

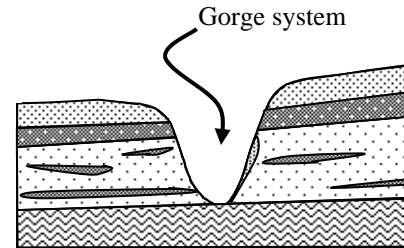
Chehalis Sloughs WAU

Appendix C

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform #1 – Inner Gorges (>70%) – Very High Hazard

Description of Mass Wasting Unit: Rule-identified inner gorges are steep (>70%) walled canyons or gullies eroded by stream action with evidence of mass wasting along their sidewalls. Inner gorges may be either symmetrical or asymmetrical in profile and are commonly intermittent in lateral extent. They are occasionally scoured by debris flows during storm events. A 10° break in slope usually separates the upper margin of the inner gorge feature from the surrounding slope forms. Inner gorge scarp slopes revegetate rapidly which can mask their appearance on aerial photos. Inner gorges are present in of a wide range of other landforms including deep-seated landslides. Buried wood is often observed in the channels from previous mass wasting events.



Slopes: Generally > 70%
Slope Shape: Convergent to concave-planar
Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash
Elevation: 30 ft to 650 ft
Total Area: 265 acres

Mass Wasting Process: This landform contains primarily shallow undifferentiated landslides with a few debris slides and small debris flows. Recent failures can often have shallow soils draped over weakly cemented bedrock. Older failed inner gorges have landslide debris accumulated in bottom of channels with alder trees growing on top of these deposits.

Forest Practice Sensitivity and Trigger Mechanisms: Root strength decline within and adjacent to inner gorges has been found to be a factor in increasing rates of mass wasting (Krogstad, 1995) therefore trees adjacent to the inner gorge can have roots extending into the slopes of the gully providing slope stability. Roads and landings can destabilize slopes by undercutting and over steepening slopes. Side cast and road (or landing) fill can also over steepen slopes and can add weight; roads and landings can also capture runoff water or shallow groundwater, channeling it to point locations that saturate road or landing fill triggering landslides.

Mass Wasting Potential: Very High for roads and timber harvest based on 81 slope failures in a landform covering 265 acres. This landform has a Landslide Frequency Rating of 6,792.45 with roads and 6,037.74 without road related landslides.

Delivery Potential/Criteria: Very High. The Landslide Area Rate of Delivery for this landform is based on 78 “delivering” landslides totaling 17.17 acres is 1,439.83 with roads and 70 “delivering” landslides totaling 13.59 acres is 1,139.62 without road related landslides.

Overall Hazard Potential Rating: Very High based on the LHZ Protocol, Table 5.

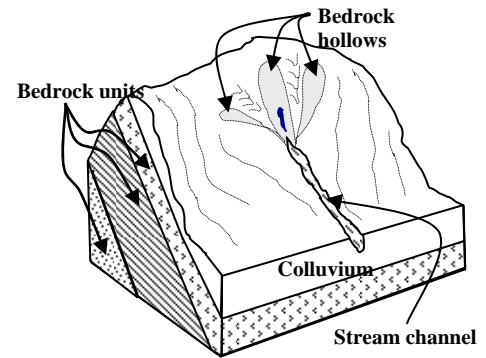
Confidence: Moderate level of confidence based on good photo coverage but concerns exist due to the number of landslides in this landform, poor DEM accuracy and limited field verification.

Comments: Computer generated DEM's slope values are much lower than actual slopes, therefore there may be many rule-identified inner gorges mapped as non-rule identified inner gorges (Landform #10) and many bedrock hollows that are present were not detected or mapped.

Form A-2 Descriptions of Landforms for the Great Bend Watershed

Landform #2 – Bedrock Hollows (>70%) – Very High Hazard

Description of Mass Wasting Unit: Rule-identified bedrock hollows are steep (>70% at the steepest point), shallow spoon- or elongate areas of convergent topography with concave profiles. Bedrock hollows are also called colluvium-filled bedrock hollows, zero-order basins, swales, bedrock depressions, or simply hollows. These features can exist on any steep hillslope and within other landforms. They seldom contain channels but commonly drain directly into inner gorges or other channels downslope. Colluvial debris that accumulates in these steep convergent areas is prone to saturation by shallow ground water making bedrock hollows highly susceptible to slope failures. Over time, bedrock hollows re-vegetate and refill with soil, which can mask their presence on air photos and on the ground.



Slopes: Generally > 70%

Slope Shape: Convergent to planar

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash

Elevation: 30 ft to 715 ft

Total Area: 113 acres

Mass Wasting Process: This landform contains numerous shallow undifferentiated landslides and debris slides. Many bedrock hollows were observed to contain headwater streams. Many bedrock hollows connect to inner gorges and non-rule-identified inner gorges.

Forest Practice Sensitivity and Trigger Mechanisms: Root strength decline within and adjacent to inner gorges has been found to be a factor in increasing rates of mass wasting (Krogstad, 1995) therefore trees adjacent to bedrock hollows can have roots extending into the slopes of the hollow providing slope stability. Roads and landings can destabilize slopes by undercutting and over steepening slopes. Side cast and road (or landing) fill can also over steepen slopes and can add weight; roads and landings can also capture runoff water or shallow groundwater, channeling it to point locations that saturate road or landing triggering landslides.

Mass Wasting Potential: **Very High** for roads and timber harvest based on 113 slope failures in a landform covering 113 acres. This landform has a Landslide Frequency Rating of 7,866.27 with roads and 7,079.65 without road related landslides.

Delivery Potential/Criteria: **Very High.** The Landslide Area Rate of Delivery for this landform is based on 36 “delivering” landslides totaling 10.81 acres is 2,125.86 with roads and 33 “delivering” landslides totaling 10.59 acres is 2,082.6 without road related landslides.

Overall Hazard Potential Rating: **Very High** based on the LHZ Protocol, Table 5.

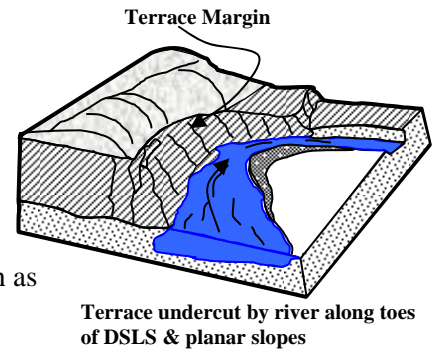
Confidence: Moderate level of confidence based on good photo coverage but concerns arose due to the number of landslides in this landform, poor DEM accuracy and limited field verification.

Comments: Computer generated DEM's slope values are much lower than actual slopes. Due to mapping constraints, several small (<0.25 ac) bedrock hollows were merged into adjacent high hazard landforms such as Steep Gradient Hillslopes and Moderate Gradient Hillslopes.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform # 4 – River Terrace Margin - High Hazard

Description of Mass Wasting Unit: The Chehalis River has cut into marine sedimentary rocks creating an unstable margin. During Pleistocene continental glaciation retreat out of the Puget Sound area, meltwater flowed to the ocean at a much higher elevation than present river flows through the watershed. The slopes of siltstones and sandstones may have been undercut by the present day Chehalis River creating many shallow & deep-seated landslides. (Note: this landform may contain rule-identified landforms such as inner gorges and deep-seated landslide toes.)



Slopes: 30% and greater

Slope Shape: Convergent to planar

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); previously mapped landslides

Elevation: 20 ft to 290 ft

Total Area: 521 acres

Mass Wasting Processes: The Chehalis River has undercut adjacent upland slopes and caused mass wasting along slopes in the form of shallow undifferentiated landslides, debris slides, and deep-seated landslides. The river also undercuts the toes of deep-seated landslides further increasing movement of land toward the river. Springs and wicking water out of slopes above “buckling” road on south side of Chehalis River.

Forest Practice Sensitivity and Triggering Mechanisms: Stream bank and terrace face erosion from the Chehalis River undercutting this landform making it prone to mass wasting even under mature forested conditions, therefore, any disturbance resulting from timber harvest or road construction can further destabilize these slopes. Loss of root strength, changes in slope gradient, and changes in hydrology from forest management activities on or near the terrace margin can destabilize these slopes especially during major storms or intense precipitation events. Roads and landings can cause instability by undercutting and oversteepening slopes. Sidecast and road (or landing) fill can oversteepen and add weight to the terrace margin; roads and landings can capture runoff water or shallow groundwater and channel it to point locations causing soil saturation.

Mass Wasting Potential: High for roads and timber harvest based on 22 slope failures in a landform covering 521 acres. This landform has a Landslide Frequency Rating of 938.4 with roads and 511.8 without road related landslides.

Delivery Potential/Criteria: High. The Landslide Area Rate of Delivery for this landform is based on 20 “delivering” landslides totaling 6.14 acres is 261.9 with roads and 11 “delivering” landslides totaling 4.2 acres is 179.1 without road related landslides.

Overall Hazard Potential Rating: High for roads and timber harvest based on LHZ Protocol, Table 5.

Confidence: High for the entire unit based on observed direct delivery to typed waters, good photo coverage, partial lidar coverage, and field verification.

Comments: Computer generated DEM’s slope values are much lower than actual slopes and can be verified by partial lidar coverage within this landform. Public roads within this landform experience repeated buckling and cracking of road surfaces which are maintained regularly likely due to deep-seated landslide toes being undercut by the Chehalis River.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform # 7 – Active Scarps of Deep-Seated Landslides – Very High Hazard

Description of Mass Wasting Unit: This unit consists of head scarps of previously failed deep-seated landslides with slopes greater than 30%. These poorly lithified bedrock slopes are located at the head of deep-seated landslides and usually contain secondary landslides.

Slopes: 30% and greater
Slope Shape: Convergent to planar
Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash
Elevation: 20 ft to 580 ft
Total Area: 204 acres

Mass Wasting Process: The landslides within this landform were mostly shallow landslides (75%) with many smaller, secondary deep-seated landslides (25%). High precipitation events increase likelihood of secondary landslides on primarily the steep slopes of this landform.

Forest Practice Sensitivity and Triggering Mechanisms: Many landslides within this landform were on very steep ground that had poor rooting strength or were road related, and a few have failed at much shallower slope gradients due to the rapid and deep weathering characteristics of the bedrock. Although some of these deep-seated landslides are stable under present drier climatic conditions, frequent small shallow rapid landslides occur on the weakened deep-seated materials. Slope failures within this landform could be reactivated by infiltration of water due to a prolonged storm event or rainy season or improper water management associated with harvest or road building activities.

Mass Wasting Potential: Very High for roads and timber harvest based on 53 slope failures in a landform covering 204 acres. This landform has a Landslide Frequency Rating of 5,773.4 with roads and 5,337.7 without road related landslides.

Delivery Potential/Criteria: Very High. The landform is most often stream adjacent which greatly increases the likelihood of delivery. The Landslide Area Rate of Delivery for this landform is based on 29 “delivering” landslides totaling 8.7 acres is 947.7 with roads and 28 “delivering” landslides totaling 8.05 acres is 876.9 without road related landslides.

Overall Hazard Potential Rating: Very High based on LHZ Protocol, Table 5.

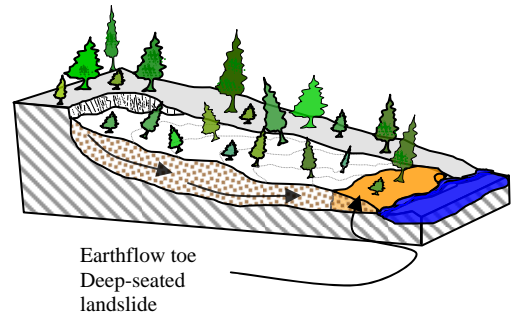
Confidence: Moderate level of confidence based on good photo coverage but concerns arose due to the number of landslides in this landform, poor DEM accuracy and limited field verification.

Comments: Computer generated DEM’s slope values are much lower than actual slopes and can be verified by partial lidar coverage within this landform.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform Number: #8 – Non-Rule Identified Deep-Seated Landslide Toes – Very High Hazard

Description of Mass Wasting Unit: The toe area is usually hummocky, slopes >30%, planar or irregular, and may contain areas of ravel, shallow deep-seated, shallow surficial landsliding, or slumping. The downslope edge of the toe can become oversteepened from stream erosion or from rotation of the slide mass. Occasionally, younger, secondary deep-seated landslides form within the footprint of an older deep-seated landslide. This may superimpose a younger toe on the body of an older toe. Due to mapping with DEM's this landform may include rule-identified deep-seated landslide toes.



Slopes: 30% and greater

Slope Shape: Convergent to planar

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash

Elevation: 20 ft to 450 ft

Total Area: 24 acres

Forest Practice Sensitivity and Triggering Mechanisms: Downcutting and undercutting by marginal streams and streams that flow across the base of these deep-seated landslide toes have over-steepened and destabilized the toes of deep-seated landslides and triggered slope ravel, debris slides, and small deep-seated landslides. Inner gorges and bedrock hollows can form within the landslide toe. Increased pore water pressure along slopes surrounding Lake Aberdeen may destabilize even gentle slopes. This landform is sensitive to any forest practice activity that redirects water onto these toes, reduces root strength, undercuts or over steepens the toes.

Mass Wasting Potential: **Very High** for roads and timber harvest based on 3 slope failures in a landform covering 24 acres. This landform has a Landslide Frequency Rating of 2,777.8 with roads and without road related landslides.

Delivery Potential/Criteria: **Very High.** The Landslide Area Rate of Delivery for this landform is based on 3 “delivering” landslides totaling 0.65 acres is 601.9 with roads and without road related landslides.

Overall Hazard Potential Rating: **Very High** based on LHZ Protocol, Table 5.

Confidence: Moderate - The excellent exposure of a large percentage of the watershed, good photo coverage, and two days field checking the photo interpretation have provided moderate level of confidence in this watershed.

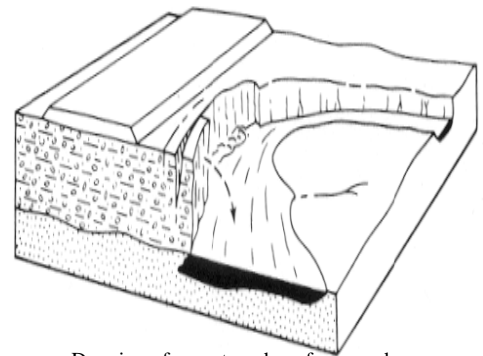
Comments: All toes of deep-seated landslides including earthflows in or near a stream or inner gorge should be field reviewed for potential for instability. Deep-seated landslides that terminate near or in Lake Aberdeen should be field reviewed to determine if toes are delivering. Channeling water onto the bodies above toes of earthflows may reactivate the toes.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform #9 - Meander Bends/Overbank Deposits within the Chehalis River Surge Plain (11-40%) – High Hazard

Description of Mass Wasting Unit: Alluvial deposits found along the Chehalis River Surge Plain fail similarly to the outsides of meander bends.

Slopes: 11 to 40%
Slope Shape: Convergent-planar
Material: Alluvium
Elevation: 0 ft to 40 ft
Total Area: 920 acres



Drawing of an outer edge of a meander bend (Forest Practices Board Manual).

Mass Wasting Processes: The Chehalis River Surge Plain (Chehalis River and its multiple sloughs) is tidally influenced with daily high and low tides. High precipitation storm events carry fine-grained sediment during flood events that are deposited on the naturally formed levees of the Chehalis River. When the tides rise and fall it alternates wet and dewater the oversteepened banks creating unstable slopes. The outer edges of meander bends are susceptible to shallow landsliding including debris slides, small-scale slumping, and sediment topples.

Forest Practice Sensitivity and Trigger Mechanisms: Any disturbance of root strength, concentrating or channeling water, or disturbance of the ground within this landform increases the likelihood of landsliding. Water concentration, sidecast, and loading from landings can cause instability by adding weight or oversteepening the outside of meander bends. Sediment delivery to the Chehalis River and its sloughs from slope failures on this landform is imminent.

Mass Wasting Potential: High for roads and timber harvest based on 37 slope failures in a landform covering 920 acres. This landform has a Landslide Frequency Rating of 893.7 with roads and 797.1 without road related landslides.

Delivery Potential/Criteria: High. The Landslide Area Rate of Delivery for this landform is based on 37 “delivering” landslides totaling 11.31 acres is 273.2 with roads and 33 “delivering” landslides totaling 9.03 acres is 218.1 without road related landslides.

Overall Hazard Potential Rating: High based on LHZ Protocol, Table 5.

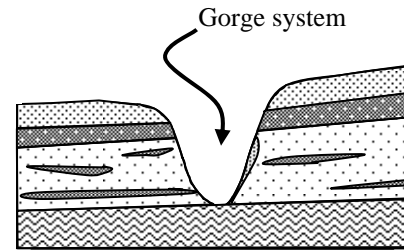
Confidence: Moderate based on the number of landslides located in this landform, good photo coverage, complete lidar coverage, and limited field observation due to location.

Comments: Meander Bends are rule-identified in the Forest Practices Rules and listed as high hazard in the LHZ Protocol. The outsides of Meander Bends are more fully described in the Forest Board Manual, Section 16 (p. M16-21). This landform falls entirely within the riparian area of the Chehalis River and the Chehalis River Surge Plain Natural Area Preserve.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform #10 – Non-Rule Identified Inner Gorges – Very High Hazard

Description of Mass Wasting Unit: This landform contains similar characteristics of rule-identified inner gorges with convergent slopes of 30-70%. They appear as gentle walled canyons or gullies on DEM slope maps and appear eroded by stream action with evidence of mass wasting along their sidewalls. These Non-Rule Identified Inner Gorges may be either symmetrical or asymmetrical in profile and are commonly intermittent in lateral extent. (Note: this landform may contain rule-identified landforms such as inner gorges and convergent headwalls.)



Slopes: 30% to 70% (based on 10 meter DEM data)

Slope Shape: Convergent to planar

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash

Elevation: 20 ft to 605 ft

Total Area: 557 acres

Mass Wasting Process: This landform contains numerous shallow undifferentiated landslides, debris slides, deep-seated landslides, and several small debris flows. These features often contain streams.

Forest Practice Sensitivity and Trigger Mechanisms: Root strength decline within and adjacent to inner gorges has been found to be a factor in increasing rates of mass wasting (Krogstad, 1995) therefore trees adjacent to the inner gorge can have roots extending into the slopes of the gully providing slope stability. Roads and landings can destabilize slopes by undercutting and over steepening slopes. Side cast and road (or landing) fill can also over steepen slopes and can add weight; roads and landings can also capture runoff water or shallow groundwater, channeling it to point locations that saturate road or landing fill triggering landslides.

Mass Wasting Potential: Very High for roads and timber harvest based on 130 slope failures in a landform covering 557 acres. This landform has a Landslide Frequency Rating of 5,186.5 with roads and 4,827.4 without road related landslides.

Delivery Potential/Criteria: Very High. The Landslide Area Rate of Delivery for this landform is based on 117 “delivering” landslides totaling 32.54 acres is 1,298.2 with roads and 109 “delivering” landslides totaling 29.48 acres is 1,176.1 without road related landslides.

Overall Hazard Potential Rating: Very High based on the LHZ Protocol, Table 5.

Confidence: Moderate level of confidence based on the number of landslides in this landform and limited field verification due to access issues. Good photo coverage, minimal lidar coverage, and limited field observations were used.

Comments: The majority of this landform is based on slope angles drawn from computer generated slopestab and DEM's which have been identified in the field as being underrepresented. Field review of accessible mapped areas of this landform always determined slopes at or >70% and were changed to rule identified landform designation. Rule-identified features such as inner gorges and bedrock hollows are likely included in this landform. Small areas of 10-40% slopes have been lumped into this landform.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform # 11 – Steep Gradient Hillslopes (>61%) - Very High Hazard

Description of Mass Wasting Unit: This landform contains slopes greater than 61% that are convergent to planar in shape. This landform is often located between mapped rule identified inner gorges along the higher ridges of the watershed and may contain isolated areas of vertical bluffs. This landform includes head scarps of deep-seated landslides that are not likely to deliver. The landslides in this landform were mapped from aerial photographs and given the inaccuracy of DEM slope determinations many of the mapped features within this landform could actually contain other high hazard landform (e.g., inner gorges, or bedrock hollows).

Slopes: 61% and greater

Slope Shape: Convergent to Planar

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash

Elevation: 2 ft to 710 ft

Total Area: 363 acres

Mass Wasting Processes: Soil saturation, loss of root strength, and/or over steepening of slopes in this landform can trigger debris slides, debris flows or small deep-seated landslides.

Forest Practice Sensitivity and Trigger Mechanisms: Timber harvest on these steep slopes may result in the loss of root strength as well as road construction and/or landing construction are major factors of slope instability. Side cast and road (or landing) fill can cause instability by undercutting, oversteepening, and loading slopes. Roads and landings can also capture runoff water or shallow groundwater and channel it to point locations that saturate road or landing fill and/or deeply weathered bedrock, triggering landslides. The loss of root strength, changes in slope gradient, and changes in hydrology caused by timber harvesting and road or landing construction has destabilized similar slopes that have failed during major storms or intense precipitation events. The majority of the landslides in this landform that deliver to streams occurred in clearcut areas that were older than 15 years which is beyond the time when roots can still hold soils in place on steep ground. Therefore it is assumed that a loss of root strength adversely influenced slope stability on this landform.

Mass Wasting Potential: Very High for roads and timber harvest based on 71 slope failures in a landform covering 363 acres. This landform has a Landslide Frequency Rating of 4,346.5 with roads and 4,101.6 without road related landslides.

Delivery Potential/Criteria: Very High. The Landslide Area Rate of Delivery for this landform is based on 63 “delivering” landslides totaling 24.82 acres is 1,519.4 with roads and 59 “delivering” landslides totaling 14.85 acres is 909.1 without road related landslides.

Overall Hazard Potential Rating: Very High based on the LHZ Protocol, Table 5.

Confidence: Moderate based on the number of landslides located in this landform, good photo coverage, inaccurate DEM data and limited field observation.

Comments: The majority of this landform is based on slope angles drawn from computer generated slopestab and DEM's which have been identified in the field as being underrepresented. Rule-identified features such as inner gorges, toes of deep-seated landslides and bedrock hollows may have been included in this landform.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform # 12 – Moderate Gradient Hillslopes (41 to 60%) – Very High Hazard

Description of Mass Wasting Unit: This landform includes slopes found throughout the watershed and frequently adjacent to inner gorges and bedrock hollows. These slopes vary in shape (the majority being convergent and planar) and have gradients between 41% and 60%. This landform includes head scarps of relict or dormant deep-seated landslides as well as other landslide processes.

Slopes: 41 to 60%
Slope Shape: Convergent to planar
Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial outwash
Elevation: 0 ft to 705 ft
Total Area: 1,823 acres

Mass Wasting Process: Shallow undifferentiated landslides, debris slides, debris flows, and deep-seated landslides occur within this map unit. The majority of landslides in this landform occurred in areas that were harvested more than 15 years ago. It is assumed that a loss of root strength adversely influenced slope stability on this landform.

Forest Practice Sensitivity and Trigger Mechanisms: Timber harvest, road construction and/or landing construction on slopes between 41 to 60% can increase slope instability. Loss of root strength can increase rates of mass wasting, as can roads and landings that undercut or load or change the hydrology of these slopes. The majority of landslides were located in the forest category of 15-50 year old trees. Side cast and landings can cause instability by over-steepening slopes, loading and undercutting them. Roads and landings can also capture runoff water or shallow groundwater and channel it to point locations that saturate fill and/or unconsolidated deposits triggering slope failures.

Mass Wasting Potential: Very High for roads and timber harvest based on 141 slope failures in a landform covering 1,823 acres. This landform has a Landslide Frequency Rating of 1,718.8 with roads and 1,560.3 without road related landslides.

Delivery Potential/Criteria: High. The Landslide Area Rate of Delivery for this landform is based on 119 “delivering” landslides totaling 32.52 acres is 396.4 with roads and 107 “delivering” landslides totaling 26.95 acres is 328.5 without road related landslides.

Overall Hazard Potential Rating: Very High based on the LHZ Protocol, Table 5.

Confidence: Moderate level of confidence based on good photo coverage, inaccurate DEM data and limited field observations.

Comments: The majority of this landform is based on slope angles drawn from computer generated slopestab and DEM's which have been identified in the field as being underrepresented. Rule-identified features such as inner gorges, toes of deep-seated landslides and bedrock hollows may have been included in this landform.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform #14 - Flats - Low Hazard

Description of Mass Wasting Unit: This map unit includes all valley and stream bottoms, glacial till plains, flat terraces, prairies, major stream flood plains, and wetlands with gradients between 0 % and 10% that exhibit a low landslide potential, and/or are not likely to deliver sediment to a stream, impact public safety or impact a public resource. The Chehalis Sloughs surge plain is entirely found in this landform, as well as the area north of the surge plain that is comprised of glacial till.

Slopes: 0% and 10%

Slope Shape: All slope shapes are found within this landform

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); glacial outwash and till; and alluvium

Elevation: 0 ft to 450 ft

Total Area: 11,882 acres

Mass Wasting Process: Shallow landslides may occur adjacent to streams but were not observed within this landform in this watershed.

Forest Practice Sensitivity and Trigger Mechanisms: Roads may be a significant triggering mechanism for erosion within this landform. Landslides have occurred adjacent to this landform on very gentle slopes.

Mass Wasting Potential: **Low** for road construction and timber harvest based on no slope failures identified in a landform covering 11,882 acres. This landform has a Landslide Frequency Rating of zero with roads and without road related landslides.

Delivery Potential/Criteria: **Low.** The Landslide Area Rate of Delivery for this unit is 0. No mass wasting features were noted within this landform. Delivery is unlikely to a stream channel. Road and landing failures do not have potential to travel great distances. Distance from stream channels and topography inhibits transport of landslide debris.

Overall Hazard Potential Rating: **Low** based on the LHZ Protocol, Table 5.

Confidence: High level of confidence based on excellent photo coverage, lidar coverage within the Chehalis River surge plain, and limited field observations.

Comments: Some areas may have been included within this landform that have slopes greater than 10% but these areas do not have a likelihood of slope failure.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform #15 - Ridge Tops and Noses – Low Hazard

Description of Mass Wasting Unit: This landform includes all ridge tops and noses of ridges with slope forms and gradients between 0 % and 10% that exhibit a low landslide potential, and/or are not likely to deliver sediment to a stream, impact public safety or impact a public resource.

Slopes: 0% and 10%

Slope Shape: Variable from convergent to planar to divergent

Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); and glacial till

Elevation: 65 ft to 685 ft

Total Area: 389 acres

Mass Wasting Process: Shallow landslides may occur but have not been observed within this landform.

Forest Practice Sensitivity and Trigger Mechanisms: Poor forest management practices on this landform could cause mass wasting on slopes below ridge tops and noses.

Mass Wasting Potential: **Low** for road construction and timber harvest based on no slope failures identified in a landform covering 389 acres. This landform has a Landslide Frequency Rating of zero with roads and without road related landslides.

Delivery Potential/Criteria: **Low.** The Landslide Area Rate of Delivery for this unit is 0. No mass wasting features were noted within this landform.

Overall Hazard Potential Rating: **Low** based on the LHZ Protocol, Table 5.

Confidence: Moderate level of confidence based on good photo coverage and limited field observations.

Comments: Some areas may have been included within this landform that have slopes greater than 10% but these areas do not have a likelihood of slope failure. This landform was mapped using DEM slope percent maps and may contain areas of steeper slope due to the inaccuracy of the available DEM data.

Form A-2 Descriptions of Landforms for the Chehalis Sloughs Watershed

Landform # 16 - Low Gradient Hillslopes – Low Hazard

Description of Mass Wasting Unit: This map unit is generally the top of the glacial till plain but also includes all hill slope shapes and gradients between 11% and 40% that exhibit a low landslide potential, and/or are not likely to deliver sediment to a stream, impact public safety, or impact a public resource.

Slopes: 11% and 40%
Slope Shape: Convergent to planar
Material: Marine sedimentary tuffaceous siltstones and sandstones (Lincoln Creek, Astoria, and Montesano Formations); glacial outwash and till; and alluvium
Elevation: 0 ft to 730 ft
Total Area: 5,455 acres

Mass Wasting Process: Shallow undifferentiated landslides dominate this landform, but debris slides, debris flows, and deep-seated landslides can occur with varying slope shapes and fail at gradients between 11 to 40%. These landslides occur after storm events and are commonly associated with the weak nature of the bedrock.

Forest Practice Sensitivity and Trigger Mechanisms: The loss of root strength, changes in slope gradient, and changes in hydrology resulting from timber harvesting and road or landing construction have the potential to initiate slope failure. Root strength loss may be a triggering mechanism for landsliding within this landform. The majority of landslides were located in the forest category of 15-50 year old trees. Roads and landings can cause instability by undercutting and over-steepening slopes. Undersized culverts may lead to road fill failures and may deliver sediment to streams. Side cast and road (or landing) fill can over steepen and add weight to slopes; roads and landings can also capture runoff water or shallow groundwater and channel it to point locations that saturate road or landing fill and trigger landslides.

Mass Wasting Potential: High for roads and timber harvest based on 70 slope failures in a landform covering 5,455 acres. This landform has a Landslide Frequency Rating of 285.2 with roads and 244.4 without road related landslides.

Delivery Potential/Criteria: Low. The Landslide Area Rate of Delivery for this landform is based on 56 “delivering” landslides totaling 13.79 acres is 56.2 with roads and 50 “delivering” landslides totaling 12.27 acres is 50.0 without road related landslides.

Overall Hazard Potential Rating: **Low** for the entire unit based on the LHZ Protocol, Table 5.

Confidence: Moderate level of confidence based on good photo coverage, and limited field observations.

Comments: The majority of this landform is based on slope angles drawn from computer generated slopestab and DEM's which have been identified in the field as being underrepresented. Rule-identified features such as inner gorges, head scarps and toes of deep-seated landslides, and bedrock hollows may have been included within this landform.