Appendix B

ENGINEERING GEOLOGIC FIELD RECONNAISSANCE

DEBRIS SLIDE AND DEBRIS AVALANCHE

VAN DEN HEUVEL PROPERTY

3800 Nelson Road
Whatcom County, Washington

Prepared for:

Jeff May
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Washington Department of Natural Resources
Land Management Division

May 29 2009

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

Caring for
your natural resources
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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 and Debris Avalanche
van den Heuvel Residential Property
3800 Nelson Road
Whatcom County, Washington

DATE: May 29, 2009

The following Engineering Geologic Field Reconnaissance report presents our findings regarding the landslides that affected the residential property at 3800 Nelson Road in Whatcom County, Washington. These landslides occurred during the January 2009 storm. This reconnaissance report addresses: 1) did the debris slide and debris avalanche 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? and 4) how much did the management activities contribute to debris slide and debris avalanche initiation?

If you have any questions, please call.

Respectfully submitted,

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ENGINEERING GEOLOGIC FIELD RECONNAISSANCE

DEBRIS SLIDE AND DEBRIS AVALANCHE

VAN DEN HEUVEL RESIDENTIAL PROPERTY

3800 Nelson Road
Whatcom County, Washington

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

SUBJECT: **ENGINEERING GEOLOGIC FIELD RECONNAISSANCE**
Debris Slide and Debris Avalanche
van den Heuvel Residential Property
3800 Nelson Road
Whatcom County, Washington

DATE: May 29, 2009

1.0. INTRODUCTION

At your request we have completed an engineering geologic reconnaissance of the debris slide and debris avalanche that occurred on the hillside above the van den Heuvel's single-family residential structure located at 3800 Nelson Road in Whatcom County. These landslides were triggered during the early January 2009 storm. The debris slide initiated in the SW¼ of Section 16, both the likely point-of-initiation (PI) of the debris avalanche and the residence are located in the SE¼ of Section 17, T38N, R5E, (WBL&M) in the US Geological Survey 7½-minute Deming Quadrangle.

As shown on Figure 1, the subject property is located near the base of the west side of a plateau-like topographic high known as Van Zandt Dike. The property is 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 and debris avalanche 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 property is not 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. However, based on the review of the same map it appears that it is either immediately adjacent to or just inside the GHA 1A Landslide Hazard Area characterized by 15% to 35% slopes. The small scale of the map (1:83,000) precludes a definitive determination of the precise location of the residence with respect to the hazard area boundary. To date there does not appear to be an Initial Incident Report (IIR) available for this site. At the DNR Northwest Region 2009 Storm Tracking Site the property is identified as 3800 Nelson Road.

The purpose of our geologic field reconnaissance was to determine if the point-of-initiation (PI) of the debris slide and debris avalanche that originated above the van den Heuvel property and residential structure is on DNR-managed lands, observe the site conditions at the PIs, observe the conditions along the path of the debris slide and debris avalanche, 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. We also provide suggestions for additional evaluation of the site.

2.0. SCOPE OF WORK

Our scope of work included the following tasks:

- Review of pertinent published and unpublished geologic reports and maps in our office files
- Review of pertinent and available site development information on file at Whatcom County Department of Planning and Development Services
- Review of watershed analysis reports
- Review of unpublished landslide hazards 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
- Field reconnaissance of the debris-slide track and PI
- Field reconnaissance of the depositional area
- Brief discussions with Mr. and Ms. van den Heuvel
- Photographing pertinent aspects of the debris slide and depositional area
- Review of pertinent historical rain and snowfall data
- Review of available rainfall and snowfall data related to the January 4th to 8th 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 LMD 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. The physical setting of the PI of the debris slide, the debris avalanche, and the area of the residence (collective referred to as the "Site") is characterized by the topography, climate, geology, landslides, and ground water. 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 and 2). The debris slide PI is in an area of very steep to precipitous hillside topography, the debris avalanche PI is thought to have been lower on the hillside in an area of 50% to 70% slopes. The residence is located on modestly-steep hillside terrain. The west-facing slopes of Van Zandt Dike exhibit an average inclination of about 85%. However, locally bedrock cliffs characterized by essentially vertical inclinations up to several tens of feet high are present; between the cliffs can be found narrow northwesterly-inclined benches. The affected residence is at an elevation of about 400 to

410 feet, and situated on subtly concave slopes (Figure 2) characterized by gentle to moderately steep (<25% to about 60% for short pitches) hillside topography, between two alluvial fans (Figure 2) which have developed at the mouths of two drainages that flank the Site. The lower slopes that transition between the precipitous upper slopes and those slopes around the residence exhibit inclinations of 50% to 100% or more. The debris slide PI is at an elevation of about 1,070 feet. The local relief between the residence in question and the area of the debris slide PI is high, approximately 660 feet vertical over a horizontal distance of about 930 feet. Subtle benchy topography was observed at the area of the PI. These benches display northwesterly inclinations. In addition, strongly convergent topography was noted south of the PI and planar slopes north of the PI. Pre-2009-storm LiDAR imaging of the ground surface at the Site does not show a detectable drainage network at the site of the slide prior to the failure, though subtle concave topography can be discerned down the length of the hillside that later became part of the landslide area. The Site is flanked by two well incised drainages (Figure 2).

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 Site is about 10½ miles southwest of the Canyon Lake and Kenney Creek watershed and is likely subject to similar general climatic conditions. Based on the general climatic description for the Canyon Lake and Kenney Creek watersheds it is reasonable to infer that in the area of the Site the majority of the rainfall occurs between mid-October and late February (Trillium Corporation, 1993). (Similar data was not available in the Acme Watershed Analysis.) Yearly rainfall in the Canyon Lake and Kenney Creek watershed is estimated to average about 70 inches in the lower elevations to about 100 inches/year at higher elevations.

The nearest weather recording station with a lengthy historic record is located at the Glacier Ranger Station (Western Region Climate Center (WRCC), 2008), about 13¼ miles to the northeast of the Site. The Glacier recording station is some distance away but is at an elevation of approximately 1,000 feet, essentially the same as the 1,070 foot elevation of the debris slide PI. In our opinion it does not appear to be unreasonable to assume that historical precipitation conditions at the PIs are at least somewhat similar to the Glacier station. The PI is in the rain-dominated zone (below 1,600 feet). 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 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. The WRCC (2008) reports the annual average rainfall at the Glacier Ranger Station varies, depending on the POR, between about 68¾ and 71 inches with a yearly standard deviation of about 12 inches. The mean annual for the 1949 to 1983 POR is 66⅔ inches of rain. 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-eight 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 snow fall is about 51¾ inches per year over the 1948 to 1982 POR for snow fall. 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 1½ feet 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 10 inches, and the January rainfall equaled or exceeded 10 inches, to try to provide a minimum match to the conditions leading up to the January 2009 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 antecedent conditions associated with the January 2009 storm.

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 or immediately near it. However, interpretation of Doppler-radar imaging of the four day period of rain bracketed above (National Weather Service, 2009) suggests that the Van Zandt Dike area 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 the Dike and slopes above the affected residences is also uncertain. However, based on anecdotal discussions with the Unit Forester at the Deming Work Center, it appears that the snow pack was about two feet thick and maybe as much as three feet thick. 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 to20 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 soil and colluvium, and possible landslide debris and debris-flow deposits. A brief description and general distribution of these earth materials is presented below and shown on Figure 2.

4.3.1. Bedrock – The bedrock geology at the Site is represented by the Chuckanut Formation (**Tec**) (Dragovich and others, 1997). The 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.

4.3.2. Surficial Deposits – Valley fill glacial deposits (**Qgo**) are composed of stratified gravel, sand, silt, and clay deposited during the last glacial advance and following retreat. They underlie the valley floor areas of the Site.

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. They are mapped at the mouths of the drainages that flank each side of the Site.

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 in 1992 classifies the soils underlying the lower portions of the Site as Chuckanut loam and those underlying the mid- and upper slopes as Andic Xerochrepts on 60 to 90% slopes. The Chuckanut loam is characterized as well drained, moderately permeable, having a high water capacity, moderate runoff, and moderate erosion hazard. The Andic Xerochrepts soil is described as a loam and characterized as well drained, moderate to moderately rapid permeable, having a high water capacity, moderate runoff, and high erosion hazard.

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. The soils occur in discontinuous patches across the upper areas of the Site including the bedrock benches noted above. Colluvium blankets the mid- and lower slopes of the Site, but also has accumulated locally on the topographic benches.

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.

4.4. LANDSLIDES

Review of historical aerial photographs and DNR data files revealed evidence for recent (last several decades) debris slide activity adjacent to the Site but not at the Site. The 1976 aerial photographs showed features that we interpretate as debris-flow tracks in both the drainages that flank the site. 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 south of the upper area of the debris slide PI (Figure 2). Debris slide processes are generally credited with the development of such landforms. In addition, the alluvial fans that have developed to the north and south of the residence also give testimony to past debris-slide processes. The Whatcom County *Geologically Hazardous Areas* map recognizes that elsewhere the topography along the base of the west side of Van Zandt Dike is a product, in part, of past landslide/debris slide processes.

4.5. GROUND WATER

Evidence for shallow ground water that may have been present prior to the occurrence of the debris slides was not obvious. We did observe shallow channels suggestive of concentrated overland flow emanating from the area of debris slide failure. These were traceable down slope for some distance suggesting at least some concentration of ground water following development of the debris slide. With respect to the deeper ground-water system, of particular interest is the possible influence of the bedrock structure upon the directivity of deeper ground-water flow. During our field reconnaissance we observed that locally, the sandstone bedrock is characterized by areas of relatively well-fractured bedrock, making the rock mass somewhat permeable. Elsewhere, we noted the spacing of fractures can be quite wide, thus making the rock mass fairly impermeable. It would not be unreasonable to expect that as ground water percolates through the subsurface, where the water encounters bedrock with widely-spaced fractures, for it to migrate northward and laterally along the bedding for some distance, at least until an area of well-fractured rock is encountered. In the area of well-fractured rock the downward (cross-bedding) migration could occur until less-fractured rock is encountered and the process of flow parallel to bedding, or parallel-to-strike, starts again. This directivity could help to concentrate ground water in some locations, such as bedrock benches and also direct ground water toward cliff areas.

An important factor affecting ground water, especially at the time of the failures, was the January 2009 storm and the associated phenomenon of rain-on-snow (ROS). It should be noted that the PI of the debris slide in question was below the 1,600 foot elevation that is considered to be the lower elevation of the ROS zone. However, the hillside area from which the slide originated extends up into the ROS zone, and the areas above the Site, including the PI, were covered by snow prior to the arrival of the early 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. For a complete list of aerial photography reviewed please see **AERIAL PHOTOGRAPHS REVIEWED** at back of text.

5.1. LANDSLIDE HISTORY

As noted above, review of historical aerial photography from 1947 to 2001 did not reveal evidence for recent landsliding at the Site. We did observe landforms (the swale just to the south of the debris slide PI) that we interpreted as evidence of past debris slide activity; perhaps several too many events over a long period of time (several 1,000s of years). We also observed on the 1976 aerial photographs evidence for two debris flows occurring (one each) in the drainages that flank the Site. As noted earlier, Whatcom County Hazards mapping recognizes some areas along the base of the slopes on the west side of Van Zandt Dike and south of the Site as alluvial fan hazard areas. This is likely based on the interpretation by others (Trillium Corporation (Acme Watershed Analysis) and work by Fox and others, 1992) that landslides, in this case debris flows, have occurred in the past on the west-facing slopes of Van Zandt Dike, depositing the slide debris at the base of the slopes of the Dike and forming alluvial fans. Though alluvial fans are present on both sides of the Site, the hazard zone was not extended northward enough to include the Site or immediately adjacent areas. Also, as noted above the location of the residence is either just in or out of the 15% to 35% Landslide Hazard Area defined on the Geologically Hazardous Areas map.

5.2. FOREST PRACTICES/LAND USE HISTORY

The following discussions are based on review of vertical, stereographic aerial photographs. The earliest photographs dated back to 1947.

5.2.1. Forest Practices – We did not observe evidence of past timber harvest activity in the area of the debris slide PI. A search of DNR files did not reveal a Forest Practices Application (FPA) for the DNR lands in which the debris slide originated. However, the lack of conifers, and the presence of skid trails, and a thick stand of young maples on the mid- and lower slopes of the Site clearly indicate that harvest activities occurred on the privately owned lands below DNR lands. As noted above, as part of our work we reviewed a sequence of aerial photographs dating from 1947 to 2001. We did not observe timber harvest activities on the DNR lands in or immediately adjacent to the Site for the period of the photographic record reviewed. We did observe evidence for past timber harvest activities on the slopes below DNR lands. On the 1947 aerial photographs, the area in question is obscured by shadows, making it very difficult to discern any hillside features or recent or past harvest activities relevant to that year. Very subdued black and white tones on the photographs make for a faint suggestion that the slopes in question may have been cut by then, but it is not certain. The 1955 aerial photographs clearly show that at the Site the slopes below DNR lands had been cut at least a decade or so before the year of those photographs. The 1955 photographs also show a younger looking narrow swath of apparent harvest activity extending, in part, through the area of the future 2009 slide. The sequence of aerial photographs from 1983 to 1991 showed clearing and minor logging activities in and about the immediate area of the existing residence. In particular the 1991 aerial photography showed timber harvest activities extending up slope from the area of the current 3800 Nelson Road residence and, in large part, in to the area that now includes the debris avalanche. Timber harvesting on DNR-managed lands (the Jack Straw Aerial Timber Sale) did occur as recently as 2004-2005 on hillside areas approximately ¼ mile to the east-southeast of the Site. An earlier sale on then privately owned lands (the Tat sale) dating to 1994-1995 occurred on slopes below the Jack Straw sale.

5.2.2. Land-Use History – Nelson Road is present on the 1947 aerial photographs. Its configuration is essentially the same as today with the 90° turn that then takes the road west to its intersection with Washington State Route 9, about 1¼ miles south of Van Zandt (Figure 1). North of the 90° turn, Nelson Road is characterized by three relatively gentle bends. After the northern most of these bends the road continues straight northward to a "T"-intersection with Potter Road, which extends eastward from Van Zandt. The Site is located east of the central portion of the "bendy" segment. Review of the 1955 photography shows no residential structures, or any other structures, east of Nelson Road from the 90° turn and through the "bendy" segment; however, structures are observed north of the "bendy" segment. In 1955, and likely back to before 1947, land use was apparently solely agricultural, and arguably some timber production along the lower slopes of the Dike.

The lower slopes of the Site have a history of logging roads and residential land use. Logging haul roads were apparently first constructed through the Site prior to 1955, and a landing (or other purpose-like pad) was graded lower down on slopes to the southwest of the future site of the residence in question. Over the years the road system was maintained and modified to varying degrees. Between 1983 and 1987 a structure was built on the lower pad noted above and another pad was graded. By 1995 a road to the area where the existing 3800 Nelson Road residence is located was completed. In addition, the 1995 aerial photographs show there was a mini-complex of structures at and about the lower pad and an access road to that pad. An additional pad had been built to the southwest of the 3800 residence site and a structure placed on that pad. The 2001 aerial photographs show a presumed mobile home located about where the existing new residence is located. The existing residence was built in 2008. We understand that some type of a soil and foundation engineering report was prepared, presumably prior to construction of the existing residence. To date we have not reviewed that report. Review of the County files produced only an untitled map that appears to be related to zoning issues at the Site. (It is our understanding that the development/construction plans have been destroyed.) The map is stamped ZONING APPROVAL and dated March 20, 2007. It shows two existing driveways and level areas. Based on our site observations it appears that the existing residence was not built at the location or in the orientation as shown on the map.

6.0. RECONNAISSANCE OBSERVATIONS

The slides that affected the van den Heuvel property are reported to have occurred around mid-night January 6th (Pers. comm, Doug Hooks, 2009). The following discussion presents salient field observations regarding the debris slide and debris avalanche 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. At the time of our reconnaissance plastic sheeting covered much of the slide deposit.

During our field reconnaissance we observed landslide features and field relationships that suggested to us that perhaps, in actuality, there might have been two episodes of failure: a debris slide at the PI shown on Figure 2 and a debris avalanche (Cruden and Varnes, 1996), on the lower slopes, separated from the debris slide PI, by a row of conifers (Figure 2). The field evidence for this scenario is presented below, followed by a discussion in section 7.0. A reference point in this discussion is the aforementioned row of mature conifers.

6.1. POINT-OF-INITIATION

The debris slide involved a wedge of colluvium perched on a bedrock bench underlain by Chuckanut sandstone (Figure 2). The wedge was perhaps up to about 10-feet thick and may have been up to 100-feet or more long (Figure 2). In this report we refer to this debris slide as the Bench Debris Slide (BDS). The failure surface of the BDS is the bedding surface of a very thick bed of Chuckanut sandstone. The bench exhibits an inclination of about 40° (85%) to the northwest. We observed a small scarp about 1-foot high just behind the 16-foot wide scarp created by the current debris slide failure. About 30-feet up the bench from the current debris slide scar we observed a possible older subdued scarp about 10 feet high. The PI is on DNR-managed lands.

Observations of the area below the row of conifers at the upper area of the Site suggest the presence of a scarp just below the row of conifers that stretches across the slide scar of the recent failure. This scarp is about 30-feet wide and a few feet high. The root systems of the line of conifers are exposed in the scarp.

6.2. DEBRIS SLIDE ROUTE AND DEBRIS AVALANCHE

We observed evidence that the debris from the BDS, as it moved down slope, took two separate routes. One was northwesterly down the length of the bench where the debris encountered a subdued southwest-northeast ridge and was deflected to the west (Figure 4), into the northern portion of the row of conifers and then down slope toward the residence. The debris moved through and around both ends of the row of conifers. The other route was over the cliff face of the rock bench that borders the southwest edge of the PI and into the row of conifers, and then on down slope. Several trees that were clearly from the bench and areas between the bench and the line of conifers, were observed piled up behind the row of conifers, in some cases as though they were "strained" out of the debris-flow material as the debris passed through the line of trees (Figure 5).

Slide debris moved down slope from the row of conifers, and into the area of the debris avalanche (Figure 6). The debris avalanche scar (Figure 2) is essentially linear and from the row of conifers down slope to the upper end of the debris deposit was about 400-feet long, from about 70- up to about 100-feet wide, and varying from 5-to 10-feet deep. In the upper area bedrock crops out sporadically. In the lower portions of the scar only colluvium is exposed. Shallow, eroded channels suggest flowing water in the scar following the failure.

At the bottom of the slope some of the slide debris accumulated as a large deposit of earth materials and organic debris. Other portions of the debris, apparently a more fluid fraction, spread out predominately around the south and east side of the house, down portions of the driveway, and across hillside areas to the south to southwest of the house to areas west and northwest of the house and around other outbuildings. Locally, organic debris does not appear to be intermingled in the more fluid fraction, but overridden by less fluid slide debris.

6.3. OBSERVED IMPACTS

A large pile of slide debris accumulated at the bottom of the slope (Figure 7). As noted above, at the time of our reconnaissance the debris pile was largely covered by plastic sheeting; however we did observe the pile during an earlier site visit before it was covered. This pile was composed of earth and rock debris, and conifers from upper slope areas and maple and alder trees from lower slope areas. As already mentioned the debris pile came to rest just south and southwest of the residence (Figure 8). It was deflected slightly toward the residence by a low ridge that varies from about 150- to about 250-feet southeast of the residence. A portion of the railing of the porch on the south side of the residence was damaged by the slide debris along with steps leading up to the porch (Figure 8). We understand that the propane tank was ripped from the piping that serves the residence. Some slide debris and mud up to several-inches thick flooded the driveway area in front (that portion facing the hillside) of the house and down the driveway some distance (Figures 7 and 9). Mud also was deposited in alcove-like areas along the south side of the residence. The more fluid components of the debris continued to spread across the property down slope of the debris deposit (Figure 10) and toward Nelson Road. The DNR Northwest Region 2009 Storm Tracking Site reports mud reaching Nelson Road and possibly mud in the residence. We could not confirm either of these conditions.

7.0. DISCUSSION

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

1) Did the debris slide and debris avalanche initiate on DNR-managed lands?
2) Were the PIs in an area 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 and debris avalanche initiation?

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

The BDS initiated on DNR-managed lands and about three-quarters of the debris avalanches scar, measured from just below the row of conifers to the top of the debris pile, is also on DNR-managed lands (Figure 2). There is no evidence that there had been forest-management activities on these lands at or near the BDS for at least the last 75 to 100 years, if ever. There were forest-management activities on the slopes of the subject property in perhaps the 1940s (certainly prior to the early 1950s) and again between 1987 and 1991 on the slopes that became involved in the debris avalanche. Because there were no DNR forest-management activities on the slopes in question in either case, it is our opinion that DNR did not contribute to the initiation of the slope failures.

The failure of the slopes above the residence was likely influenced by the physical setting of the Site, possible past slope instability, and ground-water conditions. The triggering event was the January 4th to 8th, 2009 storm. The BDS failure occurred in relatively weak earth materials (colluvial soils) on essentially very steep slopes (the bench), and at a location that may have experienced minor past instability, as suggested by the subdued scarp-like feature noted earlier.

The January 2009 storm followed a several week period of rain, snow, and near freezing to freezing temperatures. A snow pack of up to at least a couple of feet blanketed the PIs prior to arrival of the rains and accompanying winds and warmer temperatures. The PIs are located in the upper portion of the generally accepted rain-dominated zone; however, a classic ROS situation developed anyway. This likely also had an influence on triggering the debris and associated debris flow and debris avalanche.

The area of the Site has experienced at least two similar weather events in 1970/71 and 1971/72 during a record of 34 years (an approximately 9 or 17-year average recurrence interval, depending on assumptions about whether a storm might have occurred in the year just before and the year just after the POR). Review of the aerial photographs show debris slides have occurred in the past on slopes in unmanaged areas just to the north and south of the Site. This coupled with the landforms (bedrock hollows and alluvial fans) noted above indicate that even unmanaged forest lands are subject to periodic episodes of slope instability.

Above we noted the potential for the inclination of the bedrock to impart some directivity of the ground-water flow to the northwest. In the case of the debris slides that impacted the Gantman, Fox, and Knutzen properties to the south we suspect that the potential for the directivity of the bedrock to have had some influence on the direction of ground-water flow and the initiation of debris slides that affected those properties. The debris slide at the Site that is the subject of this reconnaissance developed on a bedrock bench that can be projected southward and up slope into the Tat and Jack Straw Timber Sales. However, at the debris slide site being discussed in this report, we are of the opinion that the potential influence of the directivity of ground water along the bedding toward the debris slide site is likely low. This is because of the distance; almost a quarter of a mile, and that the debris slide in question occurred on the edge of a bench, with little, if any, catchment area directly up the bedding of the location in question. At the specific failure site in the Tat sale, the site was characterized by a relatively large catchment area and evidence for overland flow that delivered water to a location very close to, and up-dip, of the failure observed in that sale.

It is our opinion that the failure history can be explained by two separate events that are likely closely related in space and time. In this scenario the BDS was a separate event from the larger debris avalanche. The BDS occurred in an unmanaged area likely in response to high pore-water pressures, created by the severe storm of January 2009, in the colluvium on the bedrock bench upon which the colluvium has collected there over hundreds of years. The BDS flowed down the bench, around and between the row of conifers. Some of the BDS materials flowed over the rock face of the sandstone cliff below the PI and rejoined the main body of the BDS. This debris continued down slope, through the area cut in the late 1980s, picking up organic debris along with soil and colluvium. This mass of material would have been relatively wet, so that when it reached the bottom of the slope it would have been fluid enough to spread and flow out across the property as observed. This debris slide and debris flow event would have been followed by initiation of the debris avalanche; a likely relatively dryer and relatively slower moving event, or sequence of events. Depending on where it started on the hillside, the debris avalanche would have either retrogressed (Cruden and Varnes, 1996) up the hillslope to the row of conifers or enlarged up and down the slope (Cruden and Varnes, 1996). This is an explanation for the accumulation of the mass of slide debris at the bottom of the slope and why it did not travel any further across the property toward Nelson Road. An alternative explanation would be that the debris avalanche developed as a result of the debris from the BDS passing over the ground surface below the row of conifers and scoured the ground as it passed over that surface. Though this usually happens in fairly confined conditions such as channels, the topography could have been convergent enough for scour of the hillside to occur as the BDS passed over it.

8.0. FURTHER EVALUATIONS

As noted, a wedge of colluvium remains on the rock bench where the earlier debris slide initiated. If this colluvium were to mobilize it would likely follow the same track down the slope toward the existing residence. The residential property owners should have this condition evaluated by a licensed geologist and engineer, and, if deemed necessary, develop appropriate mitigation measures. This action should be undertaken in light of the current discussions regarding the apparent increase in the frequency of extreme rainstorm events (Dulière and others, 2008, and Madsen and Figdor, 2007).

9.0. RECONNAISSANCE LIMITATIONS

This reconnaissance report presents a qualitative assessment of the debris slide and associated debris flow and debris avalanche that impacted the residential property located at 3800 Nelson 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 avalanche 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 stamp or authorized facsimiles of the same.

END

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AERIAL PHOTOGRAPHY REVIEWED

Date	Flight Line/Frames	Approx. Scale	Medium
8/24/47	BBK – 5B – 101 to 103	1;24,000	B/W
8/6/55	BBK – 2P – 124, 126	1:24,000	B/W
8/6/55	BBK – 2P – 167, 168	1:24,000	B/W
7/8/61	F.35 – 18 to 21, 23, 24	1:12,000	B/W
7/8/61	F.35 – 25 to 29	1:12,000	B/W
6/5/70	NW-69 228 49C-24, 27 to 32	1:12,000	B/W
6/5/70	NW-69 228 50B-24, 27 to 32	1:12,000	B/W
7/14/71	NW-H-71 351 – 11B – 13 to 15	1:80,000 (?)	B/W
7/15/76	NW-C 76-25-129, 130 to 132	1:24,000	Color
6-3-78	NW-78 62A-228 to 234	1:12,000	B/W
6-3-78	NW-78 63C-44 to 51	1:12,000	B/W
5/23/83	NW-C-83 13-49 378 to 385	1:12,000	Color
5/23/83	NW-C-83 13-49 417 to 423	1:12,000	Color
6/26/87	NW87 11-50-67 to 73	1:13,400	B/W
8/22/88	NW87 39-51-52 to 58	1:13,600	B/W
7/3/91	NW91 14-49-25 to 26	1:13,000	B/W
5/26/95	NW-95 27-49-127 to 133	1:12,000	B/W
5/26/95	NW-95 30-50-38 to 42	1:12,000	B/W
8/26/01	NW-C-01 13-49- 143 to 145, 147 to 148	1:12,000	Color
8/26/01	NW-C-01 58-50-39 to 41, 43 to 45	1:12,000	Color

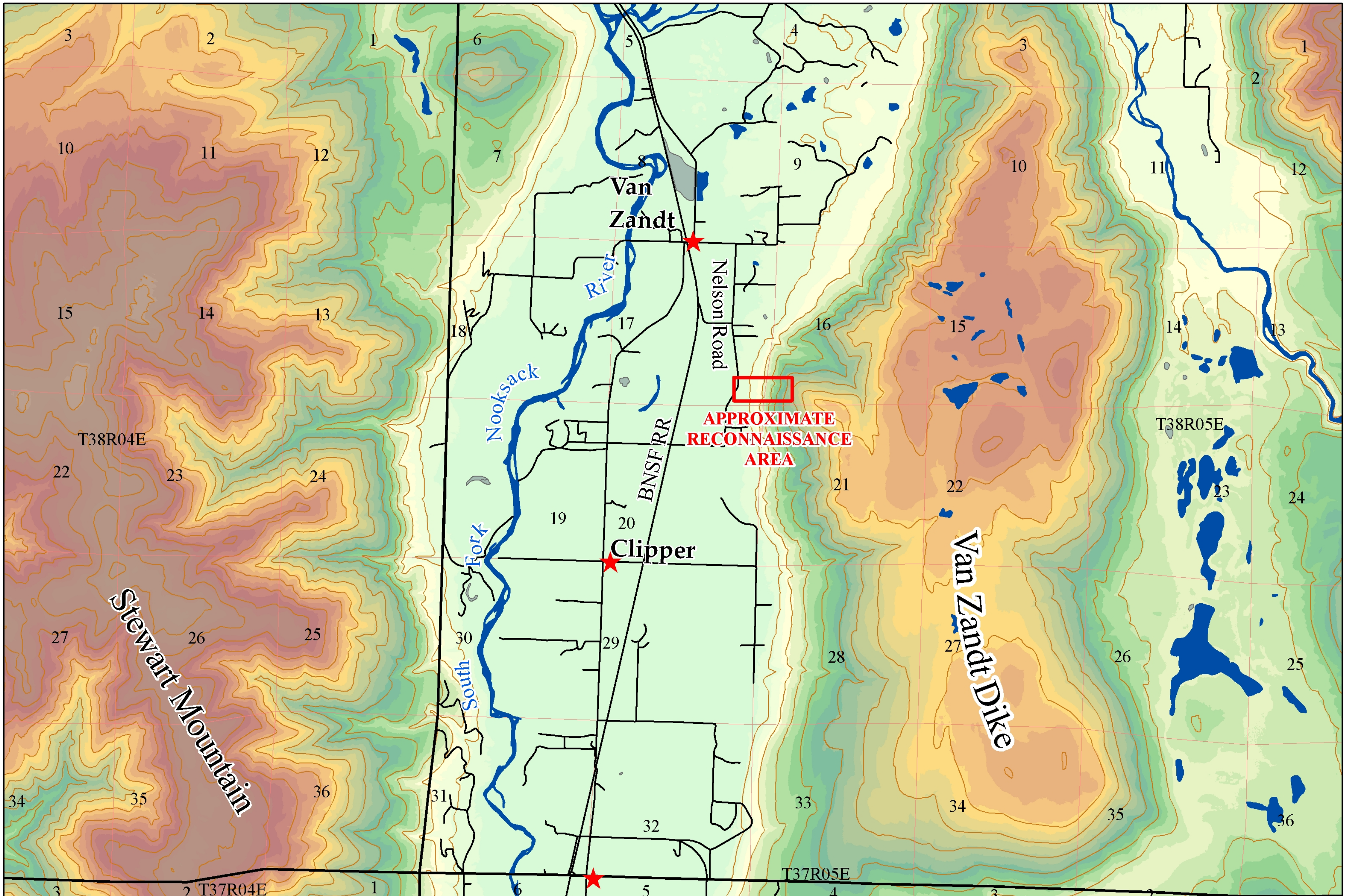
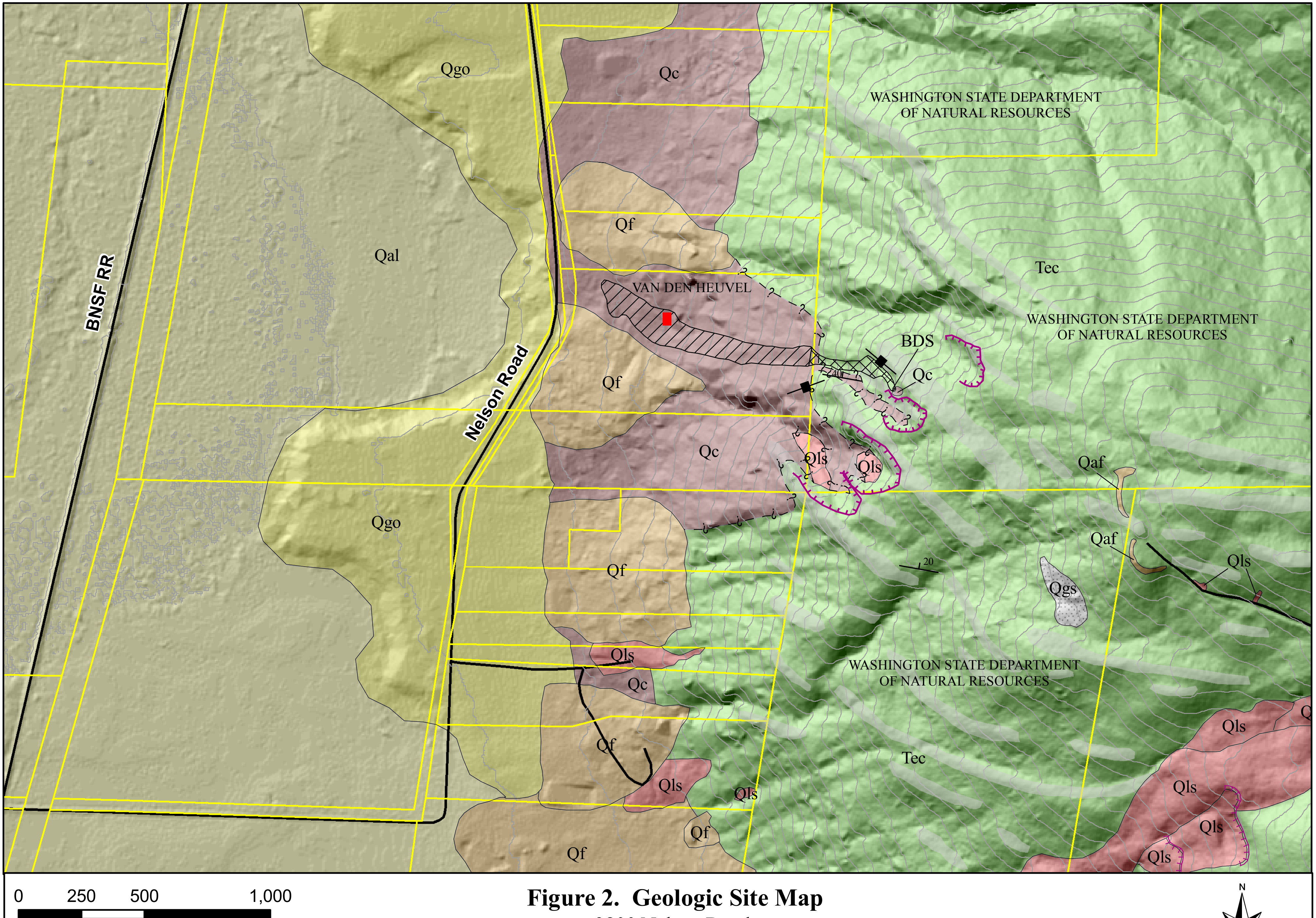


Figure 1. Location Map

Engineering Geologic Field Reconnaissance
3800 Nelson Road
Whatcom County, Washington



Contour Interval = 40 feet

Figure 2. Geologic Site Map

3800 Nelson Road

See Figure 2A for explaination.

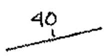
Geology mapped from field observations and interpretation of DNR LiDAR database.

EARTH MATERIALS

Qaf	Artificial fill
Qc	Colluvium, not all deposits shown
Qf	Alluvial fan deposits
Qls	Landslide debris
Qgo	Glacial outwash deposits
Tec	Chuckanut Formation

MAP SYMBOLS

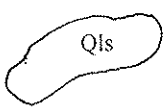

Geologic contact, dotted where concealed, locally approximate, queried where uncertain



Strike and dip of bedding

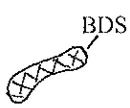

Strike and dip of vertical joints


Bedrock “rib”. See Section 4.1. for discussion

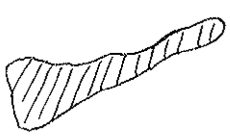


Landslide


Crown of scarp of landslide or bedrock hollow, not all such features shown



Bench Debris Slide (BDS) IP.


Debris avalanche, shows scar and depositional area


Approximate location of van den Heuvel residence

FIGURE 2A. Explanation for Figure 2 Geologic Site Map

Engineering Geologic Field Reconnaissance
3800 Nelson Road
Whatcom County, Washington

Figure 3. Bench debris slide (BDS) point of initiation. View looking southeast. (Photo by Casey Hanell, 2009)

Figure 4. BDS scar from the crown of the scarp showing the direction of movement and direction change to due west. View facing northwest. (Photo by Casey Hanell, 2009)

Figure 5. BDS from the point where it turns due west. View facing west. (Photo by Casey Hanell, 2009)

Figure 6. BDS path and upper portion of debris avalanche scar viewed from the bottom of the hill. View facing east. (Photo by John Coyle, 2009)

Figure 7. Debris avalanche deposit overlying more fluid debris deposited by the BDS. Gray gravelly area exposed by later tractor work. View looking south. (Photo by Doug Hooks, 2009)

Figure 8. Debris piled near the southeast corner of the home. Note broken ballasters in deck railing. View looking west. (Photo by Doug Hooks, 2009)

Figure 9. Lower portion of BDS deposition area illustrating fluid debris from BDS on driveway leading down to Nelson Road . View looking northwest. (Photo by Doug Hooks, 2009)

Figure 10. Lower BDS deposition area illustrating flow of debris around out building below the house. View looking northwest. (Photo by Doug Hooks, 2009)