delineated. It appears to be a mistake within the SMA jurisdiction GIS dataset. The stream is not readily evident in orthophotos or USGS topo maps.

Columbia River

Understanding that the Columbia River has little tendency to migrate and in being consistent with previous CMZ assessments, it was decided to use the existing FEMA 100-year flood zone delineation as the pCMZ. The most current digital flood-zone data available for Skamania County are the FEMA Q3 data, which often do not project well in GIS. This problem, which results in the 100-year flood delineation not aligning properly with the river and adjacent landforms, was noted during assessment of the Q3 data for the Columbia River.

The Columbia River pCMZ delineation presented by Ecology for Skamania County should be recognized in the SMP update as imprecise and should be used only in an advisory capacity. Project-level decisions should utilize existing Flood Insurance Study maps and information and/or more detailed, site-specific delineations.
**Flowage easements**

The scope of this project was only to cover the area of the Stevenson Urban Area of the Columbia River Gorge National Scenic Area. There was generally no effort to build the easements for areas outside of the project area, however some easements outside the project area were built since it is difficult to clearly identify where each legal description represents until it is actually drawn. Flowage easements were built in GIS using a variety of datasets as base information as geographic reference. The typical flowage easement legal description provides the details of a specified tract and also provides the low elevation (in this case 72 ft above sea level) and high elevation (variable by legal description). As tracts were built in GIS they were first created as lines representing the deed line calls (e.g. coordinate geometry—distance/bearing, metes and bounds descriptions, etc.). Line work was then converted into polygons representing the entire specified tract without regard to the specific elevations for which the actual easement applies. A variety of attributes were recorded along with each tract boundary (in the line and polygon GIS layers). The attributes included things like the date of the easement, the property owner, the low and high elevations, the transaction amount, the Auditor’s record book/page number and Auditor File Number, and the type of document, etc. The line GIS layer/data often also includes the deed record coordinate geometry for individual lines that is directly input from the legal record during the process of constructing the lines.

Once all records for flowage easements were built (as lines and polygons), then contours were developed from existing LiDAR data represented as a Digital Elevation Model (DEM). The contours were created for every different elevation that is specified in flowage easements:

- 82.2 ft
- 82.3 ft
- 82.4 ft
- 89 ft
- 92 ft
- 93.8 ft
- 94 ft
- 95 ft
- Also 99999 was used for any legal description that failed to define an elevation
- Also 800000 was used for any legal description that specified an elevation representing '800,000 c.f.s.' As a note for the sake of understanding...this was generally specified for flowage easements that spanned a large length of shoreline (such as the length of the railroad or highway rights-of-way). The point of specifying it this way is likely that the high elevation contour fluctuates with location. For example, for the easements established in the late 1970’s, it was common to see the use of a high elevation of 82.2 for areas closest to the Bonneville Dam up through the area of Rock Cove or so. For areas east of Rock Cove the elevation was typically 82.4 ft. For areas as far east as Underwood, it was common to see higher elevations specified, and so forth.

Next, the individual polygons were cut at their respective easement high elevation marks and the area that was above the specified elevation was considered to be outside of the encumbrance of the specific easement (and therefore removed). This finished polygon layer represents the actual flowage easement...
area and may be the most important layer in terms of understanding the actual locations of encumbered lands. However, all data is retained because it could all be considered valuable for different purposes. Also, when generating the contour line for the purpose of ‘cropping’ the tract into a specific easement area, it is important to note that the contour line represents only the elevation at the time of the LiDAR data capture (in this case the LiDAR data was collected in 2005-06). Changes to topography (e.g. cut and fill) influence the actual area of easement. Therefore it is important to have the entire area of each tract as well as its specified high elevation information. This data is available in the complete tract (polygon) dataset. Also, the full legal scope of each easement is defined within the original recorded legal document. These should be reviewed prior to making any firm judgment regarding the location of each easement.

In the case of cropping the tracts that had a defined high elevation of 800,000 c.f.s. or where the high elevation was not defined (i.e. entered as 99999 in the data), these tracts were cropped at the 95 foot contour line. While this may not be the legally defined high contour location of the easement, it allows the tracts to be cut to show an estimate of actual easement area.
Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally delineated or surveyed and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm or modify this information shown on this map. Shoreline jurisdiction will be determined at time of project review using the best available site-specific information.

**FIGURE 8:**
Wetlands
FIGURE 9: Existing Land Use

LEGEND

- Stevenson City Limits
- Public Roads
- State Border
- Railroad
- Shoreline
- Parcels
- Public Works
- Single Family Utility/Transit Parks
- Multifamily Services
- Manufacturing Culture/Recreation
- Forestry
- Undeveloped
- Open Space

Land Use

- Single Family
- Multi-Family
- Parks
- Public/Commercial Forest
- Manufacturing Culture/Recreation
- Undeveloped
- Open Space

Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally defined or surveyed and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm or modify the information shown on the map. Shoreline jurisdiction will be determined at time of project review using the best available site-specific information.
FIGURE 9A
Future Land Use

Stevenson ICR Appendix C
FIGURE 10: Zoning

LEGEND

Stevenson City Limits
Public Roads
State Road
Rail Road

Skamania County
Residential 1 (R1)
Residential 2 (R2)
Community Commercial (CC)
Commercial Rec (CR) (Skam Co)
Industrial (MI)

City of Stevenson
Commercial (C1)
Commercial Recreational (CR) (Skam Co)
Light Industrial (LI)
Public Use and Recreation (PR)
Rock Cove Public Use & Rec (PR)
Single Family Residential (SF)
Two Family Residential (R2)
Multi Family Residential (MF)
Multi Family Residential Overlay (MO)
Suburban Residential (SR)

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Ownership in shoreline jurisdiction:

- Public: 197.25 Acres
- Other: 894.95 Acres
- Total: 1,062.20 Acres

Length of OH\W:
- Public: 27,371 linear feet
- Private: 24,883 linear feet
- Total: 52,254 linear feet

*The data used in ownership determination is based on an extract of the Assessor’s database on 2/02/2015. The parcel owned by Columbia Gorge Interpretive Center Museum was assigned as public ownership. There are additional areas of public rights-of-way, or ownership (e.g. WSDOT Hwy 14) that are not symbolized in the map or included as part of the area calculation.

**FIGURE 11:**

Public Ownership
Impervious Area Calculations (Square Feet)

<table>
<thead>
<tr>
<th>Description</th>
<th>Pavement (or concrete)</th>
<th>Gravel</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Road</td>
<td>251,092</td>
<td>17,415</td>
<td>268,507</td>
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<tr>
<td>Private Road (ranged)</td>
<td>0,000</td>
<td>0,000</td>
<td>0,000</td>
</tr>
<tr>
<td>Shoreline/Beach area</td>
<td>30,967</td>
<td>146,626</td>
<td>177,593</td>
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<tr>
<td>Park/Storage area</td>
<td>215,757</td>
<td>208,836</td>
<td>424,593</td>
</tr>
<tr>
<td>Railroad</td>
<td>264,322</td>
<td>364,610</td>
<td>628,932</td>
</tr>
<tr>
<td>Total</td>
<td>651,058</td>
<td>754,446</td>
<td>1,405,504</td>
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</tbody>
</table>

Note: Rooftop area calculations are not included in these figures.

Impervious Linear Calculations (Feet)

<table>
<thead>
<tr>
<th>Description</th>
<th>Pavement (or concrete)</th>
<th>Gravel</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Road</td>
<td>31,585</td>
<td>885</td>
<td>32,470</td>
</tr>
<tr>
<td>Private Road (ranged)</td>
<td>1,418</td>
<td>1,406</td>
<td>2,824</td>
</tr>
<tr>
<td>Shoreline/Beach area</td>
<td>3,213</td>
<td>13,996</td>
<td>17,209</td>
</tr>
<tr>
<td>Park/Storage area</td>
<td>2,181</td>
<td>0,000</td>
<td>2,181</td>
</tr>
<tr>
<td>Railroad</td>
<td>7,913</td>
<td>0,000</td>
<td>7,913</td>
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<tr>
<td>Total</td>
<td>23,626</td>
<td>13,191</td>
<td>36,817</td>
</tr>
</tbody>
</table>

Note: Railroad length is that of the main track only (no sidings)

Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally delineated or surveyed and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm or modify the information shown on this map. Shoreline jurisdiction will be determined at time of project review using the best available site-specific information.

FIGURE 12: Impervious Surfaces
Rooftop Statistics:
- Sum of all rooftops = 232,076 Sq Ft
- Largest single structure = 35,425 Sq Ft (the portion falling in Shoreline)
- Average size in Shoreline per structure = 2,020 Sq Ft
- Count of structures = 105 (partially or fully within Shoreline)

Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally delineated or surveyed and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm or modify the information shown on this map. Shoreline jurisdiction will be determined at time of project review using the best available site-specific information.

FIGURE 13: Rooftops
FIGURE 14: Archeology / Historic

**LEGEND**
- Stevenson City Limits
- Rail Road
- State Border
- Parcel
- Public Roads

**Skamania / Stevenson Historic Inventory**
- Historic Property Inventory Points
- Washington Register Districts *Not on map*
- Washington Register Properties *Not on map*

Additional site-specific evaluation may be needed to confirm or modify the information shown on this map. Site line jurisdiction will be determined at time of project review using the best available site-specific information.

FIGURE 15
Shoreline Modifications

Quantities by type:

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armored</td>
<td>20,260 ft</td>
<td>30%</td>
</tr>
<tr>
<td>Not armored</td>
<td>31,994 ft</td>
<td>61%</td>
</tr>
<tr>
<td>Total shoreline</td>
<td>52,254 ft</td>
<td>100%</td>
</tr>
</tbody>
</table>

Island dimensions:

<table>
<thead>
<tr>
<th>Perimeter</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,098 sq ft</td>
</tr>
<tr>
<td>2</td>
<td>31,684 sq ft</td>
</tr>
<tr>
<td>3</td>
<td>20,520 sq ft</td>
</tr>
<tr>
<td>4</td>
<td>50,086 sq ft</td>
</tr>
<tr>
<td>5</td>
<td>32,395 sq ft</td>
</tr>
<tr>
<td>6</td>
<td>1,091 sq ft</td>
</tr>
<tr>
<td>7</td>
<td>26,433 sq ft</td>
</tr>
<tr>
<td>Total:</td>
<td>166,310 sq ft</td>
</tr>
</tbody>
</table>

* Island is not within City Limits or the Urban Area

Docks / Piers:

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<thead>
<tr>
<th>Description</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1,100 sq ft</td>
</tr>
<tr>
<td>B</td>
<td>166 sq ft</td>
</tr>
<tr>
<td>C</td>
<td>787 sq ft</td>
</tr>
<tr>
<td>D</td>
<td>1,305 sq ft</td>
</tr>
<tr>
<td>E</td>
<td>4,491 sq ft</td>
</tr>
<tr>
<td>F</td>
<td>51 sq ft</td>
</tr>
<tr>
<td>G</td>
<td>81 sq ft</td>
</tr>
<tr>
<td>H</td>
<td>730 sq ft</td>
</tr>
<tr>
<td>I</td>
<td>1,012 sq ft</td>
</tr>
<tr>
<td>J</td>
<td>615 sq ft</td>
</tr>
<tr>
<td>K</td>
<td>170 sq ft</td>
</tr>
<tr>
<td>Total:</td>
<td>9,847 sq ft</td>
</tr>
</tbody>
</table>

* Site specific information for this project is available on request.

Shoreline jurisdiction boundaries depicted on the map are approximate. They have not been formally surveyed or defined and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm or modify the information shown on this map. Shoreline jurisdiction will be determined at time of project review using best available site-specific information.