# Appendix F

# ENGINEERING GEOLOGIC FIELD RECONNAISSANCE

## DEBRIS SLIDE, DEBRIS FLOOD, AND AFFECTED PROPERTIES

## 3312, 3334, 3363, and Two Un-Addressed Properties, Clipper Road Whatcom County, Washington

Prepared for:

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Land Management Division

September 3, 2009

WASHINGTON STATE DEPARTMENT OF
**Natural Resources**
**Peter Goldmark** - Commissioner of Public Lands

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**TO:** Jeff May
Baker District Manager
Department of Natural Resources
919 Township Street
Sedro-Woolley, Washington 98284

**SUBJECT:** **ENGINEERING GEOLOGIC FIELD RECONNAISSANCE**
Debris Slide, Debris Flood, and Affected Properties
3312, 3334, 3363, and Two Un-Addressed Property, Clipper Road
Whatcom County, Washington

**DATE:** September 3, 2009

The following Engineering Geologic Field Reconnaissance report presents our findings, and a discussion regarding the debris slide and debris flood that affected the residential property at 3312, 3334, 3363, and two un-addressed properties, Clipper Road in Whatcom County, Washington. The debris slide and debris flood occurred during the January 2009 storm. This reconnaissance report addresses the following issues: 1) was the point-of-initiation of the debris slide on DNR-managed lands, 2) was the point-of-initiation in an area of recent management activity, 3) did the management activity contribute to debris slide initiation and the subsequent debris flood, and 4) how much did management activity contribute to initiation of the debris slides and debris flood.

If you have any questions, please call.

Respectfully submitted,

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## 1.0. INTRODUCTION

At your request we have completed an engineering geologic reconnaissance of the debris slide and debris flood that affected four residential properties located along the private road section of Clipper Road (herein referred to as Clipper Road) in Whatcom County (Figure 1). The private road is a north-trending extension of the public portion of Clipper Road. This extension projects northward from the Clipper Road/Strand Road intersection. Three properties have residential structures on them. These properties (Owners) are 3312 (Pulver), 3334 (Costomiris), and 3363 (Bilski) as shown on Figure 2. The other properties are an un-addressed property at the northwest corner Clipper and Strand Road (Petersen Trust); and an un-addressed property east of Clipper Road and north of Bittner Creek (Dawson Powell LLC). The debris slide was triggered during the early January 2009 storm. The slide initiated in the SW¼ of Section 21, T38N, R5E. Three of the properties (3313, 3334, and Dawson Powell LLC) are located on the east side of Clipper Road in the SW¼ of Section 21. The other two are on the west side of Clipper Road in the NE¼ of Section 29 of the same Township (WBL&M) in the US Geological Survey 7½-minute Deming Quadrangle.

As shown on Figure 1, the subject properties are located near the base of the west side of a plateau-like topographic high known as Van Zandt Dike. The properties are situated in the Acme Watershed Administrative Unit (WAU). To date Landslide Hazard Zonation mapping has not been undertaken for this area. However, watershed analysis for the Acme WAU was released in 1999 by Trillium Corporation. The debris slide originated in the Acme Watershed Mass Wasting Map Unit (MWMU) #7. This MWMU is described as a "conditionally high hazard" area. In this MWMU slope processes are characterized as predominately shallow landslides, small debris slides, and possibly bedrock-slab failures. The area in question is designated as Area of Resource Sensitivity Mass Wasting Unit 1 (ARS MW-1). This ARS is accompanied by an involved set of landform descriptions, resource concerns, linkages, and prescriptions. Please see the Acme Watershed Analysis for details. The portions of the properties and residential structure are located within an alluvial fan hazard zone as shown on the *Geologically Hazardous Areas (GHA)* map of the Whatcom County Critical Areas Ordinance prepared in 2006 for Whatcom County Planning & Development. An Initial Incident Report (IIR) for this site was prepared by Hooks (2009). At the DNR Northwest Region 2009 Storm Tracking Site the impacted area is identified as 3334 Clipper Road (Hooks, 2009). Upon our field reconnaissance it was determined that in fact several properties were affected. For this report we have chosen to identify the area using the addresses of the affected properties.

The purpose of our geologic field reconnaissance was to determine if the point-of-initiation (PI) of the debris slide and debris flood that originated above the properties and residential structures is on DNR-managed lands, observe the site conditions at the PI, observe the conditions along the path of the debris slide and debris flood, and note conditions in the area of deposition. In addition, we were asked to provide a professional opinion, based on the field evidence we observed, as to the natural and, if applicable, the anthropomorphic contributory factors that influenced the development of the debris slide, as well as the triggering event that caused the slope failure.

## 2.0. SCOPE OF WORK

Our scope of work included the following tasks:

- Review of pertinent published and reports and maps in our office files
- Review of pertinent sections of watershed analysis reports
- Review of pertinent information in the DNR electronic database
- Review of pertinent LiDAR imaging in the DNR electronic database
- Review of pertinent aerial photographs in the DNR files at the Northwest Region office
- Review of pertinent past and available Forest Practices Applications
- Review of the Initial Incident Response (IIR) for this site
- Field reconnaissance of the debris-slide track and PI
- Field reconnaissance of the depositional area
- A short discussion with Ms. Costomiris
- Photographing pertinent aspects of the debris slide, debris flood track, and depositional area
- Review of pertinent historical rainfall and snowfall data
- Review of available rainfall and snowfall data related to the January 4$^{th}$ to 8$^{th}$ 2009 storm
- Analysis of the resulting data
- Preparation of this field reconnaissance report and accompanying illustrations

In addition there was one meeting with the Northwest Regional Manager and selected assistant Northwest Regional staff, geologists from Washington Division of Geology and Earth Resources, and geologists from the DNR Land Management Division Earth Sciences Program in which the general nature of the proposed reports and estimated schedule of field work and report completion were discussed. No specific site was discussed in any detail.

## 3.0. LIST OF ILLUSTRATIONS



## 4.0. PHYSICAL SETTING

The area is dominated by the Van Zandt Dike and the South Fork Nooksack River Valley, also known as the Acme Valley. The physical setting of the PI of the debris slide, the debris flood, and the depositional area (collective referred to as the “Site”) is characterized by the topography, climate, geology, landslides, and groundwater conditions. Each of these attributes is briefly discussed below.

## 4.1. TOPOGRAPHY

The topography of the Site is represented by two distinctly different types of terrain (Figure 1, 2, and 3). The debris slide PI is in an area of steep hillside topography. The affected properties are located on relatively gentle hillside terrain or essentially the valley floor. The Site is dominated by westward-flowing Bittner Creek (Figure 3). The headwaters area and the channel side-slopes of Bittner Creek are characterizes by very steep to precipitous slopes, and two main channels; an easterly one and a westerly drainage (Figure 3). The affected residences are located at elevations between 285 and 325, on an alluvial fan that has formed at the mouth of Bittner Creek (Figure 3). The debris slide PI is at an elevation of about 1,290 feet. The local relief between the residences is about 1,000 feet over a horizontal distance of about 2,150 feet (to the 3334 residence). Bedrock hollow and inner gorge topography was observed at the area of the

PI. The bedrock hollow displayed strongly convergent, steep topography and was the debris slide PI. Post-failure topography in the bedrock hollow is likely steeper than the pre-failure condition. Pre-2009-storm LiDAR imaging of the ground surface at the Site shows a detectable inner gorge landform with side slopes in excess of 70% (Figure 3). Bittner Creek enters the valley floor on a well developed alluvial fan (Figure 3).

## 4.2. CLIMATE

The historical climatic record and pertinent details of the recent storm are briefly presented below. Details of the recent storm are as current as possible at the time of preparation of this report. These details could change as more information becomes available.

**4.2.1. Historic Record –** The area of the Site is influenced by a predominantly maritime-type climate with mild wet winters and cool dry summers. The area receives frequent and sometimes intense storms that approach from the Pacific Ocean, about 120 miles to the west.

The nearest weather recording station with a lengthy historic record is located at the Glacier Ranger Station (Western Region Climate Center (WRCC), 2008), about 13½ miles to the east-northeast of the Site. The Glacier recording station is some distance away but is at an elevation of approximately 1,000 feet, in the range of the elevation of the PI (1,290 feet) of the debris slide. The generally accepted zone of greatest or most frequent rain-on-snow influence in this portion of the Cascades is from 1,600 to 4,000 feet (Trillium Corporation, 1993). The Glacier Ranger Station is well into the foothills of the Cascade Mountains, unlike the site of the PIs, which are essentially at the front of the range of the foothills. These geographic disparities are important and do not allow a simple inference of the climatic history from one site to the other. However, it appears to be the closest weather station with a historic record of significant length. Though totals at the Site and at the Glacier Recording Station are surely different and the amount of the difference is uncertain, at a minimum it is probably safe to assume that if a large storm resulted in significant precipitation at the Glacier Station then the same storm likely resulted in significant precipitation at the Site. The area of the PI is in the rain-dominated zone (below 1,600 feet). The precipitation history is summarized below, keeping in mind that the precipitation history is assumed to be similar, only with likely lower totals at the Site.

The three periods-of-record (POR) for the Glacier Ranger Station include the following: 1949-1983, 1961-1990, and 1971-2000; in total a 51-year record. (In the station database the tabulated data is reported in this manner.) The WRCC (2008) reports the annual average rainfall at the Glacier Ranger Station varies from about 68⅔ and 71 inches, for PORs 1961 – 1990 and 1971 – 2000, respectively. The mean annual for the 1949 to 1983 POR is 66⅔ inches of rain, with a yearly standard deviation of about 12 inches. The highest recorded January rainfall for the POR was

19½ in 1974; for a December it was 21 inches in 1979. The mean January and December rainfalls are 9⅓ and 10½ inches, respectively. Average daily precipitation in January and December it is about ⅓ of an inch, within a daily range that varies from about one-eight inch to five-eights inches for both months. However, the maximum one-day total in January during the POR is about 3½ inches, while in December it is about 4⅔ inches. It appears that during one very unusual December storm event the daily average rainfall was exceeded by about 1,225%. The mean average snowfall is about 51¾ inches per year over the 1948 to 1982 POR for snowfall. The greatest snowfall in January was 73¾ inches in 1954; in December, 25 inches in 1971. The monthly mean is about 17 and 8 inches for January and December, respectively. Daily average snowfall for January and December has varied from 0 to about 1¾ inches; however, during extreme events up to at least 17 inches of snow has fallen in a single day. Snow depths at the Glacier station during January average between about 1 and 6⅓ inches over the POR; in December the average for the POR is between 0 to about 1 inch. Over the POR, snow-depth extremes for January range from about 11 inches to about 37¼ inches; for December, the range is from 0 to about 11 inches.

Since 2000 (the end of the POR) the National Climatic Data Center (2009) reports that Whatcom County has experienced one heavy snow event in February 2001, three heavy snow events in January and February of 2002, one heavy rain event in October 2003, a winter-weather mix event in January 2004, heavy rains in November and December 2004, one heavy snow event followed by a flood (heavy rain?) event in January 2005, and finally a flood (heavy rain?) event in November 2006. In December 2008, the area experienced a prolonged period of severe winter weather during which snow accumulations reached about a foot-and-a-half in the low lying areas.

The January 2009 storm followed a several-week period of snow storms, prolonged freezing temperatures, and thick accumulations of snow, even at the lower elevations. We reviewed the available historic climate data to determine how often such a sequence of weather events has occurred in the area of the Site. Only the data for the years 1949 to 1983, a 34 year period, from the WRCC contained totals for monthly accumulations of snow and rain. We arbitrarily chose months where the December snowfall equaled or exceeded about 24 inches, and the January rainfall equaled or exceeded 10 inches, attempting to match the snow conditions leading up to the January 2009 storm and the rainfall of that storm. For the time period reviewed there were only two periods that matched these criteria: December/January 1970/71 (snow 30”/rain 13”, respectively) and December/January 1971/72 (snow 45”/rain 13” respectively). It should be noted that in both Januarys there was significant snowfall in addition to the rainfall. It should also be noted that there were several January snowfall and rainfall totals that came close or exceeded the 10-inch minimum (January 1954, ’60, ’68, ’70, ‘74, ‘76, and ’82) but because it is uncertain whether the rain followed the snow or vice-versa we could not be sure how representative these storms would be of the climatic setting leading up to the January 2009 storm. We should be clear that the POR have only monthly totals, not daily totals. As noted above we have only monthly totals, we have no daily totals (the POR summaries only report average rain and snow for any given day of the year), thus we have assumed that from the monthly December snowfall totals, at least about 1½ to 2 feet of snow was present at the end of December, and that a large portion of the January rain fell on the December snow during a several-days storm, in effect a worse-case scenario.

**4.2.2. January 2009 Storm –** The damaging storm in question began about January 4 and continued to about January 8, 2009, and followed on the heels of the December 2008 snow storms mentioned above. No recording stations are located at the Site. However, interpretation of Doppler-radar imaging of the four day period of rain bracketed above (National Weather Service, 2009) suggests that the area of the Site received about 9 to 11 inches of rain during that period. The January 4 to 8 period was preceded and followed by showers and light rain and snow so that the actual total could be somewhat greater. The time-intensity relationships are uncertain, but likely were characterized by periods of heavy rainfall interspersed with periods of lighter to no rainfall. The amount of snowfall on Van Zandt Dike and the slopes above the affected properties is also uncertain. However, based on the IIR, it appears that the snow pack was about two, and maybe as much as three feet thick (Hooks, 2009). Temperature and wind data from University of Utah TSUNA weather station east of Deming near the base of Sumas Mountain recorded almost three weeks of below or just above freezing temperatures prior to the January 4 to 8 storm. During the storm, temperatures rose over the four day period from below freezing to almost 50°F during the last couple of days of the storm. Also, wind speeds between 20 to 30 mph from the SSW with sustained speeds of 15 to 20 mph were recorded at the weather station during the latter days of the storm (University of Utah, 2009).

## 4.3. GEOLOGY

The geology of the Site is represented by the underlying bedrock and the surficial deposits that overlie the bedrock. Surficial deposits include alluvial fan deposits, soil and colluvium, landslide debris, and artificial fill. A brief description and general distribution of these earth materials is presented below and shown on Figure 3.

**4.3.1. Bedrock –** The bedrock geology at the Site is represented by the Jurassic age Darrington Phyllite (**Jdp**) and Eocene age Chuckanut Formation (**Tec**) (Dragovich and others, 1997). The Darrington Phyllite is a muscovite, quartzose graphic rock characterized by crenulations, secondary cleavage planes, and open to tight folding. The Chuckanut Formation is characterized by sandstone interbedded with lesser amounts of siltstone and shale. The sandstone varies from locally laminated to very thick bedded and exhibits a general east-west strike and a moderate (40°) to steep (70°) northerly dip. Locally the bedrock is broken by sets of generally steeply-dipping northeast- and northwesterly-striking joints. The bedrock crops out in the upper reaches of the Site and is assumed to underlie the surficial deposits from the mid-slope areas down to the lower slopes of the Site and beneath the deposits that carpet the valley floor.

The Chuckanut unconformably overlies the Darrington Phyllite. Dragovich and others (1997) report that the Darrington Phyllite is a low-grade metamorphic rock of the Easton Metamorphic Suite of the Shuksan Nappe within the Northwest Cascade System.

**4.3.2. Surficial Deposits –** Surficial deposits include alluvial fan deposits, soil and colluvium, and landslide debris.

**Alluvial fan deposits** (**Qf**) are composed of interbedded debris-flow deposits and fluvial sediments. The debris-flow deposits, where exposed, are poorly-stratified, poorly-sorted deposits of coarse angular accumulations of bedrock debris and soil in a finer-grained matrix. They are mapped at the mouth of Bittner Creek. As shown on Figure 3, at the Site the valley floor at the base of the slope is characterized by a complex of alluvial fans that have developed at the mouths of the creek in question and other adjacent creeks.

**Soil** and **colluvium** (**Qc**) are derived from the mechanical and chemical weathering of the underlying bedrock. These deposits are composed of varying amounts of sand, silt, and clay intermixed with blocks of bedrock and organic debris. Soil mapping published by Goldin (1992) has identified four major soil types on the slopes and top of the plateau and one on the valley floor of the Site. Welcome loam is mapped on the upper slopes and plateau top. Andic Xerochrepts – Rock Outcrop Complex, Van Zandt very gravelly loam, and Montborne-Rinker complex soils are mapped on the mid- and lower slopes of the Site. Within the Site Wiseman very channery sandy loam blanket the valley floor.

The Welcome soils are characterized as well drained; having a moderate permeability; moderate water capacity; slow runoff; and a slight erosion hazard. Andic Xerochrepts soils are characterized as well drained; moderate to moderately rapid permeability; moderate to high water capacity; moderate runoff; and a sever erosion hazard. The Van Zandt soils are characterized as well drained; having a moderate permeability, but very slow permeability where glacial till is present; moderate water capacity; slow to moderate runoff; and slight erosion hazard. The Montborne-Rinker complex soils are characterized as well drained; having a moderate permeability, but very slow permeability where glacial till is present; moderate water capacity; slow runoff; and slight to moderate erosion hazard. Locally perched-water conditions can be present. The Wiseman soils are characterized as excessively drained, having a rapid permeability, low water capacity, slow runoff, and slight erosion hazard. These soils are subject to rare flooding. The soils form more or less in-place; however, the colluvial deposits are formed by the accumulation of soil moved down slope in response to gravity driven processes (e.g., soils creep, etc.). Herein colluvial deposits are considered to be soil deposits thicker than about 3 to 4 feet. Colluvium locally blankets the mid- and lower slopes of the Site.

**Landslide debris** (**Qls**) is composed of predominately debris slide materials. These earth materials are intermingled in the colluvial deposits that underlie the mid- and lower slopes of the Site and the alluvial fans. The landslide deposits are composed of essentially the same earth materials that characterize colluvium. Debris slide deposits, if exposed, may occur as poorly-stratified, poorly-sorted deposits of coarse angular accumulations of bedrock debris and soil.

**Artificial fill** is derived locally from grading for logging roads, skid trails, and landings. It is composed of a mixture of rock, soil, and varying amounts of organic debris. Though it is not shown on Figure 3 its present along the outside margins of roads, skid trails, and landings should be assumed.

### 4.4. LANDSLIDES

Review of historical aerial photographs and the LiDAR generated topography did not reveal evidence for even current minor, occasional landslide activity. However, during our field reconnaissance of the areas adjacent to the upper portion of the Site we observed landforms generally considered indicative of past landslide activity. A modest-size swale, also known as a bedrock hollow, characterized by steep slopes and convergent topography was observed just upslope of the main debris slide PI. Landslide processes are generally credited with the development of such landforms. In addition, the alluvial fan that has developed at the base of the slope that the residences are located on also gives testimony to past debris-slide processes. The Whatcom County *Geologically Hazardous Areas* map recognizes that the topography along the base of the west side of Van Zandt Dike in the area of the Site is a product, in part, of past landslide processes.

### 4.5. GROUNDWATER

Evidence for groundwater at the PI was not abundant. We did observe a shallow channel suggestive of concentrated surface flow emanating from the eastern most point of scour within the inner gorge. The channel was traceable down to the base of the Van Zandt Dike slope suggesting at least some concentration of groundwater and surface water following development of the debris slide. Fractures and joints in the bedrock noted during our reconnaissance are certainly an avenue for groundwater flow through the bedrock. The permeability through the pore spaces of the bedrock is uncertain and could be quite variable. The soil cover on the bedrock above the PI is relatively thin and the contact between the soil and the bedrock likely represents a significant barrier to the rapid movement of groundwater from the soil downward into the bedrock, forcing some flow parallel to the bedrock surface, and at this location into the inner gorge. During our traverse of the headwaters area the prominent western drainage was dry. However, at its junction with the eastern drainage, water was observed flowing on the rock surface beneath the organic debris that fills the channel and into the waestern channel to form the mainstem of Bittner Creek.

An important factor affecting groundwater, especially at the time of the failures, was the January 2009 storm and the associated phenomenon commonly known as rain-on-snow (ROS) precipitation. It should be noted that the PI of the debris slide in question was below the 1,600 foot elevation that is often considered to be the lower elevation of the ROS zone. Generally ROS conditions develop most frequently above this elevation, but not exclusively. The Site, including the PI, was covered by snow at the time of the January 2009 rain storm.

## 5.0. HISTORICAL SETTING

The historical setting of the Site is briefly summarized below. This includes the past landslide history and past forest-practices and land-use history. Interpretation of stereoscopic aerial photography was relied upon for preparation of this section along with past Forest Practices Applications (FPAs) information in the electronic files of DNR Division of Land Management. For a complete list of aerial photography reviewed please see **AERIAL PHOTOGRAPHS REVIEWED** at back of text.

### 5.1. LANDSLIDE HISTORY

Review of historical aerial photography from various years dating back to 1947 through to 2001 revealed no certain evidence for historic landsliding at the Site, save for the 1978 and 1983 photography. A few very small whitish tones were noted on the 1978 aerial photographs. They were observed on southeast facing slopes well above any drainage channel. The degree of resolution of the photographs did not allow determination of whether these tonal peculiarities were actual slides or some other non-landslide feature on the hillside. On the 1983 photographs a couple of whitish patches were note in the channel. Again, the degree of resolution of the photographs did not allow determination of whether these tonal features were actual slides. It appeared that one might be a waterfall. In addition there was no evidence for any historic debris flood run-out, suggesting any significant failures up channel, on the alluvial fan at the mouth of Bittner Creek.

### 5.2. FOREST PRACTICES/LAND USE HISTORY

As noted above the following discussions are based on review of vertical, stereographic aerial photographs and pertinent FPAs. The earliest photographs dated back to 1947.

**5.2.1. Forest Practices –** Review of the 1947 aerial photographs shows that prior to that time the plateau area of the Site had been logged. Judging from the nature of the canopy observed on the photographs the entry was likely a clear cut some 20 years or so earlier. Logging did not extend down slope onto the steep slopes or headwaters area of Bittner Creek. In addition, it appears that a relatively small isolated area on a bench on the plateau slopes near the lower reaches of the creek was also cut by 1947. Review of the 1955 aerial photographs suggests that additional harvest activity occurred on slopes above the spur road that crosses the lower reaches of Tinling Creek. Between the 1955 and 1987 aerial photographs essentially no timber harvest activity is shown within the area of the Site.

By the time of the 1991 aerial photographs a clear cut had occurred. In the area of the Site this clear cut involved essentially the same ground that was cut prior to the 1947 aerial photographs. It did not extend down slope into the steep slopes of the headwaters area of Bittner Creek. Review of the 2001 aerial photographs reveals some type of harvest activity on the slopes of privately held property to the north of the mouth of Bittner Creek, and on a small patch of private property to the south of Bittner Creek. In 2004/2005, areas around the steep headwaters slopes of Bittner Creek were cut as part of the Jack Straw Aerial Timber Sale (Figure 3), save for a small “window” on a prominent ridge in the central area of the Bittner Creek headwaters. It appears that no harvest activities occurred on slopes that drain directly into the several streams that combine to form Bittner Creek. At the time of the Jack Straw Aerial sale the harvest boundaries of the sale complied with or exceeded the Acme Watershed prescriptions for unstable slopes (Wolff, 2003).

**5.2.2. Land-Use History –** Strand Road, that connects Clipper Road to Washington State Highway 9, and the public (southern “extension”) portion of Clipper Road are present on the 1947 photos. There is no northern (private “extension”) of Clipper Road. At best there barely exists a farm path. There are no buildings to the north of Strand/Clipper Road intersection. Between the 1947 and 1976 photos, the land use appears to be only agricultural. By the time of the 1976 aerial photography the route that eventually becomes the private extension of Clipper Road can be seen. On the 1983 photography the private extension of Clipper road is clearly visible and the residence at 3334 is present as is a residential structure and outbuildings at 3363. The 1987 aerial photography shows a residential structure southeast of the Costomiris (3334) residence at the 3312 address; from 1987 to the present little else changes.

## 6.0. RECONNAISSANCE OBSERVATIONS

The slide that affected the several properties is reported to have occurred between midnight and 4:00 am on January 7$^{th}$ (Pers. comm, Doug Hooks, 2009). Ms. Costomiris reports that two distinct pulses of debris came down Bittner Creek and into her backyard (pres. comm., 2009). The following discussion presents salient field observations regarding the debris slide and debris flood that impacted the property. This discussion proceeds from the debris slide PI down slope to the areas of deposition. Resulting damage to private property is summarized in the Areas of Deposition discussion.

## 6.1. POINT-OF-INITIATION (PI)

The PI is located on DNR-managed land. The debris slide PI involved the detachment of the soil layer from the underlying bedrock within an inner-gorge landform, and the channelized transport of this soil and debris down slope (Figure 4). The inner-gorge landform was within a buffer of standing conifer trees with diameters of approximately 2 feet – 4 feet at breast height. Slopes outside of the inner gorge landform in the vicinity of the PI were recently clear-cut as part of the Jack Straw Aerial Timber Sale.

Fresh scour down to bedrock was noted along the channel in the inner gorge for 250 feet upslope to the east of the PI. Two small scale translational debris slides were noted in this reach, one approximately 210 feet upslope of the PI to the east and the other at the beginning of the scoured section 250 feet upslope of the PI (Figure 5). The scoured portion of the channel above the PI is evidence that a larger than usual volume of water was flowing through the channel during the January 2009 storm event. This likely eroded soil from the base of the inner-gorge slopes, destabilizing the soil layer on the steep inner-gorge slopes. In addition, the likely increase in soil moisture as a result of the storm increased the weight of the soil upslope. The removal of the soil down slope and the increase in weight of the soil upslope were likely major contributors to the translational failure of the soil layer over the bedrock.

## 6.2. DEBRIS FLOW ROUTE

The pulses of debris, likely originating at the main PI, travelled down Bittner Creek as a debris flow (Hungr, 2001) in the channel to depositional area at the base of the slope. Evidence of scour was observed along the entire length of the channel, from the PI to the mouth of the creek (Figure 6). In addition, we observed two translational earth slides in the inner-gorge along our traverse (Figure 3). In both cases, most of the material involved in the slides remained on the hillslope.

## 6.3. AREAS OF DEPOSITION

When the debris flows reached the mouth of Bittner Creek and the valley floor the abrupt change in gradient resulted in deposition of the entrained debris. The deposits observed at the base of the slope are best described as debris flood deposits following criteria developed by Hungr and others (2001). Much of the deposition at the base of the slope and on the gentle slopes to the west was likely the result of sediment and debris transported in the large volume of water generated by the January 2009 storm.

A large pile of slide debris accumulated at the base of the slope (Figure 2 and 3). Evidence for at least three separate lobes of material was observed in the field and likely represents the flow of debris and water into topographic lows and around topographic highs. The main lobe of material and a reportedly newly formed stream channel flowed around and to the north of the house and outbuildings at 3334 Clipper Road (Figure 7, 8, and 9). Remnants of a water intake system for domestic water use were observed in the debris deposit along with wood, rocks, and sediment. Debris deposited west of the base of the slope generally consisted of cobble size particles and smaller. Evidence of particle sorting was observed indicating significant amounts of water likely deposited or reworked the material post deposition. In addition, a lobe of sediment and organic debris was observed trending toward the residence at 3312 Clipper Road.

The DNR Northwest Region 2009 IIR reports substantial amounts of mud surrounding the house and several outbuildings at 3334 Clipper Road (Pers. comm, Doug Hooks, 2009). In addition, it reports mud and sediment crossing Clipper Road with minimal damage. We observed evidence of surface water flow from the base of the slope to Clipper Road and into the brush on the west side of the road (Figure 2).

## 7.0. DISCUSSION

As part of our charge we were asked to determine the following:

1) Did the debris slide and debris flood initiate on DNR-managed lands?
2) Was the PI in an area of recent forest-management activities?
3) Did the forest management-activities contribute to initiation of the slide?
4) How much did the management activities contribute to debris slide and debris flood initiation?

In the following discussion we provide our observations and opinions with respect to these questions.

The debris slide and debris flood that impacted the properties in question initiated on DNR-managed lands (Figure 2 and 3). The PI is located in a buffer of standing timber that was left to protect an inner gorge landform as part of the Jack Straw Aerial Timber Sale, a DNR timber sale that was harvested in the fall and winter of 2004/2005. The slopes on either side of the inner-gorge buffer were harvested as part of the above mentioned timber sale, however the harvested areas were small patch cuts and there does not appear to any area that was cut that would contribute surface water toward the PI. The basin, based on surface topography, that contributes water to the inner gorge above the PI is forested by mature timber and has not been a part of recent forest management activities.

Since a buffer of standing timber was left to protect the inner gorge and the entire basin contributing water to the inner gorge above the PI is standing timber, there are very few mechanisms in which DNR forest-management activities could have contributed to the initiation of the slide. The buffer of standing timber within the inner gorge means that DNR forest-management activities did not reduce root strength within the inner gorge at the PI. In addition, since the drainage basin as defined by surface topography is completely forested above the PI, no increase in water flowing in the inner gorge as a result of timber harvest would be a factor. There were several large trees that were part of the buffer that were observed lying across the channel at and near the PI. It is unclear whether these trees were blown down and then the debris slide initiated or the debris slide initiated and the trees fell down. If the trees were blown down first, it could have had an impact on debris slide initiation.

Another possible contribution DNR forest-management activities could have had on the debris slide initiation is a localized increase in snow pack on the edge of the inner gorge buffer. This could have contributed additional water to infiltrate into the soil, potentially increasing the weight of the soil and increasing pore pressures within the soil, and leading to slope failure.

In our opinion the Bittner Creek failure was a localized event. The effects of the long-term degradation of hillside strength (Terzaghi, 1950) along with the weak nature of the bedrock and adverse orientation of planar structures in the bedrock, combined with the severe nature of the early January 2009 storm, must be considered as the primary factors in the development of the Bittner Creek debris slide. Review of the climate history suggests the early January storm was comparatively an extreme event. The water introduced by the melting snow and accompanying rainfall on a possibly already weak slope provided the proverbial “straw that broke the camel’s back” and triggered the slope failures and subsequent debris flood. In other words the Bittner Creek failure most likely occurred as a result of natural causes.

In our opinion, forest-management likely did not have much or any impact on debris slide initiation. Due to the observed evidence of an unusually large volume of water flowing in the channel during the January 2009 storm event, it is our opinion that the storm event of early January 2009 overwhelmed the site conditions at the PI and led to the debris slide and debris flood event. In addition, the residence at 3334 Clipper Road is located within an alluvial fan hazard zone as shown on the *Geologically Hazardous Areas (GHA)* map of the Whatcom County Critical Areas Ordinance. Our observations in the field and our interpretations of LiDAR topography from the DNR digital database indicate the landform the residence is located on is an alluvial fan and we concur with the hazard area identified on the Whatcom County map. The presence of the alluvial fan indicates that landslides debris and alluvial materials have been deposited due to natural processes in this location over time. It is our opinion that DNR forest-management activities contributed very little, if any, to the development of the debris slide and debris flood at this location.

**8.0. RECONNAISSANCE LIMITATIONS**

This reconnaissance report presents a qualitative assessment of the debris slide and associated debris flood that impacted the properties located at 3312, 3334, 3363, and two un-addressed properties, Clipper Road in Whatcom County at the time of the early January 2009 storm. The charge of this reconnaissance was to develop an opinion with respect to the following questions:

1) Did the debris slide and debris flood initiate on DNR-managed lands?
2) Were the points-of-initiation in areas of recent forest-management activities?
3) Did the forest-management activities contribute to initiation of the slides?
4) How much did the management activities contribute to debris slide initiation?

In this reconnaissance report we provide our observations and opinions, with respect to these questions, based on our field reconnaissance and review of office derived data. If new information should become available, our geologic interpretations, and thus, our discussion could require modification.

The signatures and stamps for this engineering geologic field reconnaissance report are on the cover letter that accompanies this report; just behind the title page. This report, or any copy, shall be considered incomplete without the cover letter signed with original signatures and stamps, or authorized facsimiles of the same.

END

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**AERIAL PHOTOGRAPHY REVIEWED**

In the set of aerial photographs reviewed, stereo coverage of the area in question was not always available for the years represented. In those cases observations are based on review of the single photograph. Those years are marked by an *

| Date | Flight Line/Frames | Approx. Scale | Medium |
|---|---|---|---|
| 8/24/47* | BBK – 5B – 103 | 1;24,000 | B/W |
| 8/6/55* | BBK – 2P – 167 | 1:24,000 | B/W |
| 7/8/61 | F.35 – 23, 24 | 1:12,000 | B/W |
| 7/14/71* | NW-H-71 351 – 11B – 13 | 1:80,000(?) | B/W |
| 7/15/76 | NW-C 76-25-130 to 131 | 1:24,000 | Color |
| 6-3-78 | NW-78 63C-45, 46, 47 | 1:12,000 | B/W |
| 5/23/83 | NW-C-83 13-49 417 to 418 | 1:12,000 | Color |
| 6/26/87 | NW87 11-50-67, 69 to 70 | 1:13,400 | B/W |
| 7/3/91* | NW91 16-50-91 | 1:13,000 | B/W |
| 5/26/95 | NW-95 30-50-38 to 39 | 1:12,000 | B/W |
| 8/26/01 | NW-C-01 58-50-39, 41, 41 | 1:12,000 | Color |

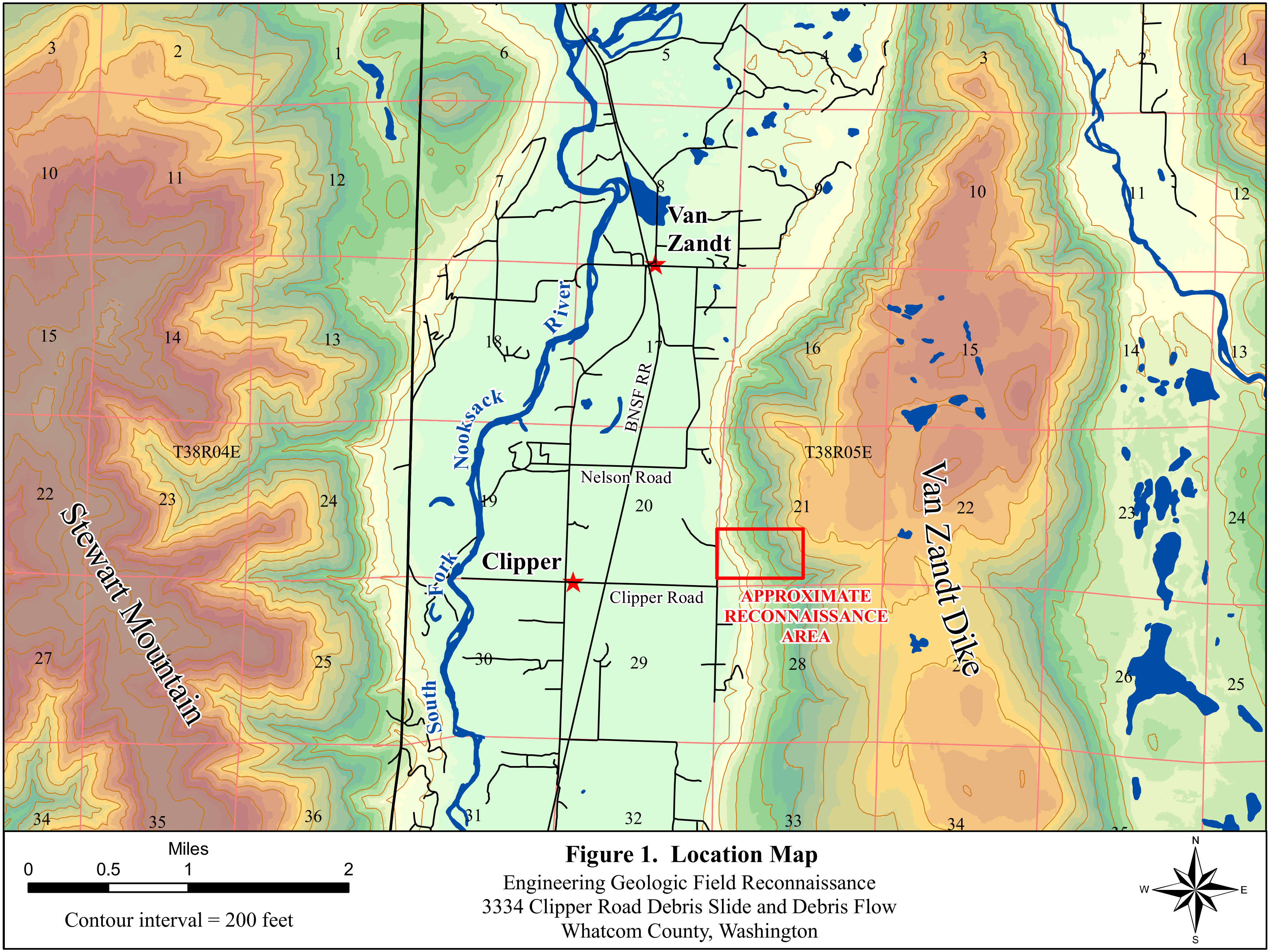



**Figure 1. Location Map**

Engineering Geologic Field Reconnaissance
3334 Clipper Road Debris Slide and Debris Flow
Whatcom County, Washington

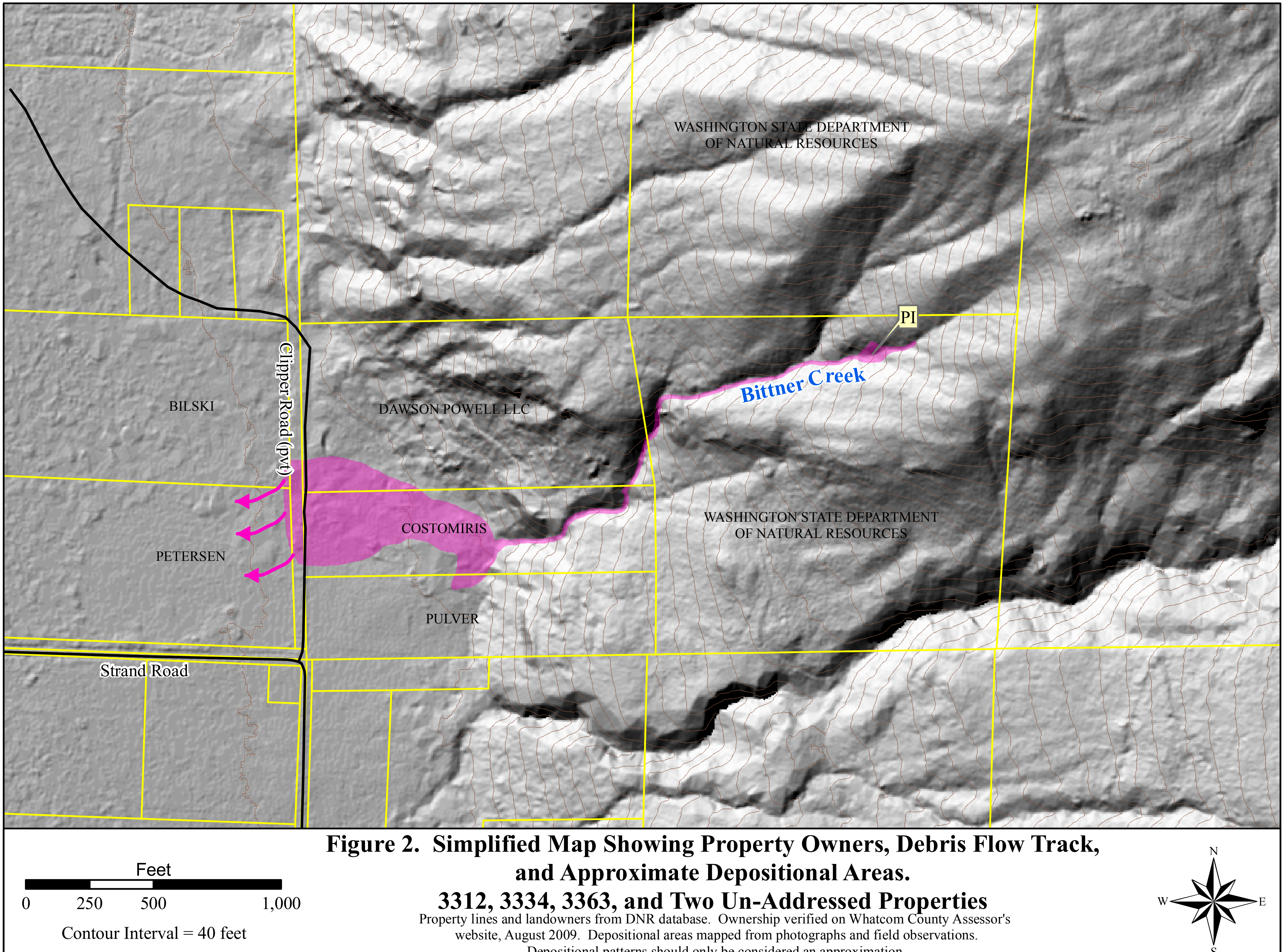



**Figure 2. Simplified Map Showing Property Owners, Debris Flow Track, and Approximate Depositional Areas. 3312, 3334, 3363, and Two Un-Addressed Properties**

Property lines and landowners from DNR database. Ownership verified on Whatcom County Assessor's website, August 2009. Depositional areas mapped from photographs and field observations. Depositional patterns should only be considered an approximation.

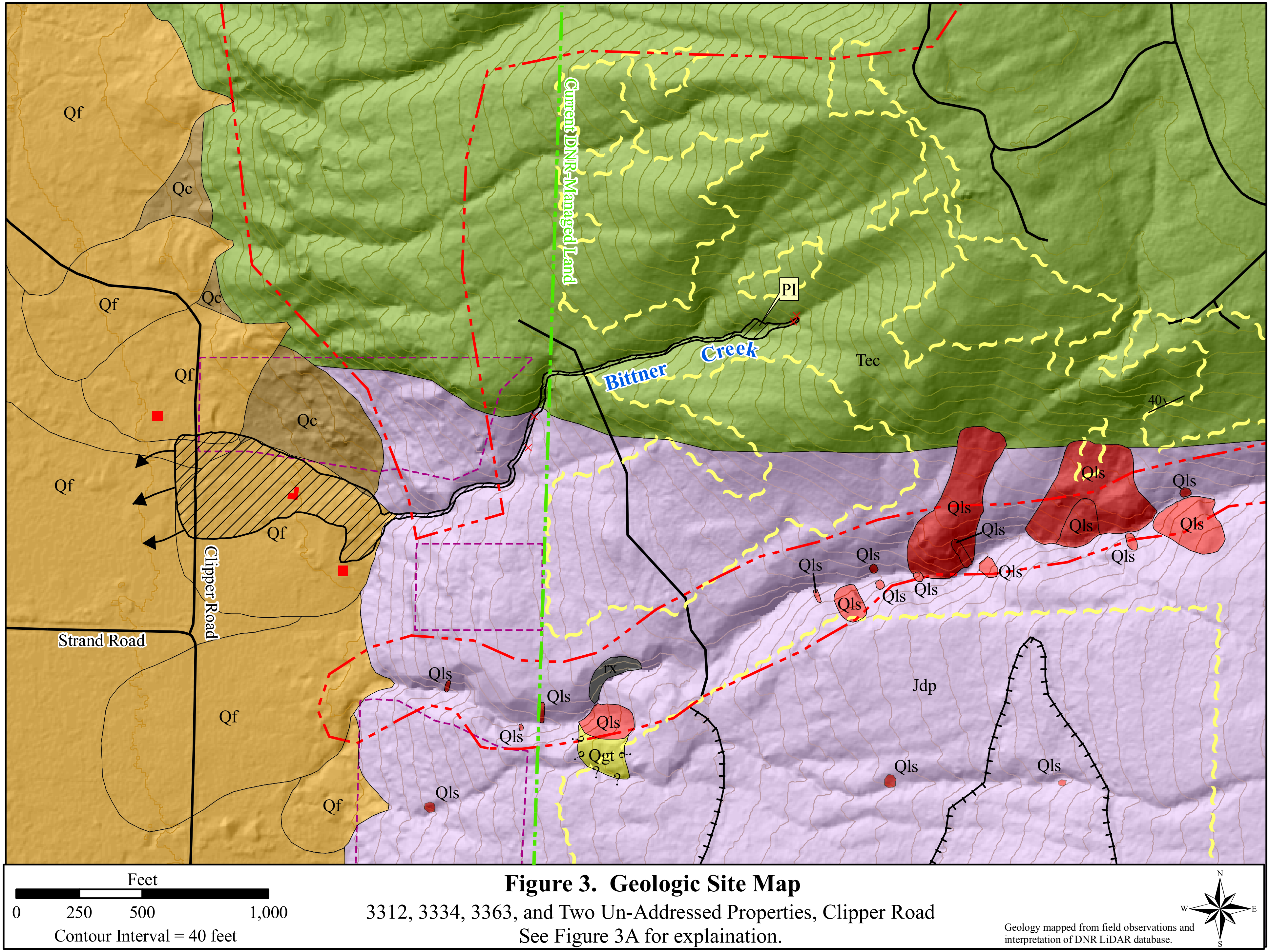



**Figure 3. Geologic Site Map**

3312, 3334, 3363, and Two Un-Addressed Properties, Clipper Road

See Figure 3A for explaination.

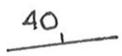
Geology mapped from field observations and interpretation of DNR LiDAR database.

## EARTH MATERIALS

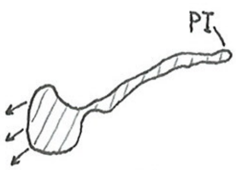
| | |
|---|---|
| Qls | Landslide debris |
| Qc | Colluvium (likely more extensive than shown) |
| Qf | Alluvial fan deposits |
| Qg | Glacial deposits (likely more extensive than shown) |
| Tec | Chuckanut Formation |
| Jdp | Darrington Phyllite |

## MAP SYMBOLS


Geologic contact, locally approximate to (?) uncertain

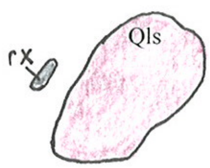



Strike and dip of bedding




Debris slide PI, flow track, and depositional area. Arrows show general direction of flood waters and debris west of Clipper Road.

Small channel side landslide in Bittner Creek




Active channel side-slope landslides observed during field reconnaissance of Tinling Creek. Large deep-seated landslides are inferred by topographic contours; rx = rock fall

Boundary of Acme Watershed MWMU #2 around Tinling Creek; MWMU #7 on slopes north of Tinling Creek



Boundary of Strand Extension or Jack Straw Aerial Timber Sales

Older harvest boundaries, pre-1980s

Residential structures

Roads; short ticks on abandoned roads



Current State Lands property line.

**FIGURE 3A. Explanation for Figure 3. Geologic Site Map**

Engineering Geologic Field Reconnaissance
3312, 3334, 3363, and Two Un-Addressed Properties, Clipper Road
Whatcom County, Washington

**Figure 4** Main Bittner Creek PI. Soil layer and organic debris slid off of bedrock surfaces on both sides of channel. View looking east. (Coyle, 2009)

**Figure 5** Beginning of scour in Bittner Creek channel, approximately 250 feet upslope and to the east of the main PI. Note bedrock hollow landform and small debris slide scar indicated by the red arrow. View looking east. (Coyle, 2009)

**Figure 6** Bittner Creek channel scoured to bedrock. View looking east. (Coyle, 2009)

**Figure 7** Debris flood deposition area. House at 3334 Clipper Road is indicated by the red arrow. View looking southwest. (Coyle, 2009)

**Figure 8** Debris flood deposition along the east side of the residence at 3334 Clipper Road. View looking south.
(Hooks, 2009)

**Figure 9** Debris flood deposition area. Note newly formed stream running through deposition area. View looking west.
(Hooks, 2009)