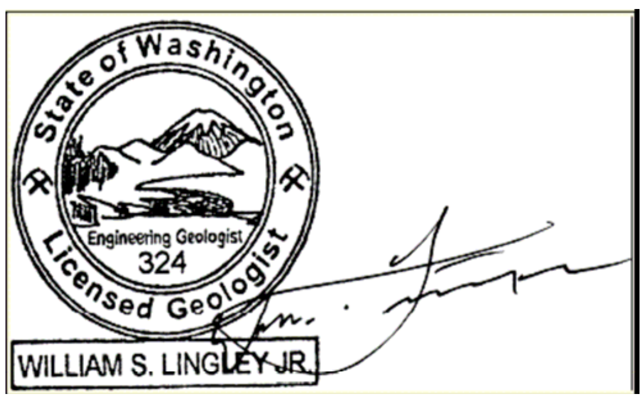
WASHINGTON STATE DEPARTMENT OF
Natural Resources

Mass Wasting Assessment for the Tahuya Block: Parts of Kitsap Southwest and Kitsap East-Southwest Watershed Administrative Units, Mason County, Washington

State Lands Landslide Hazard Block Mapping Project



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1.0 Introduction and Summary of Methods

1.1 Use of This Report

The purpose of this mass-wasting assessment is to identify State Lands within portions of the Kitsap East and Kitsap East-Southwest Watershed Administrative Units (WAU) that have landforms[1] with moderate or high risk of landslides both naturally and due to the effects of forest management (logging, roading, thinning, yarding, etc.). Adjacent non-federal, non-tribal lands are addressed, but only insofar as these are necessary to evaluate State Lands. Maps of these watershed-specific landforms (Map A-2 herein) will be used by the Department of Natural Resources (DNR) region staff to identify those timber sales and Forest Practice Applications (see Chapter 222-20 WAC) that will require a site investigation prior to assigning the class of forest practice relative to potential unstable slopes and landforms (Chapter 222-16-050).

Note: this is a reconnaissance study and its level of resolution must be kept in mind when using this document and Maps A-1 and A-2. For example, analysis of individual landslides or slopes is not an appropriate use of this report nor should it be used for zoning purposes. Moreover, the report was prepared according to the schedule necessary to produce a statewide State lands screening tool as quickly as reasonably possible. For this reason, it is likely that some landslides or landforms have been accidentally omitted, some benign features are improperly mapped as landslides, and some data have been miscoded herein.

Joe Brady, Ana Pierson, and Laura Vaugeois of DNR reviewed this report and edited the text.

1.2 Previous Investigations

Smith and Carson (1977) published a 1:62,500 map showing relative stability of natural slopes in the southern Hood Canal and delineated five stability classes ranging from stable landforms to zones of recently active and rapid slope movement. Gerald Thorsen of DNR, working on behalf of the Washington Department of Ecology (1980), mapped slope stability within 2000-feet of the shoreline and identified 12 deep-seated landslides along the shoreline of Hood Canal in the study area. Several letter-reports on slope stability have been included with DNR Forest Practices Applications, but are not specifically referenced herein.

1.3 Summary of Methods

This assessment generally follows the Landslide Hazard Inventory Protocol dated August 17, 2004 (Department of Natural Resources, 2004).

Five sets of aerial photographs (Table 1) acquired between 1978 and 1997 were viewed using a mirrored stereoscope with 3x magnification or an optical stereo zoom with up to 30x magnification. Unfortunately, many key images were missing from DNR's collection and could not be viewed. In addition, 1997 orthophoto coverage was used as a layer during GIS analysis and mapping. Note that many landslides identified from the orthophotos and indicated as having a 1997 identification date in Appendix A are probably considerably older than the 1997 acquisition date of these data.

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[1] Landforms as defined herein can be more inclusive than the small-scale unstable landforms commonly defined in rule (WAC 222-16-050). These rule-identified landforms include inner gorges, convergent headwalls, the outsides of meander bends, bedrock hollows, and the toes of deep-seated landslides. These will be referred to as "rule-identified landforms" herein.

Table 1. Photographic surveys used in this study.

Year	Scale	Image	Flight number and lines	Reference/ ownership	Comment
1978	1:12,000	black & white	NW-78 19B to 31A	DNR	Complete coverage
1981	1:40,000	black & white	OSI-81 19 to 31	DNR	3 available photos
1981	1:12,000	black & white	SP-81 19 to 32	DNR	23 missing photos
1985	1:12,000	black & white	SP-85 19 to 32	DNR	7 missing photos
1997	1:12,000	black & white	OL-97 79 to 91	DNR	3 missing photos

Over 40 additional landslides were located during reconnaissance field investigations on April 6, 7, 10, and 11, 2005. Fourteen percent of landslides mapped from aerial photographs were confirmed or rejected during field reconnaissance.

Mapping was generally accomplished by heads-up digitizing the landslides directly in ArcGIS. Additional control has been established by rectifying some landslides with DNR digital orthophotos as well as with topographic contours and a variety of hillshade layers created with lidar digital elevation models (DEM). The lidar data used herein have approximately 1-foot vertical and 6-foot horizontal resolution, which allows for precise characterization of the landscape due to high resolution. These data are especially useful for identifying numerous glacial deep-seated landslides that were not identified with aerial photo analysis.

The resulting landslide mapping is displayed as Map A-1 and is available as PDF files or ArcInfo coverage from the DNR Forest Practices Division. Pertinent attributes of the landslides are recorded on data sheets (Appendices A and B). Slope gradients not measured in the field were determined by exploring lidar DEM-derived slope percent pixels within the upper parts of each landslide polygon on the Map A-1 shapefile. Note that the steepest slope increment only corresponds to the “slope at failure” in medium to large translational landslides. (See *Angle of Slide* in Jackson, 1997).

Once the locations of mass-wasting features were mapped and evaluated, watershed specific landforms[2] with similar mass-wasting potential were delineated. These landforms are shown on Map A-2, which is also available in other formats from the DNR Forest Practices Division.

[2] Referred to simply as “landforms” hereafter.

2.0 Physical Setting Pertinent to Mass-Wasting Interpretations

2.1 Introduction

The study area covers approximately 71 mi^2 of the DNR South Puget Sound Region, west of the town of Belfair in Mason County (Map A-1). The study area is approximately 50,000 acres, which contains the Tahuya State Forest and parts of the 100,000-acre Kitsap Southwest and Kitsap East-Southwest WAUs. Elevation ranges from sea level along Hood Canal to a maximum of 570 feet.

Precipitation within the watershed is high, averaging about 50 inches per year (Western Regional Climate Center, 2005), with the highest precipitation occurring between October and April. Snow falls occasionally occur in the area, however rain-on-snow events are not considered a major concern.

Groundwater is critically important to understanding aspects of local slope stability throughout the study area. A cap of poorly permeable till forms a plain that separates groundwater from direct recharge in some areas. Elsewhere, late Ice Age ice scouring has removed the till exposing the underlying sand to input from surface water. In these areas, and at the edges of the till-plain, surface water infiltrates downward into the underlying porous sand and gravel. (See Geologic Unit Qga below.) This porous sand and gravel is, in turn, underlain by older compact and cemented gravel. (See Geologic Unit Qoa below.) The older, cemented gravel forms an impermeable layer for the overlying porous sand and gravel aquifer and perches groundwater. During high wet periods, elevated groundwater level can cause create instability and trigger deep-seated landslides, as described in more detail below.

In most small, upland portions of the drainages, water flowing at the surface is not common in sand-dominated substrates. Small, slow-flowing Type 5 (Type N_S) drainages are generally observed between low-elevation ridges on the upland plain. Type 5 and higher order drainages (Types S, F, and N_P) are common in steep inner gorges developed in cemented sand and gravel substrates nearer to Hood Canal.

2.2 Geology

No bedrock crops out in the study area.

2.2.1 Poorly-Consolidated Surficial Units

Qga Surficial units in the study area consist of sediments[3] deposited from the continental glaciers and alluvium deposited from streams. About 15,000 years ago, a continental glacier flowed south-southwestward and covered the entire study area. As the ice advanced, streams flowing from the leading edge of the glacier shed sand and gravel of Geologic Unit Qga (*Advance Outwash*) covering older preglacial material (Figure 1). The advance outwash consists of sand to pebble/cobble gravel. The thickness of the advance outwash varies and can be as thick as 100-feet in the Hood Canal area (Gold, 2004). See Dragovich and others (2002) for more detailed descriptions of this and the following geologic units.

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[3] The term 'sediment' is used in the strict sense, e.g., unconsolidated material such as free-flowing sand, gravel, boulders, etc., and semi-cohesive, clay rich deposits such as glacial till.

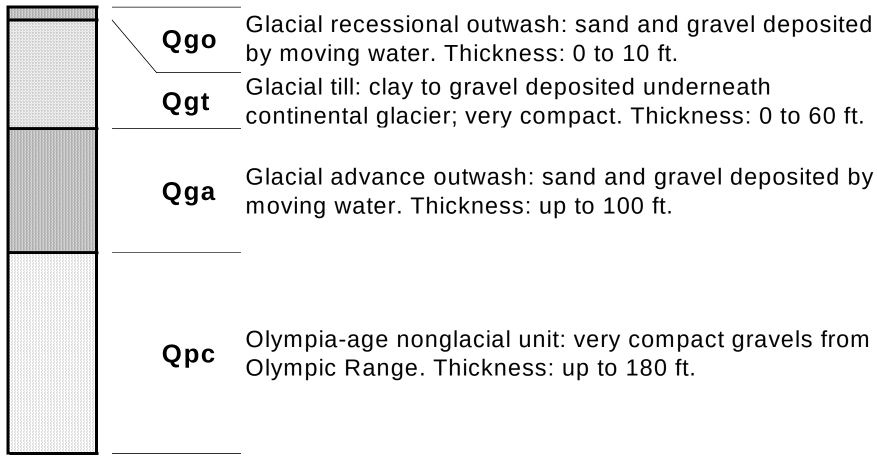


Figure 1: Idealized stratigraphic column of geologic units in the Tahuya area.

Qgt As the glacier advanced southwestward, it overrode the advance outwash deposits and deposited a layer of glacial '*Till*' (Geologic Unit Qgt) beneath the ice. The glacial till consists of an unsorted, very compact, concrete-like mixture of olive-colored clay, silt, sand, gravel, cobbles, and boulders supported by its matrix[4]. The thickness of glacial till can vary in thickness from thin lenses to blanket deposits up to 60-feet thick (Deeter, 1979). This material is resistant to erosion and, as a consequence, forms the aforementioned plain. It also has low permeability and ponds surface water, permitting stream water to slowly infiltrate into ground.

Qgo At the end the ice age, as the rate of glacial melting exceeded the rate of southward advance, "*Recessional Outwash*' (Geologic Unit Qgo) sand and gravel washed over the till. The recessional outwash partially covered the till, especially in lower elevation areas. Recessional outwash appears similar to the advance outwash; the main criterion for distinguishing the two is that recessional outwash overlies the till. In places where the till is thin or nonexistent, distinguishing recessional from advance outwash can be difficult. Recessional outwash has high permeability and varies in thickness from thin lenses up to 10 feet (Deeter, 1979).

2.2.2 Consolidated Nonglacial Sediments

Qpc Underlying the glacial units are Olympia-aged (about 36,000 to 17,000 years old) nonglacial units (Qpc) that primarily consist of fluvial gravels derived from the Olympic Mountains (Deeter, 1979). These streams deposited immense alluvial fans, which consist of well-rounded pebble- to cobble-sized clasts (Deeter, 1979). Maximum unit thickness ranges from an observed 100 feet (Deeter, 1979) to in excess of 180 feet (Molenaar and Nobel, 1970). In outcrop (i.e.: not covered by soil), the unit is clast-supported, colored an oxidized reddish-orange, perches ground water, and in fresh exposures, is cemented to the point that the unit could be considered a conglomeritic rock. Within the unit, discontinuous lenses of clay, silt, and sand, all typically less than 3 feet thick, are present locally. The compact, cemented nature of the nonglacial gravels makes them an excellent

[4] Matrix (as opposed to clast) support indicates that in a deposit of mixed sizes, the finer material carries the weight. Therefore, these deposits can flow. In clast-supported deposits, the weight is carried by grain-to-grain contacts between the larger particles, and these tend to be more resistant.

water-perching unit. This unit crops out primarily in the inner gorges, stream drainages, and along Hood Canal.

2.2.3 Geomorphology

The study area is divided into five main physiographic elements and subdivided into six landforms. The physiographic elements are:

1. *A low-relief upland plain consisting of impermeable till.* The till plain has been scoured by the last phases of ice movement to form striated ridges parallel with the south-southwestward direction of ice flow. The resulting low ridges are called drumlins. Depressions between the drumlins form numerous small swamps and ponds and focus surface water into south-southwest flowing streams that issue into the deeply incised gorge systems described below. A thin veneer of recessional outwash sand and gravel (Qgo) locally covers the uppermost part of the till plain.
2. *Plain adjacent slopes opening onto Hood Canal or the deeply incised gorge systems.* These plain-adjacent slopes are developed where the resistant till cap is eroded through and well-drained glacial advance outwash (Qga) is exposed. The slopes are generally on the order of 30 to 60%, except where landslide scarps create locally steeper topography. These slopes locally show signs of mass-wasting and have the potential to deliver to a public and private resource (i.e., roads and houses) that have been built along the entirety of the Hood Canal shoreline, many with little or no consideration for the risk of slope failure.
3. *Deeply incised gorge system in nonglacial, cemented gravel and clay (Qpc).* Where inter-drumlin and other streams incise through Qgo, Qgt, and Qga and into water-perching Qpc, steep slopes (steeper than 70%) are formed. These steep slopes are maintained by parallel slope retreat resulting from continual small sloughs and other shallow-rapid landslides in weathered Qpc. These landslides form on virtually every slope configuration because groundwater refluxes everywhere from the contact of Units Qga and Qpc saturating and weathering the underlying clay-rich units. Eventually, the resultant mud sloughs off the slope, regardless of its shape. These surficial landslides together with the cemented nature of Unit Qpc result in steep inner gorge systems, not unlike inner gorges in bedrock. These are the least stable landform in the study area.
4. *Narrow valleys with meandering stream systems.* Four main valleys trending southwest contain flood plains wide enough to permit streams to meander between the valley walls. The Tahuya River is an example. Valleys contain sand and gravel with minor silt and clay, which were deposited from streams (alluvium).
5. *Narrow beaches along the margins of Hood Canal.* These beaches are locally wider where fans and deltas derived from landslides and fluvial deposits build out into the canal. These wider areas are commonly the sites of high-density housing.

The majority of observed landslides occur at or below the contact between the glacial advance outwash sand and gravels (Qga) and the nonglacial gravels (Qpc). This occurs principally due to the permeability contrast between Units Qga and Qpc that destabilizes overlying Qga sands and due to the weathering characteristics of Unit Qpc. Unit Qga is characterized by moderate slopes (gentler than 60%) and the presence of flora favoring well-drained ground such as Oregon grape, salal, evergreen huckleberry, and rhododendron. Unit Qpc is identified by steep slopes (typically steeper than 70%) and moist ground vegetation such as salmon berry, devils club, and western red cedar. The soil below the contact becomes observably wetter and/or water freely seeps from oversteepened outcrops of exposed nonglacial gravels.

Most landslides observed on the compact nonglacial gravels (Qpc) consist of soil less than 6 feet thick sliding down steep slopes and revealing near-vertical unweathered Qpc. These may form on any slope shape and are interpreted as weathering phenomena.

2.2.4 Glacial Deep-Seated Recharge Areas

There are eight locations on the map where areas of glacial deep-seated recharge are identified. These areas have been delineated based on the catchment area of a deep-seated landslide using 20 foot contour lines from the lidar DEM. We feel this provides appropriate protection of the recharge areas. The Landslide Hazard Zonation protocol does not require that recharge areas be mapped, so it should be noted that map A-2 <u>does not identify all the glacial deep-seated recharge areas within the study area</u>.

3.0 Summary of Results

Aerial photograph analysis of the area proved totally insufficient to provide an accurate representation of shallow-rapid landslide hazards of the inner gorge system. Numerous small, shallow-rapid landslides that do not disturb the canopy were discovered during fieldwork. Subsequent, re-examination of aerial photographs of these areas demonstrates that most of these small landslides cannot be identified with aerial photographs. For example, a 1000 foot traverse parallel to the drainage in the E 1/2 of Section 8, T22N, R3W revealed over 14 mappable landslides (Landslide ID Numbers 1901 to 1915) not previously identified from aerial photograph analysis. Difficulty in locating the failures in aerial photographs was partially due to the small area of the landslides, which ranged from 0.003 to 0.47 acres (average 0.05 acres) and were less than 6 feet deep. Two landslides in the drainage identified from aerial photograph analysis (Landslide ID Numbers 1787 and 1821) were field checked and both were reclassified as landforms incorporating numerous small landslides. In a second example, 3000 feet of the main drainage in the NE 1/4 of Section 18, T22N, R3W, was traversed together with several tributaries. In this drainage, aerial photograph analysis revealed only three landslides, but fieldwork showed many more landslides, most of which were small.

In this respect, the Tahuya study area is unique in the junior author’s experience, but similar to an area in British Columbia reported by Brardinoni and others (2002). In addition, relief on most of these shallow-rapid landslides is insufficient to allow identification with lidar imagery.

We are able to extrapolate risk from areas of detailed field observation to other parts of the study area, because of the relatively simple stratigraphy and regionally consistent geomorphology that characterize these watersheds. This in turn, allows adequate landslide hazard zonation and determination of relative risk consistent with the reconnaissance nature of this study.

During this review, a representative sample of 320 landslides ranging from ‘questionable’ to ‘definite’ field-confirmed landslides were inventoried using data obtained between 1978 and 2005 (Form A-1, Appendices A, B) within the study area.

Figures 2 through 7 characterize landslides in the study area. Compared to other watersheds of similar size in Washington, the landslide frequency is moderate to low. (See Section 5.0 below.)

Of the landslides identified during this mass-wasting assessment, 69% were mapped as shallow-rapid - undifferentiated failures, 9% were debris flows, 19% were deep-seated undifferentiated, 3% were small sporadic deep-seated, and less than 1% were earthflows (Figure 2).

A large percentage of mapped landslides are small relative to most Landslide Hazard Zonation Project watersheds. Of all shallow-rapid failures, 89% are smaller than 0.2 acres and all but 2 are smaller than 1 acre (Figure 3). The small size of these landslides results from two main factors: 1) unstable slopes in the steepest parts of the watershed (Landforms 5) are so steep that thick soils do not accumulate, and 2) much of the watershed is covered by stable landforms in cohesive soils.

On managed lands, landslides associated with clear-cuts (0 to 5 years) represent 18% of all recorded failures and young stands (5 to 15 years) represent 4% (Figure 4). The bulk of the landslides occurred in submature stands (15 to 50 years) and represent 58% of all landslides. Landslides in mature stands represent a combined total of 12% of observed slope failures.

Throughout the watershed, most landslides are associated with rule-identified features including inner gorges and convergent headwalls (Figure 5). Terrace faces had the greatest number of landslides (150) in the area and are considered rule-identified under WAC 222-16-050(1)(d)(i)(E). Undercutting of rule-identified meander scarps (Landform 4) by the Tahuya River has resulted in two mapped landslides (1606 and 1608). Most of the stream-influenced failures mapped during this study are located in the incised inner gorge system. The majority of the failures occurred on terrace faces (48%).

Table 2. Average slopes for various landslide components and physiographic elements in the Tahuya study area.

Failure Component	Average Slope Percent (post landslide)	Standard Deviation
Deep-seated initiation	86	20
Deep-seated toe	74	21
Shallow-rapid initiation	87	20

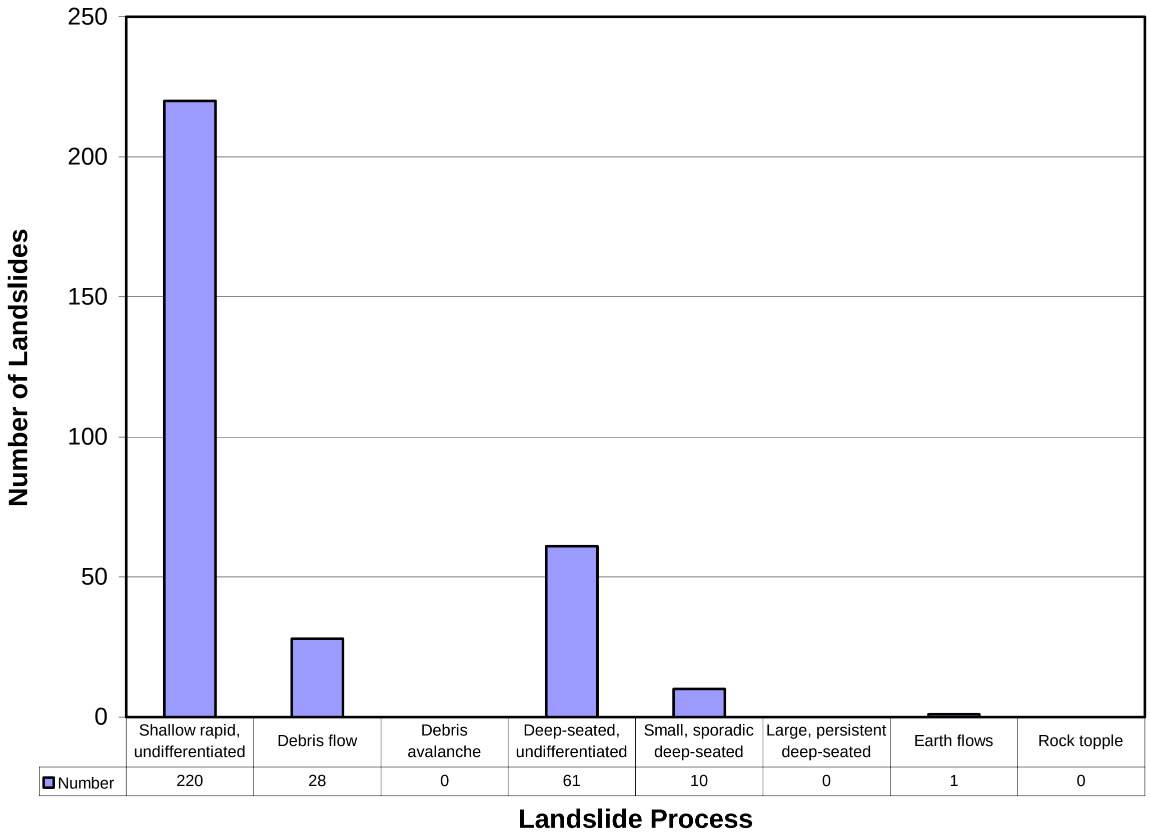
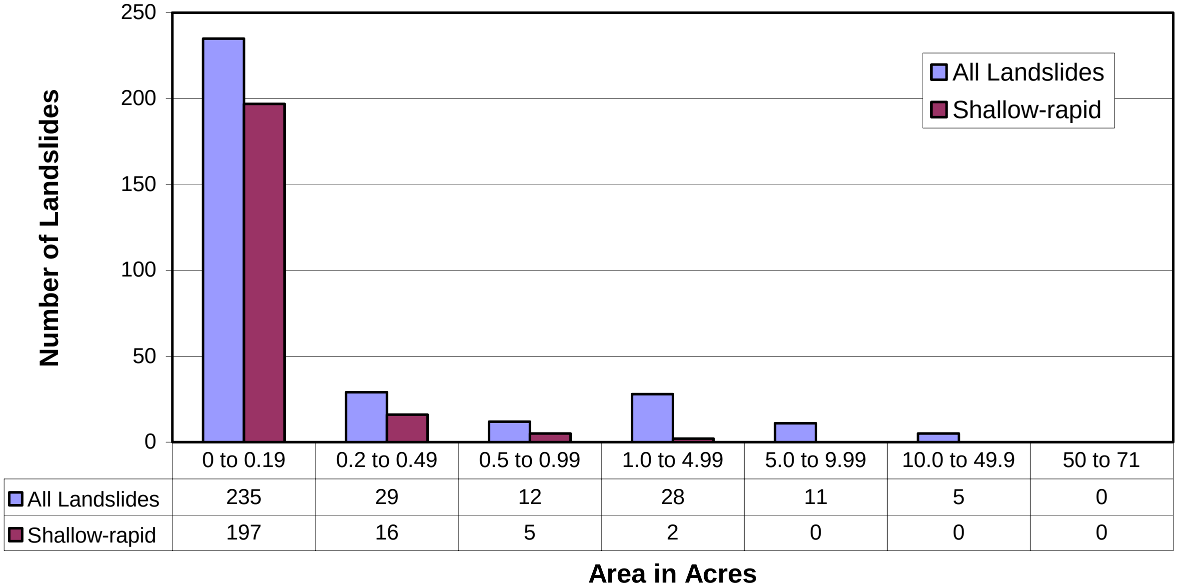
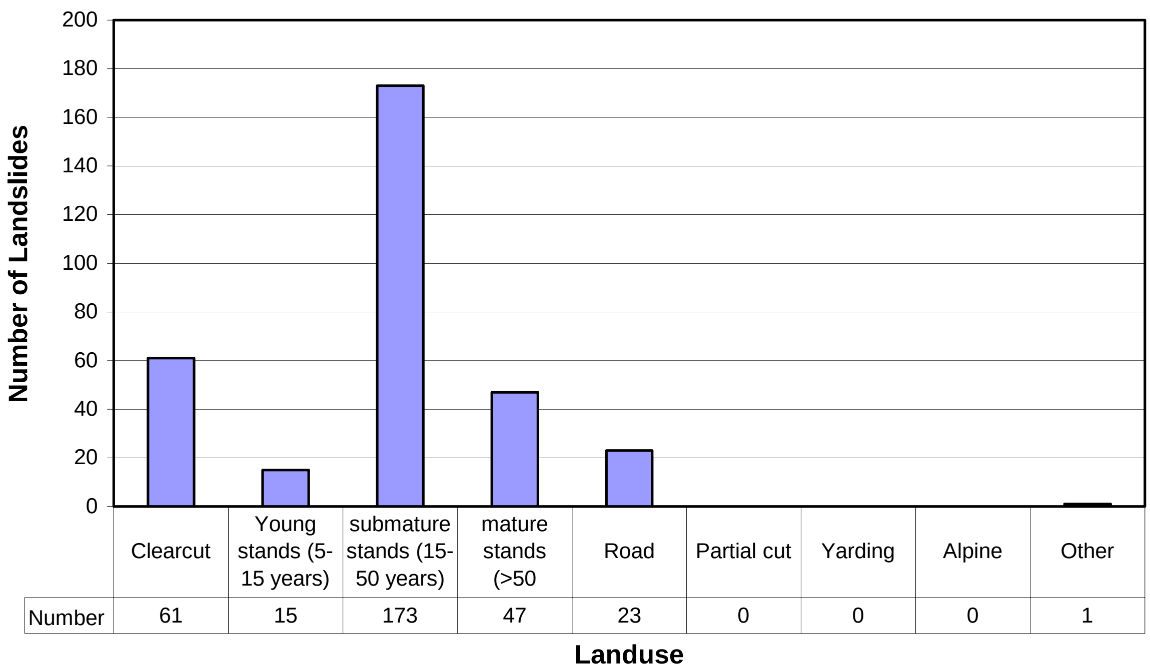


Figure 2. Number of landslides observed within the study area.



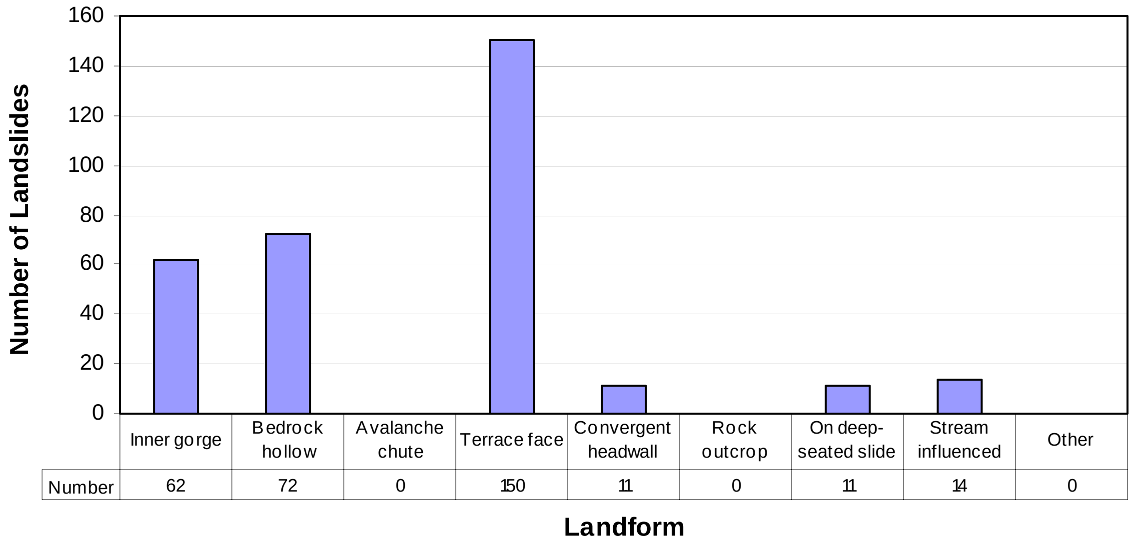
	0 to 0.19	0.2 to 0.49	0.5 to 0.99	1.0 to 4.99	5.0 to 9.99	10.0 to 49.9	50 to 71
All Landslides	235	29	12	28	11	5	0
Shallow-rapid	197	16	5	2	0	0	0

Figure 3. Size distribution of landslides within the study area.



	Clearcut	Young stands (5-15 years)	submature stands (15-50 years)	mature stands (>50	Road	Partial cut	Yarding	Alpine	Other
Number	61	15	173	47	23	0	0	0	1

Figure 4. Number of landslides observed within the study area by land use association.



	Inner gorge	Bedrock hollow	Avalanche chute	Terrace face	Convergent headwall	Rock outcrop	On deep-seated slide	Stream influenced	Other
Number	62	72	0	150	11	0	11	14	0

Figure 5. Number of landslides observed within the study area by rule identified or similar small-scale landform association.

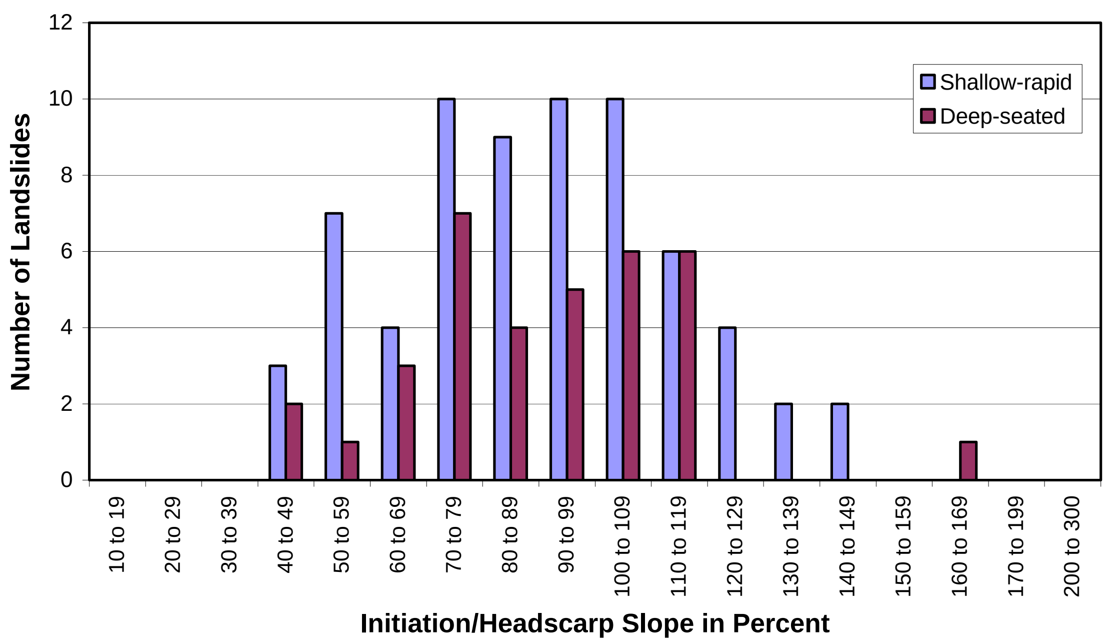


Figure 6. Distribution of all landslides by initiation/headscarp slope for the study area.

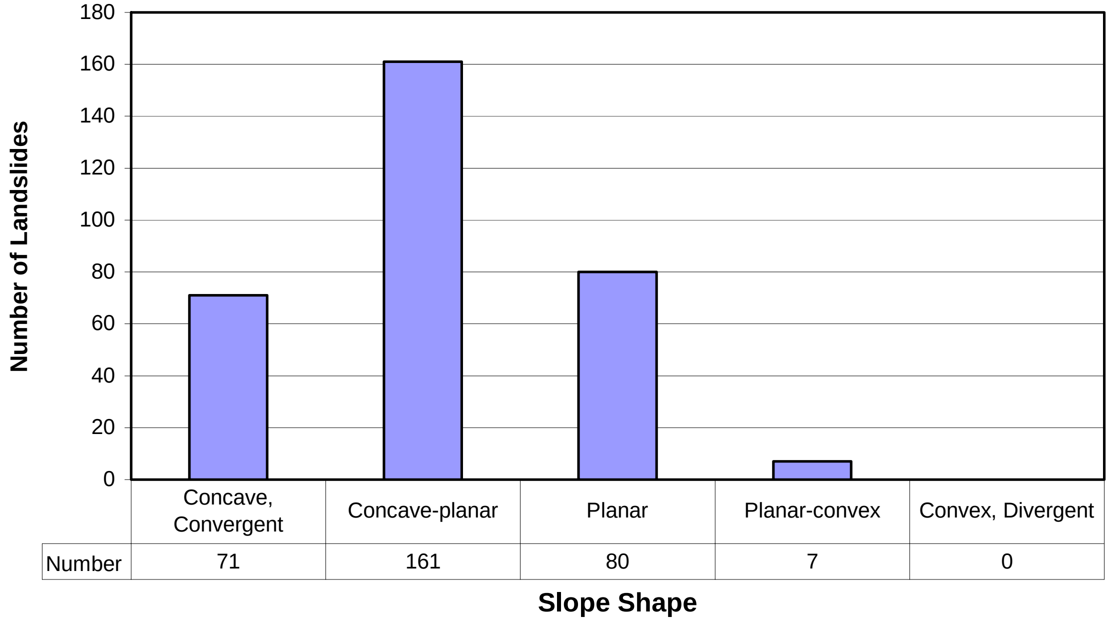


Figure 7. Distribution of landslides by slope shape.

4.0 Landform Descriptions (Form A-2)

4.1 Introduction

The five watershed-specific landforms defined herein have been delineated to show areas having similar mass-wasting potential and potential to deliver to public resources and threaten public safety. Mass-wasting potential is based mainly on landslide process, geology, failure density, lithology, hydrology, geomorphology, and topography. The following sections briefly describe the characteristics of each Landform. Additional information is given in Appendices A and B.

The delineation process of Landform boundaries follows reproducible procedures based on field observations augmented with aerial photographic analysis, and analysis with ArcGIS. The procedures for creating the moderate and high hazard landforms are as follows:

Landforms 3 and 5 outline deeply incised gorges and related stream systems. The boundaries of the Landforms were established from the lidar DEM, a slope-percent layer derived from the lidar DEM, and field observations of the geology and landslide initiation factors.

Landform 5 (high hazard) bounds slopes steeper than 60% and includes rule-identified features such as inner gorges, soil hollows, and convergent headwalls. The majority of the shallow-rapid and colluvial landslides occur in Landform 5, so this area is of greatest concern for potential management-related landslides. A 100 foot moderate hazard buffer (Landform 3) was placed around this unit to assure that field examination by staff trained in slope-stability will help to protect areas where the slope changes from greater than 60% to near-horizontal within a few feet of horizontal distance.

Landform 3 (moderate hazard) ranges from 30 to approximately 60% slopes and consist of Vashon glacial deposits Qga, Qgt, and Qgo. The slopes are gentler than the angle of repose, typically well drained, and show little if any signs of mass-wasting. The Landform was delineated at the 30% slope with a 75 foot buffer upslope to assure qualified staff will examine the area considered a secure distance from the drainage. This buffer will assure that low hazard areas are on low gradient ground, which in most cases, should be on or near the cohesive glacial till.

Landform 6 (high hazard) bounds slopes steeper than 30% and includes rule-identified features such as inner gorges, soil hollows, and convergent headwalls. This unit consists of the terrace face along Hood Canal, where these slopes locally show signs of mass-wasting and have the potential to deliver to a public and private resource (i.e.: roads and houses) that have been built along the entirety of the Hood Canal shoreline. A moderate hazard buffer (Landform 3) of 100 feet has been placed upslope of Landform 6 to assure that field examination by staff trained in slope-stability will help to protect the private and public resources along the Hood Canal shoreline.

Landform 4 (high hazard) bounds rule-identified outer edges of meander bends along valley walls or high terraces of an unconfined meander stream. The unit protects the entire slope above the cut-bank and places a 100 foot moderate hazard buffer (Landform 3) to assure that field examination by staff trained in slope-stability will help to protect the high hazard landform.

4.2 Form A-2: Landform Descriptions

In the following descriptions, “Confidence” statements refer to the confidence in the specific landform. Generally confidence in landslide identification and the precision of mapping is generally moderate as the study is designed to provide representative samples rather than exhaustive analysis. In the following sections, low hazard landforms are described with an abbreviated description (Form A-2), whereas moderate and high hazard landforms that will trigger a field investigation by Department of Natural Resources Region personnel are described with a complete Form A-2.

LANDFORM NUMBER: **1**
LANDFORM NAME: **Alluvium**
OVERALL HAZARD: **Low**

Description of Mass-Wasting Unit:

Landform 1 includes sand, gravel, and boulders deposited recently on floodplains (inclusive of channel migration zones) by creeks and rivers (Geologic Unit Qa). No landslides were mapped in this 2,788-acre landform and the Landslide Area Rate for Delivery (See below) is zero. High confidence. Note: alluvial fans may exist in this unit and are identified as “sensitive sites” in the Washington Forest Practices Rules. Landform 1 contains 480 acres or 2% of the total DNR Trust land in the Tahuya study area.

LANDFORM NUMBER: **2**
LANDFORM NAME: **Low Relief, Till-Plain with Ice-Scoured Hills**
OVERALL HAZARD: **Low**

Description of Mass-Wasting Unit:

Low-relief hills (drumlins) and the till plain (terrace top) locally covered with sediments deposited during the later stages of the continental glaciation. During the late ice age about 17,000 years ago, the most recent continental glacier flowed down from Canada’s Fraser River valley and deposited a blanket of sediments creating the tilt plain and low relief hills of the study area. These deposits have been differentiated as glacial till (Qgt), a compact olive gray mix of sand, gravel, clay, and boulders, which was deposited beneath the ice or differentiated as recessional outwash sand and gravel (Qgo), which was deposited beyond the edge of the ice. The outwash is well-drained and the glacial till, though poorly permeable, is cohesive. No landslides were mapped in this 36,624 acre landform. Therefore, Landform 2 is stable. Landform 2 contains 18,768 acres or 79% of the total DNR Trust land in the Tahuya study area.

LANDFORM NUMBER: **3**
LANDFORM NAME: **Lower Angle Terrace Edges**
OVERALL HAZARD: **Moderate**

Description of Mass-Wasting Unit:

Consists primarily of sediments deposited by continental glaciers: till and outwash sand and gravel. Slopes are between 30 and 60% and typically surround steeper areas. Landform 3 contains 2,649 acres or 11% of the total DNR Trust land in the Tahuya study area.

Number- and Cumulative Area of All Landslides: 19 25.67 acres

Observed Slope: min: 30% max: 60%

Slope Shape: Concave to planar.

Materials:

Continental glacial sediments deposited from the Vashon glacier, including clay, silt, sand, gravel, cobbles, and boulders.

Elevation of Landslides: Min: 99’ Max: 496’ Typical: 305’

Total Area: 6,015 acres

Mass-Wasting Processes: Shallow-rapid and deep-seated rotational slides possible.

Forest Practice Sensitivity: Moderate

Mass-Wasting Potential:

High. Further incision in inner gorge streams could oversteepen Landform 3, creating potentially unstable slopes with a high probability of delivery.

Number of Delivering Landslides: 13

Area of Delivering Landslides: 4.67 acres

Landslide Area Rate For Delivery: 139

Delivery Potential and Delivery Criteria Used:

Delivery possible if the nonglacial sediments (Qpc) fail and oversteepens Qga beyond the angle of repose.

Trigger Mechanisms:

Confidence: High.

Comments:

LANDFORM NUMBER: **4**
LANDFORM NAME: **Active Meander Bends**
OVERALL HAZARD: **High (Rule Identified)**

Description of Mass-Wasting Unit:

Landform 4 comprises the arcuate scarps where a river is actively eroding at meander bends in adjacent glacial and nonglacial units. Continued erosion at the toe of these slopes will generate landslides with high certainty of delivery. Landform 4 is rated as high-hazard in part because it is rule-identified. Landform 4 contains 18 acres or less than 1% of the total DNR Trust land in the Tahuya study area.

Number- and Cumulative Area of All Landslides: 2 1.85 acres.

Observed Slope: min: 0 max: vertical

Slope Shape: Concave-planar and planar

Materials:

Continental glacial sediments deposited from the Vashon glacier and pre-Vashon nonglacial sediments.

Elevation of Landslides: Min: 219' Max: 269' Typical: 244'

Total Area: 34 acres

Mass-Wasting Processes: Shallow-rapid and deep-seated rotational slides possible.

Forest Practice Sensitivity: High (rule-identified).

Mass-Wasting Potential: High. Natural undercutting undoubtedly will result in future landslides.

Number of Delivering Landslides: 1

Area of Delivering Landslides: 0.1 acres

Landslide Area Rate For Delivery: 139

Delivery Potential and Delivery Criteria Used:

Delivery potential is high when streams cut into the outside meanders in a channel.

Trigger Mechanisms:

Undercutting by erosion along the outside of meander bends.

Confidence: High

Comments:

LANDFORM NUMBER: **5**

LANDFORM NAME: **Steep Gorge Systems and Other Steep Convergent Topography**

OVERALL HAZARD: **Very High (Rule Identified in part)**

Description of Mass-Wasting Unit:

Landform 5 comprises of areas with moderate slopes forming the rule-identified inner gorges, soil hollows, convergent headwalls, and incised gorge systems throughout the study area. These are concentrated along inner gorge systems resulting from incision into nonglacial sediments (Unit Qpc) due to an uplift of the land and re-equilibration of the land following the last continental glaciation. These landforms are generally on the order of 20 to 120 feet tall. Landslides have been identified on all slope shapes (planar, convergent, and divergent). Landform 5 is rated high hazard because some parts consist of rule identified inner gorges, hollows, and convergent headwall systems and because other areas are characterized by constant small-scale slope failure. All other areas of steep convergent topography are included in Landform 5. Landform 5 contains 1,538 acres or 6% of the total DNR Trust land in the Tahuya study area.

Total Number and Cumulative Area of All Landslides: 241 152.5 acres.

Observed Slope: min: 60 max: vertical

Slope Shape:

All slopes shapes (planar, convergent, and divergent) are included and may fail, however convergent slopes have the greatest potential to deliver.

Materials:

Olympia-aged nonglacial fluvial gravels derived from the Olympic Mountains (Geologic Unit Qpc). (See Deeter, 1979.) Ancient streams deposited immense alluvial fans that consist of an overly compact, well-rounded, pebble to cobble-sized gravels (Deeter, 1979). Contains discontinuous lenses of clay, silt, and sand typically less than 3 feet thick. In other included convergent topography, continental glacial outwash (sand and gravels of geologic Unit Qga) is also responsible for failures where oversteepened (steeper than 70%).

Elevation of Landslides: Min: 99 ’ Max: 496’ Typical: 305’

Total Area: 3,306 acres

Mass-Wasting Processes: Mostly shallow-rapid slides with minor debris flows and small sporadic deep-seated slides.

Forest Practice Sensitivity: High

Mass-Wasting Potential: High. This is a very unstable landform and contains the majority of the failures in the Tahuya area.

Number and Area of Delivering Landslides: 179 21.29 acres

Landslide Area Rate For Delivery: 1294

Delivery Potential and Delivery Criteria Used:

Landslides can deliver to any of the numerous fish-bearing streams contained within Landform 5. In addition, a large landslide or debris flow can potentially deliver to a public resource on any of the numerous alluvial fans along Hood Canal. These fans typically contain densely packed communities that take advantage of the nearly flat ground.

Trigger Mechanisms:

Soil on oversteepened slopes on Qpc fail due to loss of root strength and/or excess groundwater seeping from the contact between impermeable Qpc and very permeable Qga.

Confidence:

High. Field observations at several locations in Landform 5 revealed similar processes throughout the Tahuya area.

Comments:

LANDFORM NUMBER: **6**
LANDFORM NAME: **Terrace face**
OVERALL HAZARD: **Very High**

Description of Mass-Wasting Unit:

Moderate (30%) to oversteepened slopes (steeper than 70%) that contain numerous water seeps and stream drainages within 2000 feet of the shoreline of Hood Canal. These slopes show signs of mass wasting and have the potential to deliver to public resources and threaten public safety (i.e.: roads and houses) that occupy the entire Hood Canal shoreline in the study area. Landform 6 contains 425 acres or 2% of the total DNR Trust land in the Tahuya study area.

Total Number and Cumulative Area of All Landslides: 54 55.40 acres.

Observed Slope: min: 30% max: vertical

Slope Shape: Convergent to planar.

Materials: All geologic units

Elevation of Landslides: Min: 99' Max: 496' Typical: 304'

Total Area: 3241 acres

Mass-Wasting Processes: Mostly shallow-rapid and deep-seated slides. Minor debris flows.

Forest Practice Sensitivity: High

Mass-Wasting Potential: High.

Number and Area of Delivering Landslides: 34 total 4.31 acres

Landslide Area Rate For Delivery: 283

Delivery Potential and Delivery Criteria Used:

Any failures on Landform 6 have a high potential of delivery to a public resource.

Trigger Mechanisms:

Soil on oversteepened slopes on Qpc fail due to loss of root strength and/or excess groundwater seeping from the contact between impermeable Qpc and very permeable Qga.

Confidence:

Moderate. Landform 6 is rated a high hazard solely because of the potential to deliver to a public resource and threaten public safety. In the field, evidence of mass wasting is abundant, but aerial photograph analysis proved ineffective and access was limited because the shoreline is almost entirely privately owned.

Comments:

Landform 6 comprises all slopes greater than 30%. This is due to the high probability of delivery that can threaten public safety (i.e.: roads and houses) and public resources that occupy the entire Hood Canal shoreline in the study area.

5.0 Hazard Ratings

Overall Hazard Ratings under this protocol may be determined from the following: 1) Specific criteria, such as rule-identified status (WAC 222-16-050), or 2) a combination of the Landslide Frequency Rate and the Landslide Area Rate For Delivery.

The Landslide Frequency Rate For Delivery is simply the area of all landslides normalized for the period of study and the area of each Landform. These values are multiplied by one million to provide whole numbers. Landslide Area Rate For Delivery is calculated in the same manner but includes only delivering landslides (Table 3). The Area Rate for Delivery is especially useful for helping to quantify the potential for delivery of sediment where rule-identified status may mischaracterize slope stability in the landform as outlined in Table A-2 of Washington Forest Practices Board (1997). Note that higher Landslide Area Rates For Delivery can be achieved by reducing the size of the Landform. While this may appear to be ‘data gerrymandering’, it has a favorable effect, which is to help limit the area of high-hazard Mass-Wasting map units to those areas that are actually demonstrated to have high hazard.

Limited application suggests that Landslide Area Rates For Delivery less than 76 might be considered low; rates of 76 to 150 are probably moderate, rates of 151 to 799 are probably high, and rates greater than 799 are very high (Table 3). Frequency Rates less than 450 are probably low, rates of 451 to 999 are probably moderate, rates of 1,000 to 2,000 are probably high, and rates greater than 2,000 appear to be very high.

Aerial photograph analysis proved totally insufficient to provide accurate representation of shallow rapid landslide hazards throughout the study area. The lack of identified landslides created hazard rates lower than observed in the field. Thus, in Table 3, Landform 5 contains a hazard calculation based on the entire landform area and a hazard calculation based on smaller areas of the field transects discussed in Section 3.0 of this report. Landform 6 also contains a hazard calculation based on the entire landform area followed by a hazard calculation for a smaller area in the E 1/2 of Section 27 and the W 1/2 of Section 26, T22N, R3W. We feel that Landform 6 requires a very high hazard rating due to the high potential to deliver to a public resource all along Hood Canal, as discussed above in Section 4.0.

Landslide Area Rates For Delivery for study area-specific landforms described herein are present in Table 3. The Landslide Area Rates For Delivery for the Tahuya area is lower than corresponding landforms or Mass-Wasting map units in most other watersheds studied to date (Table 4).

The overall study area, inclusive of all Mass-Wasting map units, is rated as low hazard, consistent with the author’s informal comparison with fourteen Priority 1 and three western Olympic Peninsula watersheds. The Tahuya area is in among the more stable watersheds that have been analyzed during the Landslide Hazard Zonation Project.

Table 3. Form A-4 Landslide Area Hazard Rates. The annualized rate of landslides that deliver to public resources and threaten public safety in terms of Landslide Frequency Rates and Landslide Area Rates for Delivery during the 19-year study period. For the purposes of this analysis, 'delivering landslides' are taken to include those that move rapidly and have a 'probable' or 'yes' delivery rating. Landslide Frequency Rates include deep-seated failures, but Landslide Area Rates for Delivery generally do not include any deep-seated failures.

	Landform 1	Landform 2	Landform 3	Landform 4	Landform 5[a]	Landform 5[b]	Landform 6[c]	Landform 6[d]
Area of Landform (acres)	2788	36624	6015	34	3306	48	3241	145
Number of Landslides	0	0	18	2	241	27	54	14
Landslide Frequency Rate = (number of slides * 1,000,000 / Landform area / 19 years)	0	0	158	3096	3837	29605	877	5082
Number of 'Delivering' Landslides	0	0	13	1	179	19	34	11
Area of 'Delivering' Landslides (acres)	0.00	0.00	4.67	0.09	21.29	1.18	4.31	0.78
Landslide Area Rate for Delivery = (area of delivering landslides * 1,000,000 / Landform area / 19 years)	0	0	41	139	339	1294	70	283
Overall Rating from Frequency & Area Rates, only	Low	Low	Low	High	Very High	Very High	Low	Very High
Overall Hazard Including Rule-Identified Status	**Low**	**Low**	**Moderate**	**High**	**Very High**	**Very High**	**High**	**Very High**

a: Calcuation based on the entire map area of Landform 5.

b: Calculation of field-identified landslides in the combined drainages in the NE 1/4 of Section 18, T22N, R3W and the E 1/2 of Section 8, T22N, R3W.

c: Calcuation based on the entire map area of Landform 6.

d: Calculation based on an area in the E 1/2 of Section 27 and the W 1/2 of Section 26, T22N, R3W.

Table 4. Comparison of Landslide Area Rates For Delivery for parts of landforms in nine Washington State watersheds. Note that the landform categories tabulated herein include all such features regardless of the angle of the contained slope (i.e., rule-identified unstable slopes and lower angle features are both included).

Watershed	Gorges, headwalls, hollows	Inner gorges	Bedrock Hollows	Convergent hadwalls	Superimposed on relict landslides	Cliff-dominated slopes	Lower hazard hills	Incised river	Glacial Outwash terraces	Valley floors	WAU or study area
Tahuya (Slaughter and Lingley, 2005)							0	1294	41	0	31
South Prairie Creek (Lingley, 2005)	158	50			2545	899	3	163		0	8
South Prairie Creek (Lingley, 2005)	189					0	0	26			
Lower Calawah Valley (Lingley, 2004a)	404						24	405		37	68
Jackman Corkindale (Lingley, 2004b)	1167				1217	213	24		35		461
Jackman Corkindale (Lingley, 2004b)	1142						10		19		
Nookachamps (Wegmann, 2004)		273	173	384					31		11
Lime and Dan Creeks (Wegmann, 2004)	119										4
Finney Miller (Lingley, 2004c)	1306	376			356	510	1		567		224
Finney Miller (Lingley, 2004c)					383	414			408		
West Fork Teanaway (Powell, 2004)									978		
Averages	**641**	**233**	**173**	**384**	**1125**	**407**	**9**	**472**	**297**	**12**	**115**

5.1 Note on Confidence in Work Products

The overall confidence in this Mass-Wasting assessment is moderate. This moderate rating results because the Landslide Hazard Zonation Project is designed to provide a watershed-scale overview of slope stability throughout the state in the shortest reasonable period. It is to be used as a screening tool only. As a consequence, fieldwork and the number of aerial photograph sets examined are held to reasonable minimums and the work is performed rapidly with little time given to crosschecking results. **This assessment would be entirely insufficient and misleading if it is used as a stand-alone document for protecting private resources or for land-use planning**. **Keep in mind that some landslides may have been accidentally omitted or miscoded and some benign features may be improperly mapped as landslides herein**.

Another important source of potential error in this assessment is in the accuracy and precision of measurements of Mass-Wasting features. Because only 14% of mapped landslides were actually visited in the field and the quantity of landslides not readily identified by aerial photograph analysis, it is not possible to report the degree to which location and measurement error in the GIS environment compares to on-the-ground field measurements. Given these sources of error, the confidence in the precise location and accuracy of measurements of individual landslides is considered moderate.

6.0 References

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Appendix A -- A-1 Form: Landslide Inventory

Mass-Wasting Inventory Data for the Tahuya study area that includes parts of the Kitsap SW and Kitsap E-SW WAUs. Codes for this table are presented on the DNR Forest Practices website. Under Photo_number column "LIDAR" indicates that the landslide was found using GIS lidar layers including layers derived from lidar such as contour lines, slope percent, and various hillshades. "FIELD" indicates that the landslide was discovered in the field after aerial photograph analysis was completed.

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	init elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
18	4	D	1980	5			152		4	2	42	N	4	2	D	5.37	Qpc	Washington Department of Ecology, 1980
19	4	D	1980	5			261		4	2	83	N	4	4	C	5.42	Qpc	Washington Department of Ecology, 1980
20	5	D	1980	5					4	2	94	N	4	4	C	182.70	Qpc	Washington Department of Ecology, 1981
21	4	D	1980	5			262		4	2	102	N	4	2	B	6.41	Qpc	Washington Department of Ecology, 1980
22	4	D	1980	5					4	2		N	4	2		1.22	Qpc	Washington Department of Ecology, 1980
1504	1	D	1978	2	1981	2	265	NW-78 29A-88	9	2	85	Y	1	3		0.06	Qpc	
1505	1	D	1978	2	1981	2	327	NW-78 29A-88	1	2	72	Y	1	3		0.08	Qga	
1506	1	D	1978	2			280	NW-78 29A-88	1	2	90	Y	1	3		0.06	Qpc	
1507	1	D	1978	3			265	NW-78 29A-88	1	2	97	Y	2	3		0.14	Qpc	
1508	1	D	1978	3			280	NW-78 29A-88	1	2	85	Y	2	3		0.31	Qgt	
1510	1	D	1978	2			229	NW-78 29A-88	1	2	55	Y	2	2		0.07	Qga	
1511	4	D	1978	3	2005	2	344	NW-78 29A-88	1	2	75	N	3			0.19	Qga	Entirely coarse sand and gravel; 20 ft wide by ~100 ft long; near verticle headscarp
1512	1	D	1978	4	1981	4	356	NW-78 29A-88	1	2	76	Y	1	3		0.74	Qgt	Field checked
1513	1	D	1978	2			311	NW-78 29A-88	1	2	98	Y	1	3		0.09	Qga	Field checked
1514	1	D	1978	2			317	NW-78 29A-88	1	2	77	Y	1	3		0.07	Qga	Field checked
1515	1	D	1978	3			272	NW-78 29A-88	1	2	50	Y	1	2		0.17	Qga	
1522	4	D	1978	5			360	NW-78 27A-86	1	2	80	N	4	4	B	5.45	Qpc	
1523	1	P	1978	1			337	NW-78 27A-86	8	2	75	Y	4	4		0.01	Qgt	Canopy hole
1524	1	P	1978	2			325	NW-78 27A-86	8	2	96	Y	4	4		0.02	Qgt	Canopy hole
1525	1	P	1978	2			260	NW-78 27A-86	8	2	53	Y	4	4		0.05	Qga	Canopy hole
1533	4	P	1978	5			462	NW-78 25A-77	4	1	72	N	4	2	C	19.98	Qga	
1534	1	P	1978	4			287	NW-78 25A-77	1	2	80	Y	3	3		0.58	Qgt	
1535	1	P	1978	2			239	NW-78 25A-77	1	2	67	Y	3	3		0.10	Qpc	Canopy hole
1536	1	P	1978	3			280	NW-78 25A-77	1	2	81	Y	3	2		0.11	Qga	Canopy hole
1539	2	P	1978	3			259	NW-78 27A-82	1	2	50	Y	3	3		0.34		Canopy hole; initiation and deposit not visible.
1552	1	P	1978	2			141	NW-78 23C-3	4	2	59	Y	3	4		0.04	Qgo	Canopy hole
1553	4	P	1978	5			391	NW-78 23C-3	4	1	83	N	4	3	D	8.65	Qgt	Canopy/vegetation change
1554	1	P	1978	2			336	NW-78 23C-3	1	2	140	Y	3	3		0.07	Qgt	Canopy hole
1555	1	P	1978	2			293	NW-78 23C-3	4	2	91	Y	3	3		0.06	Qpc	Canopy hole
1556	1	P	1978	3			329	NW-78 23C-3	4	2	95	Y	3	3		0.19	Qpc	Canopy hole
1557	1	P	1978	2			332	NW-78 23C-3	1	2	88	Y	3	3		0.05	Qpc	Canopy hole
1558	1	P	1978	2			444	NW-78 23C-1	4	2	50	Y	3	2		0.04	Qgt	Canopy hole
1559	1	D	1978	2	1981	2	482	NW-78 23C-1	4	2	108	Y	3	3		0.06	Qpc	Canopy hole
1560	1	P	1978	2	1981	2	487	NW-78 23C-1	4	2	82	Y	3	3		0.04	Qpc	Canopy hole
1562	1	P	1978	2			472	NW-78 23C-1	1	2	85	Y	3	3		0.07	Qpc	Canopy hole
1563	1	D	1978	2	1985	2	337	NW-78 23B-54	2	2	78	Y	3	3		0.05	Qpc	Canopy hole
1564	1	D	1978	2			390	NW-78 23B-54	2	2	74	Y	3	3		0.03	Qgt	Field checked
1566	1	D	1978	2			295	NW-78 23B-54	2	2	80	Y	3	3		0.04	Qpc	Canopy hole
1567	1	D	1978	1			270	NW-78 23B-54	2	2	78	Y	3	3		0.02	Qpc	Canopy hole
1568	1	D	1978	2			310	NW-78 23B-54	2	2	88	Y	3	3		0.04	Qpc	Canopy hole
1569	1	D	1978	2			274	NW-78 23B-54	4	2	72	Y	3	3		0.02	Qpc	Canopy hole
1570	1	D	1978	1	1981	1	285	NW-78 23B-54	4	2	86	Y	3	3		0.02	Qpc	Canopy hole
1571	1	D	1978	2			313	NW-78 23B-54	4	2	82	Y	3	3		0.04	Qpc	Canopy hole
1573	1	D	1978	1	1981	1	274	NW-78 23B-54	4	2	74	Y	3	3		0.01	Qpc	Canopy hole
1574	1	D	1978	1	1981	1	280	NW-78 23B-54	4	2	86	Y	3	3		0.01	Qpc	Canopy hole
1575	1	D	1978	2	1981	2	304	NW-78 23B-54	4	2	86	Y	3	3		0.02	Qpc	Canopy hole
1576	1	D	1978	2			293	NW-78 23B-54	4	2	75	Y	3	3		0.04	Qpc	Canopy hole
1578	1	P	1978	2			400	NW-78 23B-52	2	2	82	Y	3	2		0.07	Qgt	
1580	2	P	1978	4			222	NW-78 23B-53	1	1	47	Y	3	2		0.70	Qga	Canopy hole; initiation and deposit not visible.

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	init elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1581	1	P	1978	3			362	NW-78 23B-53	4	4	40	Y	5	2		0.18	Qga	Canopy hole; initiation and deposit not visible.
1582	1	P	1978	4			385	NW-78 23B-53	4	1	70	Y	3	2		0.59	Qgt	Canopy hole
1584	1	P	1978	3			185	NW-78 23B-53	4	1	88	Y	3	3		0.16	Qpc	Canopy hole
1587	1	P	1978	3			378	NW-78 23B-52	4	2	55	Y	3	2		0.26	Qga	Canopy hole; initiation and deposit not visible.
1589	1	P	1978	2			377	NW-78 23B-52	4	2	74	Y	1	2		0.05	Qgt	Canopy hole
1590	1	P	1978	2			382	NW-78 23B-52	4	2	65	Y	1	2		0.07	Qgt	Canopy hole
1592	1	P	1978	2			293	NW-78 23B-50	2	2	84	Y	3	2		0.10	Qpc	Canopy hole
1593	1	P	1978	3			300	NW-78 23B-50	2	2	130	Y	3	2		0.14	Qpc	Canopy hole
1594	1	D	1978	2			336	NW-78 23B-50	4	3	95	Y	3	2		0.06	Qpc	Canopy hole
1595	1	D	1978	2			268	NW-78 23B-50	4	1	97	Y	3	2		0.05	Qpc	Canopy hole
1596	1	D	1978	1			250	NW-78 23B-50	4	4	97	Y	3	2		0.02	Qpc	Canopy hole
1597	1	D	1978	2			285	NW-78 23B-50	4	4	105	Y	3	2		0.05	Qpc	Canopy hole
1598	1	D	1978	2			283	NW-78 23B-50	4	2	116	Y	3	2		0.09	Qpc	Canopy hole
1599	4	P	1978	3			486	LIDAR	2	1	90	N	3	3		0.32	Qpc	
1605	2	D	1978	3			306	NW-78 29A-88	4	3	80	Y	1	2		0.16	Qgt	Field checked
1606	4	D		5	2005	5	268	LIDAR	4	3	50	Y	4	4	C	1.76	Qgt	Pierson, 2005
1607	4	D		5	2005	5	268	LIDAR	4	3	73	Y	4	4	C	3.62	Qgt	Pierson, 2005
1608	1	D	1985	2	1997	2	219	SP-85 11-026-176/FIELD	8	2	82	Y	9	4		0.09	Qga	Pierson, 2005
1609	5	D	1978	2	1997	2	213	NW-78 25A-89/FIELD	8	2	77	Y	4	4		0.08	Qga	Pierson, 2005
1610	1	P	1978	3			250	NW-78 21A-79	2	2	95	Y	5	3		0.13	Qpc	
1611	1	P	1978	2	1985		337	NW-78 21A-79	4	1	74	Y	3	2		0.09	Qgt	Canopy hole
1613	1	D	1978	1			99	NW-78 21A-79	4	3	93	Y	3	2		0.02	Qpc	Stream undercut bank; stream has incised up to 12 ft into colluvium in valley bottom
1614	1	D	1978	2			122	NW-78 21A-79	4	1	99	Y	3	2		0.04	Qpc	Field checked
1615	1	P	1978	2			297	NW-78 21A-79	2	1	71	Y	3	3		0.05	Qpc	Canopy hole
1616	1	P	1978	2	1981	2	384	NW-78 21A-79	2	1	74	Y	3	3		0.05	Qgt	Canopy hole
1619	1	P	1978	2	1985	2	353	NW-78 21A-82	2	1	73	Y	3	3		0.04	Qgt	Canopy hole
1620	1	P	1978	2			346	NW-78 21A-82	1	1	80	Y	3	3		0.06	Qpc	Canopy hole
1621	1	P	1978	1			380	NW-78 21A-82	2	1	73	Y	3	3		0.02	Qgt	Canopy hole
1622	2	P	1978	2			335	NW-78 21A-82	2	1	26	Y	3	2		0.06	Qga	Canopy hole; initiation and deposit not visible.
1623	1	P	1978	2			350	NW-78 21A-82	2	2	81	Y	3	3		0.02	Qpc	Canopy hole
1624	1	P	1978	2			415	NW-78 21A-82	4	2	51	Y	3	2		0.03	Qgt	Canopy hole
1625	1	P	1978	1			336	NW-78 21A-82	4	3	91	Y	3	3		0.01	Qpc	Canopy hole
1626	1	P	1978	1			309	NW-78 21A-82	4	3	83	Y	3	3		0.02	Qpc	Canopy hole
1627	1	P	1978	1			315	NW-78 21A-82	4	3	84	Y	3	3		0.02	Qpc	Canopy hole
1628	1	P	1978	1			303	NW-78 21A-82	4	3	92	Y	3	3		0.02	Qpc	Canopy hole
1629	1	P	1978	2			390	NW-78 21A-84	2	2	91	Y	3	3		0.06	Qpc	Canopy hole
1630	1	p	1978	2			376	NW-78 21A-84	2	1	94	Y	3	3		0.03	Qpc	
1633	1	P	1978	1			257	NW-78 21A-87	4	3	74	Y	3	3		0.01	Qpc	Canopy hole
1634	1	P	1978	1			255	NW-78 21A-87	4	3	75	Y	3	3		0.01	Qpc	Canopy hole
1635	1	P	1978	1			347	NW-78 21A-87	4	3	95	Y	3	3		0.01	Qpc	Canopy hole
1636	1	P	1978	1			411	NW-78 21A-87	4	3	80	Y	3	3		0.01	Qpc	Canopy hole
1637	1	P	1978	1			417	NW-78 21A-87	4	3	85	Y	3	3		0.01	Qpc	Canopy hole
1638	1	P	1978	1			427	NW-78 21A-87	4	3	77	Y	3	3		0.01	Qpc	Canopy hole
1639	2	P	1978	2			368	NW-78 19B-28	1	1	72	Y	3	2		0.09	Qpc	Canopy hole; initiation and deposit not visible.

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	init elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1640	2	P	1978	2	1981	2	339	NW-78 19B-28	2	1	44	Y	3	3		0.04	Qga	Canopy hole; initiation and deposit not visible.
1643	1	D	1981	2			356	SP-81 5-29-74	2	1	115	Y	1	3		0.10	Qgt	Field checked; recent 2 ft vertical slip; man-made culvert feeds water through gravel from depression swamp; seeping about 1 gpm, vertical scarp in till 10 ft high
1647	1	D	1981	1			278	SP-81 5-29-74	2	2	92	Y	1	3		0.01	Qpc	Exposed soil/scar
1648	1	P	1981	1			291	SP-81 5-29-74	2	2	106	Y	1	3		0.02	Qpc	Exposed soil/scar
1649	1	P	1981	2			316	SP-81 5-29-76	2	2	92	Y	3	3		0.02	Qgt	Canopy hole
1650	1	P	1981	2			374	SP-81 5-29-76	2	2	65	Y	3	3		0.06	Qga	Canopy hole
1653	1	D	1981	1			222	SP-81 2-19-72	2	2	66	Y	5	3		0.01	Qpc	
1654	1	D	1981	1			424	SP-81 2-19-72	4	2	66	N	5	2		0.02	Qga	
1655	2	D	1981	2			323	SP-81 2-19-72	4	2	33	Y	1	2		0.05	Qga	Canopy hole; initiation and deposit not visible.
1668	1	P	1981	2			194	SP-81 2-19-72	2	2	72	Y	3	3		0.06	Qpc	Canopy hole
1669	2	P	1981	2			308	SP-81 2-19-72	4	2	34	Y	3	2		0.08	Qga	Canopy hole; initiation and deposit not visible.
1670	1	D	1981	1			225	SP-81 2-19-72	4	3	92	Y	3	3		0.02	Qpc	Canopy hole; probable earthflow
1671	1	D	1981	2			325	SP-81 2-19-72	4	3	83	Y	3	3		0.02	Qpc	Canopy hole
1672	1	D	1981	1			302	SP-81 2-19-72	4	3	104	Y	3	3		0.01	Qpc	Canopy hole
1674	1	D	1981	2			234	SP-81 1-21-74	4	3	97	Y	5	3		0.06	Qpc	Canopy hole
1676	1	P	1981	2	1985	2	300	SP-81 1-21-172	4	3	83	Y	5	3		0.04	Qpc	Canopy hole
1678	1	P	1981	2			406	SP-81 1-21-172	2	2	84	Y	3	3		0.02	Qgt	Canopy hole
1679	1	P	1981	2			422	SP-81 1-21-172	2	1	92	Y	3	3		0.03	Qgt	Exposed soil/scar
1681	1	P	1981	2			354	SP-81 1-21-172	4	3	90	Y	1	3		0.03	Qpc	Exposed soil/scar
1682	1	P	1981	2			361	SP-81 1-21-172	2	2	100	Y	5	3		0.02	Qpc	Exposed soil/scar
1683	1	P	1981	2			265	SP-81 1-21-172	2	3	93	Y	5	3		0.03	Qpc	Exposed soil/scar
1684	1	P	1981	1			384	SP-81 1-21-175	4	3	72	P	5	2		0.01	Qga	Exposed soil/scar
1685	1	P	1981	1			332	SP-81 1-21-175	4	3	88	P	1	3		0.01	Qga	Exposed soil/scar
1686	1	P	1981	1			331	SP-81 1-21-175	4	2	70	P	1	3		0.02	Qga	Exposed soil/scar
1687	1	D	1981	2			295	SP-81 1-21-175	4	3	86	Y	1	3		0.04	Qpc	Canopy hole
1688	1	P	1981	1			261	SP-81 1-21-175	4	3	76	P	1	3		0.01	Qpc	Canopy hole
1691	2	D	1981	3			355	SP-81 1-21-175	2	1	98	Y	1	3		0.31	Qgt	Canopy hole
1692	1	P	1981	1			256	SP-81 1-21-175	2	2	82	Y	1	3		0.01	Qpc	Canopy hole
1693	1	P	1981	2			400	SP-81 2-21-175	2	1	84	Y	3	3		0.09	Qgt	Canopy hole
1694	1	P	1981	2			310	SP-81 4-23-271	2	1	83	Y	1	2		0.03	Qpc	Exposed soil/scar
1698	1	P	1981	2			238	SP-81 4-23-271	4	2	77	P	1	2		0.08	Qga?	Exposed soil/scar
1703	1	P	1981	2			304	SP-81 4-23-274	4	3	93	Y	3	3		0.05	Qpc	Canopy hole
1704	4	P	1981	2			207	SP-81 4-23-274	2	2	75	N	3	3		0.05	Qpc	Canopy hole
1706	1	P	1981	2	1985	2	342	SP-81 4-23-274	4	2	82	Y	1	3		0.05	Qpc	Canopy hole
1707	1	D	1981	2	1985	2	392	SP-81 4-23-276	4	4	65	Y	5	3		0.06	Qgt?	Canopy hole
1708	1	P	1981	1			304	SP-81 1-22-79	4	2	83	Y	3	3		0.01	Qpc	Canopy hole
1709	1	P	1981	1			293	SP-81 1-22-79	1	1	99	Y	3	3		0.02	Qpc	Canopy hole
1710	2	P	1981	2			471	SP-81 1-22-79	1	1	71	Y	3	3		0.07	Qpc	Canopy hole; initiation and deposit not visible.
1711	1	P	1981	1			362	SP-81 1-22-79	4	4	71	Y	2	3		0.02	Qpc	Canopy hole
1714	1	P	1981	2			428	SP-81 1-22-80	4	2	47	Y	3	2		0.05	Qga	Canopy hole
1715	1	P	1981	2			399	SP-81 1-22-80	2	2	84	Y	3	3		0.04	Qpc	Canopy hole
1716	1	P	1981	2			343	SP-81 1-22-80	2	3	107	Y	3	3		0.03	Qpc	Canopy hole
1717	1	P	1981	1			286	SP-81 1-22-80	2	2	95	Y	3	3		0.01	Qpc	Canopy hole
1718	1	P	1981	2			219	SP-81 1-22-80	4	3	95	Y	3	3		0.03	Qpc	Canopy hole

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	init elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1722	2	D	1985	2			261	SP-85 13-030-286	1	1	78	Y	5	2		0.03	Qgt	Canopy/vegetation change
1724	1	P	1985	2			324	SP-85 13-030-288	2	2	85	N	3	3		0.05	Qpc	
1725	1	P	1985	2			296	SP-85 13-030-288	2	2	95	Y	3	3		0.02	Qpc	
1731	2	P	1985	2			375	SP-85 13-028-079	1	1	65	Y	3	3		0.05	Qgt?	Exposed soil/scar
1732	1	P	1985	2			284	SP-85 13-028-079	4	3	94	Y	3	3		0.04	Qpc	
1736	1	P	1985	2			253	SP-85 13-028-079	2	2	98	Y	5	3		0.03	Qpc	Field checked; not obvious but slope and geology suggest landslide is probable
1743	1	P	1985	2			224	SP-85 11-026-172	8	2	112	Y	3	3		0.06	Qpc	
1744	1	P	1985	2			182	SP-85 11-026-172	2	3	86	Y	1	3		0.02	Qpc	
1745	2	D	1985	3			268	SP-85 11-026-172	2	1	113	Y	1	3		0.21	Qpc	
1746	1	D	1985	2			133	SP-85 11-026-172	4	3	91	Y	1	3		0.03	Qpc	
1747	1	D	1985	2			190	SP-85 11-026-172	4	3	94	Y	1	3		0.05	Qpc	
1750	1	P	1985	2			279	SP-85 11-026-172	4	3	108	Y	3	3		0.02	Qpc	
1752	1	D	1985	2			319	SP-85 12-024-130	4	3	57	P	5	2		0.04	Qga?	
1753	1	D	1985	2			320	SP-85 12-024-130	4	3	62	P	5	2		0.07	Qga?	
1754	1	D	1985	2			393	SP-85 12-024-130	2	2	73	P	5	2		0.04	Qga	
1757	1	P	1985	3			374	SP-85 12-024-130	4	2	67	P	5	2		0.25	Qga	
1758	1	P	1985	3			300	SP-85 12-024-130	4	1	70	Y	5	2		0.19	Qga?	
1761	2	D	1985	3			338	SP-85 12-024-130	4	1	49	P	1	2		0.11	Qga	
1762	2	D	1985	2			384	SP-85 12-024-130	4	2	41	P	1	2		0.04	Qga	
1763	1	D	1985	1			224	SP-85 12-024-132	2	3	98	Y	5	3		0.01	Qpc	
1764	1	D	1985	1			261	SP-85 12-024-132	4	3	82	Y	5	3		0.01	Qpc	
1767	1	P	1985	1			346	SP-85 12-024-132	4	3	65	Y	1	3		0.01	Qpc	
1769	2	P	1985	2			288	SP-85 12-024-134	2	2	100	Y	3	3		0.10	Qpc	
1770	1	P	1985	2			193	SP-85 12-024-134	4	3	107	Y	3	3		0.03	Qpc	
1786	1	D	1985	3			370	SP-85 08-022-243	1	1	115	Y	3	3		0.28	Qga?	
1787	1	D	1985	2			267	SP-85 08-022-243	4	2	74	Y	1	3		0.09	Qpc	Failed directly below 50% slope break at Qga/Qpc contact; scarp face seeping water
1788	1	D	1985	2			192	SP-85 08-022-243	2	1	87	Y	3	3		0.05	Qpc	
1789	1	D	1985	2			125	SP-85 08-022-243	2	2	101	Y	3	3		0.02	Qpc	
1790	1	D	1985	2			248	SP-85 08-022-243	4	3	84	Y	3	3		0.02	Qpc	
1791	1	D	1985	2			243	SP-85 08-022-243	4	3	84	Y	3	3		0.04	Qpc	
1792	2	D	1985	2			180	SP-85 08-022-243	9	1	34	Y	3	3		0.09	Qpc	220 ft runout section of debris flow
1793	1	P	1985	2			324	SP-85 08-022-243	1	2	100	Y	3	3		0.08	Qpc	
1796	1	D	1985	2			322	SP-85 08-022-243	8	3	67	Y	1	3		0.03	Qpc?	
1800	1	P	1997	2			106	OL97 18-79-78	1	1	109	P	1	2		0.03	Qpc	
1802	1	Q	1997	2			248	OL97 18-79-78	4	2	93	P	1	2		0.02	Qpc	
1804	4	Q	1997	5			366	OL97 18-79-78	4	2	90	N	4	3	B	5.48	Qpc	
1806	4	Q	1997	5			430	OL97 18-79-81	5	2	77	N	4	3	B	15.49	Qpc	
1807	4	Q	1997	5			482	OL97 18-79-81	5	2	102	N	4	2	B	1.59	Qpc	
1808	4	Q	1997	5			485	OL97 18-79-81	5	2	72	N	4	2	B	1.15	Qpc	
1809	4	D	1997	5			496	OL97 18-79-81	4	2	92	N	3	3	A	2.41	Qpc	
1810	2	D	1997	2			305	OL97 18-79-84	1	1	70	Y	1	2		0.09	Qpc	
1811	1	D	1997	2			356	OL97 38-81-79	2	1	103	Y	3	3		0.09	Qpc	
1812	1	P	1997	2			238	OL97 38-81-79	2	3	88	Y	3	3		0.04	Qpc	
1813	1	P	1997	1			206	OL97 38-81-79	2	3	134	Y	1	3		0.02	Qpc	
1814	1	D	1997	2			211	OL97 38-81-79	1	3	100	Y	1	3		0.02	Qga	
1815	1	P	1997	2			334	OL97 38-81-76	2	3	83	Y	2	3		0.03	Qpc	
1816	1	P	1997	2			270	OL97 38-81-76	1	3	102	Y	2	3		0.03	Qpc	
1817	1	P	1997	2			250	OL97 38-81-76	1	2	74	Y	2	3		0.02	Qpc	
1818	1	P	1997	1			216	OL97 38-81-76	1	2	71	Y	2	3		0.02	Qpc	
1819	2	D	1997	3			392	OL97 38-81-72	1	1	65	Y	1	3		0.16	Qpc	
1820	1	D	1997	2			329	OL97 38-81-72	1	1	114	Y	1	3		0.05	Qpc	

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	init elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1821	4	D	1997	5			377	OL97 38-81-72	5	2	117	N	3	3	B	1.23	Qpc	Unit contains at least three recent debris slides too small to map; 75 ft by 15 ft; 15 ft by 15 ft; and 60 ft by 5 ft; all delivered and all < 10 years old
1822	4	Q	1997	5			383	OL97 38-81-72	5	2	116	N	3	3	B	1.16	Qpc	
1823	4	Q	1997	5			396	OL97 38-81-72	5	2	104	N	3	3	B	1.18	Qpc	
1824	4	Q	1997	5			331	OL97 38-81-72	1	1	165	N	3	3	B	2.69	Qpc	
1825	4	Q	1997	5			397	OL97 38-81-70	5	2	112	N	3	3	B	1.39	Qga	
1826	4	P	1997	5			400	OL97 38-81-70	1	2	109	N	1	3	B	1.12	Qga	
1827	1	P	1997	5			288	LIDAR	1	1	113	Y	1	3		2.81	Qpc	
1828	1	D	1997	1			228	OL97 39-83-17	4	3	94	N	1	2		0.01	Qga	
1829	1	D	1997	2			269	OL97 39-83-17	2	2	115	Y	1	2		0.04	Qpc	
1830	1	P	1997	3			340	OL97 39-83-17	2	3	104	Y	1	2		0.11	Qpc	
1831	4	Q	1997	4			387	OL97 39-83-17	4	2	90	N	4	3	C	0.63	Qpc	
1832	4	Q	1997	5			363	OL97 39-83-17	4	2	95	N	4	2	C	1.16	Qpc	
1833	1	P	1997	3			260	OL97 39-83-17	8	2	100	Y	1	2		0.12	Qpc	
1834	1	P	1997	1			205	OL97 39-83-17	4	2	93	Y	1	2		0.01	Qpc	
1835	2	D	1997	2			417	OL97 39-83-17	1	2	91	Y	1	2		0.06	Qgt	
1836	1	D	1997	2			300	OL97 39-83-17	1	3	42	Y	1	2		0.10	Qpc	
1837	1	D	1997	2			230	OL97 39-83-19	1	2	88	Y	1	3		0.06	Qpc	
1838	1	D	1997	2			257	OL97 39-83-19	2	3	56	Y	3	3		0.06	Qpc	
1839	1	P	1997	4			294	OL97 39-83-19	2	2	124	Y	3	3		0.92	Qpc	
1840	1	Q	1997	2			230	LIDAR	2	2	114	Y	3	3		0.07	Qpc	
1841	1	P	1997	2			448	OL97 39-87-181	1	2	112	Y	1	3		0.10	Qgt	
1842	4	Q	1997	3			383	OL97 10-89-250	5	2	93	N	1	3	B	0.11	Qga	
1843	1	P	1997	2			295	OL97 39-87-181	1	1	75	Y	1	3		0.05	Qpc	
1844	4	Q	1997	5			300	OL97 10-89-250	5	2	90	N	1	3	C	1.31	Qgt	
1846	2	P	2005	2			367	LIDAR	1	1	76	Y	1	3		0.06	Qga	
1847	2	P	2005	2			342	LIDAR	2	2	117	Y	1	3		0.07	Qga	
1848	1	P	2005	2			308	LIDAR	2	1	81	Y	1	3		0.05	Qpc	
1849	1	P	2005	3			342	LIDAR	2	2	85	N	5	2		0.30	Qga	
1850	4	P	2005	4			400	LIDAR	2	1	104	N	4	3	C	0.88	Qpc	
1851	1	P	2005	3			400	LIDAR	1	1	102	Y	1	3		0.24	Qpc	
1852	1	P	2005	4			377	LIDAR	5	1	88	Y	3	3		0.62	Qga	
1853	5	P	2005	4			388	LIDAR	2	1	103	Y	3	3		0.42	Qpc	
1854	1	P	2005	4			380	LIDAR	2	1	103	Y	2	3		0.46	Qpc	
1855	1	P	2005	3			400	LIDAR	2	1	94	Y	3	3		0.33	Qpc	
1856	1	P	2005	3			395	LIDAR	1	1	115	Y	3	3		0.35	Qpc	
1867	2	P	2005	2			370	LIDAR	1	1	80	Y	3	3		0.08	Qpc	
1858	5	P	2005	4			407	LIDAR	1	1	94	Y	3	3		0.50	Qpc	
1859	1	P	2005	3			265	LIDAR	2	1	144	Y	3	3		0.32	Qpc	
1860	1	P	2005	3			273	LIDAR	2	1	129	Y	3	3		0.38	Qpc	
1861	1	P	2005	3			342	LIDAR	1	1	122	Y	3	3		0.28	Qpc	
1865	2	P	1981	3			421	SP-81 2-19-74	4	1	74	Y	5	2		0.18	Qga	
1866	1	P	1981	2			255	SP-81 2-19-74	2	2	75	Y	3	3		0.06	Qpc	
1867	1	P	1981	3			148	SP-81 4-23-271	4	2	81	Y	3	3		0.29	Qpc	
1868	2	P	1985	4			301	SP-85 13-028-077	4	1	66	Y	2	2		0.50	Qga	Exposed soil/scar
1869	1	P	1985	2			343	SP-85 08-022-245	4	3	73	Y	2	3		0.05	Qpc	Exposed soil/scar
1870	1	P	1985	3			291	SP-85 22-020-201	4	1	104	P	3	3		0.19	Qpc	Canopy hole
1871	1	P	1985	3			305	SP-85 22-020-201	1	1	130	P	3	3		0.24	Qpc	Canopy hole
1873	1	D	1985	2			348	SP-85 22-020-201	4	2	50	Y	3	2		0.05	Qpc	Field checked
1874	1	D	1985	2			356	SP-85 22-020-201	4	2	93	Y	3	3		0.04	Qpc	Field checked
1875	1	P	1985	2			395	SP-85 22-020-203	4	2	92	Y	1	3		0.07	Qpc	Canopy hole
1876	1	P	1985	2			269	SP-85 22-020-203	4	3	70	Y	3	3		0.05	Qpc	Canopy hole
1877	1	P	1985	2			311	SP-85 22-020-203	4	2	140	Y	3	3		0.10	Qpc	Canopy hole
1878	1	P	1985	2			278	SP-85 22-020-203	4	2	106	Y	3	3		0.07	Qpc	Canopy hole
1880	1	D	2005	3			412	FIELD	8	2	122	Y	3	2		0.12	Qpc	

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	nit elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1881	1	D	2005	3			142	FIELD	4	3	80	Y	3	2		0.16	Qpc	
1882	1	P	2005	2			116	FIELD	2	3	110	Y	3	2		0.08	Qpc	
1883	4	D	1980	4	2005	4	440	FIELD	5	2	108	N	3	3	B	0.46	Qpc	13" dbh hemlock
1884	1	D	2005	1			403	FIELD	8	2	79	P	3	3		0.02	Qpc	
1885	1	D	2005	3			205	FIELD	2	3	110	Y	3	3		0.13	Qpc	
1886	1	D	2003	2	2005	2	191	FIELD	4	3	75	N	5	3		0.09	Qpc	off conglomerate in Qpc
1887	1	D	2005	2			348	FIELD	4	3	110	Y	3	3		0.03	Qpc	off conglomerate in Qpc
1888	1	D	2005	1			381	FIELD	4	3	140	Y	3	3		0.02	Qpc	
1889	1	D	2004	3			327	FIELD	2	2	75	Y	1	3		0.23	Qpc	off clearcut above
1890	5	D	2005	2			400	FIELD	2	2	75	N	2	3		0.07	Qpc	
1891	7	D	2005	2			272	FIELD	1	1	80	Y	3	3		0.07	Qpc	
1892	5	D	2005	2			239	FIELD	9	3	76	Y	3	3		0.04	Qpc	
1893	1	D	2005	2			235	FIELD	9	3	84	Y	3	3		0.05	Qpc	
1894	5	P	2005	3			284	FIELD	1	3	76	Y	3	3		0.17	Qpc	
1895	1	D	2005	2			188	FIELD	9	2	112	Y	3	3		0.05	Qpc	
1896	1	D	2005	4			248	FIELD	9	3	84	Y	3	3		0.50	Qpc	16" dbh maple
1897	1	D	2005	5			215	FIELD	9	4	100	Y	3	3		1.57	Qpc	
1898	4	P	2005	4			297	FIELD	8	2	80	N	3	3		0.41	Qga	almost earthflow
1900	1	D	2005	3			292	FIELD	4	3	92	Y	3	3		0.18	Qpc	Thin debris slide ~3 ft thick; recent.
1901	1	D	2005	1			285	FIELD	4	1	120	P	2	3		0.02	Qpc	Slope break increase (>110%); scarp seeping water.
1902	1	D	2005	2			279	FIELD	4	3	85	P	3	3		0.02	Qpc	Recent secondary initiation at midslope; 5 ft wide, 40 ft long, 75% initiation
1903	1	D	2005	2			230	FIELD	4	3	80	Y	3	3		0.04	Qpc	Debris slide ~6 ft thick; at least three small failures in deposit up to 6 ft wide and 20 ft long; stream related
1904	1	D	2005	2			222	FIELD	4	2	87	Y	3	3		0.04	Qpc	Debris slide ~6 ft thick; at least two small failures in deposit up to 6 ft wide and 15 ft long; stream related
1905	1	D	2005	2			199	FIELD	4	3	82	Y	3	3		0.04	Qpc	Debris slide ~6 ft thick; small deposit at base
1906	1	D	2005	1			257	FIELD	4	2	80	N	3	3		0.00	Qpc	Debris slide initiated from fallen tree
1907	1	P	2005	2			228	FIELD	4	3	86	Y	3	3		0.09	Qpc	Probable debris slide; overgrown but toe and evacuated are evident
1908	1	D	2005	1			261	FIELD	4	2	85	Y	3	3		0.01	Qpc	Debris slide; scarp seeping water; occurred post-landslide 1787
1909	1	D	2005	1			260	FIELD	4	2	85	Y	3	3		0.01	Qpc	Debris slide; scarp seeping water; occurred post-landslide 1788

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	nit elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1910	1	D	2005	1			244	FIELD	4	2	85	Y	3	3		0.01	Qpc	Debris slide; scarp seeping water; occurred post-landslide 1789
1911	1	D	2005	2			227	FIELD	4	1	82	Y	3	3		0.05	Qpc	Shallow rapid; 3 ft scarp consists of clay; body of slide is Qc; ~20 ft down slope 2 ft clay unit perching 2 gpm stream
1912	1	D	2005	2			205	FIELD	9	2	80	Y	3	3		0.02	Qpc	Shallow rapid; 5 ft incision; stream influenced; deposit pushed stream out ~9 ft radius
1913	1	D	2005	1			214	FIELD	4	1	110	Y	2	3		0.01	Qpc	Debris slide
1914	4	P	2005	4			294	FIELD	4	3	80	N	4	3	B	0.47	Qpc	Alder covered; very hummocky surface; wet ground seeping numerous springs; broken ground
1915	1	D	2005	1			209	FIELD	9	3	90	Y	3	3		0.01	Qpc	Debris slide; approximately 4 ft thick
1916	1	D	2005	2			416	FIELD	4	1	140	Y	5	3		0.09	Qga	Debris slide; 25 ft wide and ~120 ft long; recent activity delivered a Dodge mini-van
1917	1	D	2005	2			354	FIELD	1	3	82	Y	3	3		0.05	Qpc	Debris slide; 30 ft wide, ~80 ft long, <2 ft deep; exposing outcrop of Qpc
1918	1	D	2005	2			383	FIELD	1	1	110	Y	3	3		0.09	Qgt	Older shallow rapid from Qgt; secondary slide recently failed at toe due to undercutting from stream
1919	1	D	2005	2			353	FIELD	1	2	82	Y	3	3		0.03	Qpc	Recent debris slide; approximately 20 ft wide by 50 ft high
1920	4	D	2005	2			149	FIELD	1	3	105	N	3	3	A	0.07	Qpc	Recent deep-seated landslide; 3 ft vertical scarp exposed; toe is undercut by stream
1921	4	D	2005	3			222	FIELD	1	2	110	N	4	3	B	0.30	Qpc	At slope break and probable contact is initiation point of scarp; hummocky body; foot/toe removed by stream
1922	4	D	2005	3			115	FIELD	9	2	72	N	3	3	B	0.10	Qpc	Observed from road
1923	4	D	2005	2			107	FIELD	9	2	79	N	3	3	B	0.05	Qpc	Observed from road
1924	4	D	2005	3			150	FIELD	9	2	82	N	3	3	B	0.16	Qpc	Observed from road; 100 ft high and 50 ft wide
1925	1	D	2005	2			161	FIELD	4	2	80	N	3	3		0.04	Qpc	Observed from road

Slide_id	Lsi_process	Certainty	ld_date	Ls_size	ld2_date	ld2_size	Init elev	Photo_number	Landform	Slp_shp	Gradient (%)	Delivery	Landuse	Tahuya Landform	Deep-Seated Activity	Acreage	Geologic Unit	Comments
1926	1	D	2005	2			271	FIELD	1	3	110	Y	2	3		0.06	Qga	Initiated at Qga/Qgt contact; 60 ft wide by 100 ft long by 1 ft deep
1927	4	D	2005	2			181	FIELD	9	3	65	N	3	3	B	0.03	Qpc	Observed from road
1928	2	D	2005	2			276	FIELD	1	2	96	N	3	3		0.06	Qpc	
1929	2	D	2005	2			270	FIELD	1	2	76	N	3	3		0.06	Qpc	
1930	4	D	2005	2			288	FIELD	9	3	78	N	3	3	B	0.05	Qga	Observed from road; vertical headscarp appears to be Qga
1932	4	D	2005	2			181	FIELD	1	1	73	N	3	3	B	0.08	Qpc	
1933	1	D	2005	3			222	FIELD	2	3	86	Y	3	3		0.15	Qpc	
1934	5	D	2005	2			138	FIELD	1	1	65	Y	1	2		0.08	Qpc	
3000	4	P	2005	4			302	LIDAR	4	3	93	N	3	3	B	0.48	Qpc	
3001	4	D	2005	5			340	LIDAR/FIELD	4	3	72	N	4	3	B	10.95	Qpc	Prominent bench midslope; oversteepened foot (120%) and headscarp (72%); several recent small landslides on toe delivering into stream
3002	4	D	2005	5			385	LIDAR	4	1	113	N	4	3	B	1.69	Qpc	
3003	4	D	2005	5			360	LIDAR	4	4	95	N	4	3	B	3.83	Qpc	
3004	4	D	2005	5			307	LIDAR	4	2	75	N	4	3	B	2.26	Qpc	
3005	4	P	2005	5			399	LIDAR	4	2	82	N	4	3	B	1.49	Qpc	
3010	4	Q	2005	5			268	LIDAR	4	2	48	N	4	4	C	1.63	Qgo	
3011	4	Q	2005	5			252	LIDAR	4	2	41	N	4	4	C	1.31	Qgo	
3012	4	P	2005	5			301	LIDAR	4	2	94	N	4	3	C	11.26	Qpc	
3013	4	P	2005	5			288	LIDAR	4	2	71	N	4	3	C	8.30	Qpc	
3014	4	P	2005	5			311	LIDAR	4	2	101	N	4	3	B	6.72	Qpc	
3015	4	P	2005	5			314	LIDAR	4	2	111	N	4	3	B	6.77	Qpc	
3016	5	P	2005	4			334	LIDAR	4	1	100	Y	4	3	B	0.80	Qpc	
3017	4	P	2005	5			416	LIDAR	4	1	64	N	4	3	B	4.92	Qpc	
3018	4	P	2005	5			386	LIDAR	4	2	95	N	4	3	B	3.94	Qpc	
3019	4	P	2005	5			323	LIDAR	4	2	75	N	4	4	C	3.77	Qpc	
3020	5	P	2005	4			236	LIDAR	4	2	88	N	4	4	C	0.60	Qpc	
3021	4	P	2005	4			183	LIDAR	4	2	95	N	4	4	B	0.63	Qpc	
3022	5	P	2005	5			270	LIDAR	4	2	75	N	4	4	C	4.06	Qpc	
3023	4	P	2005	4			320	LIDAR	4	2	87	N	4	3	B	0.53	Qpc	
3024	4	P	2005	5			353	LIDAR	4	2	65	N	4	3	C	3.98	Qpc	
3025	4	P	2005	3			404	LIDAR	4	2	61	N	4	3	C	0.33	Qgt	
3026	2	P	2005	5			247	LIDAR	4	1	93	N	4	3		1.86	Qpc	
3027	4	P	2005	5			430	LIDAR	4	1	64	N	4	3	C	14.40	Qga	

Appendix B -- Mass-Wasting Summary Tables

Table B-1: Mass-Wasting Summary of Landform 3

Activity	Shallow-Rapid Landslides	Debris Flows	Debris Avalanches	Deep-Seated Landslides	Shallow Sporadic Deep-Seated Landslides	Large Persistent Deep-seated Landslides	Earthflows	Totals
Clear Cut (timber 0-5 Yrs.)	2	3	-	-	-	-	-	5
Young Timber (5-15 yrs.)	-	-	-	-	-	-	-	0
Submature Timber (15-50 yrs.)	5	2	-	-	-	-	-	7
Mature Timber (>50 yrs.)	1	-	-	1	-	-	-	2
Road Related	3	-	-	-	-	-	-	3
Partial Cut	-	-	-	-	-	-	-	0
Yarding	-	-	-	-	-	-	-	0
Alpine	-	-	-	-	-	-	-	0
Other (e.g., housing)	-	-	-	-	-	-	-	0

Table B-2: Mass-Wasting Summary of Landform 4

Activity	Shallow-Rapid Landslides	Debris Flows	Debris Avalanches	Deep-Seated Landslides	Shallow Sporadic Deep-Seated Landslides	Large Persistent Deep-seated Landslides	Earthflows	Totals
Clear Cut (timber 0-5 Yrs.)	-	-	-	-	-	-	-	0
Young Timber (5-15 yrs.)	-	-	-	-	-	-	-	0
Submature Timber (15-50 yrs.)	-	-	-	-	-	-	-	0
Mature Timber (>50 yrs.)	-	-	-	1	-	-	-	1
Road Related	-	-	-	-	-	-	-	0
Partial Cut	-	-	-	-	-	-	-	0
Yarding	-	-	-	-	-	-	-	0
Alpine	-	-	-	-	-	-	-	0
Other (e.g., housing)	1	-	-	-	-	-	-	1

Table B-3: Mass-Wasting Summary of Landform 5

Activity	Shallow-Rapid Landslides	Debris Flows	Debris Avalanches	Deep-Seated Landslides	Shallow Sporadic Deep-Seated Landslides	Large Persistent Deep-seated Landslides	Earthflows	Totals
Clear Cut (timber 0-5 Yrs.)	32	5	3	-	-	-	-	40
Young Timber (5-15 yrs.)	13	-	-	-	1	-	-	14
Submature Timber (15-50 yrs.)	112	9	-	16	4	-	1	142
Mature Timber (>50 yrs.)	2	1		24	3	-	-	30
Road Related	13	1	-	-	-	-	-	14
Partial Cut	-	-	-	-	-	-	-	0
Yarding	-	-	-	-	-	-	-	0
Alpine	-	-	-	-	-	-	-	0
Other (e.g., housing)	-	-	-	-	-	-	-	0

Table B-4: Mass -Wasting Summary Table: Landform 6

Activity	Shallow-Rapid Landslides	Debris Flows	Debris Avalanches	Deep-Seated Landslides	Shallow Sporadic Deep-Seated Landslides	Large Persistent Deep-seated Landslides	Earthflows	Totals
Clear Cut (timber 0-5 Yrs.)	12	3	-	-	1	-	-	16
Young Timber (5-15 yrs.)	-	1	-	-	-	-	-	1
Submature Timber (15-50 yrs.)	17	1	-	3	-	-	-	21
Mature Timber (>50 yrs.)	-	-	-	9	1	-	-	10
Road Related	5	1	-	-	-	-	-	6
Partial Cut	-	-	-	-	-	-	-	0
Yarding	-	-	-	-	-	-	-	0
Alpine	-	-	-	-	-	-	-	0
Other (e.g., housing)	-	-	-	-	-	-	-	0