Section A
MASS WASTING

INTRODUCTION

This module summarizes the methods and results of a mass wasting assessment conducted on the Mendocino Redwood Company, LLC (MRC) ownership in the Elk Creek watershed, the Elk Creek Watershed Analysis Unit (Elk Creek WAU). California Planning Watersheds included in the Elk Creek WAU include portions of the Lower Elk Creek (CL) and Upper Elk Creek (CE). This assessment is part of a watershed analysis initiated by MRC and utilizes modified methodology adapted from procedures outlined in the Standard Methodology for Conducting Watershed Analysis (Version 4.0, Washington Forest Practices Board).

The principle objectives of this assessment are to:

1) Identify the types of mass wasting processes active in the basin.
2) Identify the link between mass wasting and forest management related activities.
3) Identify where the mass wasting processes are concentrated.
4) Partition the ownership into zones of relative mass wasting potential based on the likelihood of future mass wasting and sediment delivery to stream channels.

Additionally, the role of mass wasting sediment input to watercourses is examined. This information combined with the results of the Surface and Fluvial Erosion module is used to construct a sediment input summary for the Elk Creek WAU, contained in the Sediment Input Summary section of this watershed analysis.

The products of this report are: a landslide inventory map (Map A-1), a Terrain Stability Unit (TSU) map (Map A-2), and a mass wasting inventory database (Appendix A). The assembled information will enable forestland managers to make better forest management decisions to reduce management-induced risk of mass wasting. The mass wasting inventory will provide the information necessary to understand the spatial distribution, causal mechanisms, relative size, and timing of mass wasting processes active in the basin with reasonable confidence.

The Role of Mass Wasting in Watershed Dynamics

Mass wasting is a naturally occurring process, but can be accelerated by anthropogenic disturbances. Forest management practices can alter the natural frequency and magnitude of mass wasting events by changing the relative resisting and driving forces acting on a hillslope, altering soil and bedrock pore water pressures, and/or altering the effective cohesion of soil and bedrock. Increases in sediment yield due to mass wasting can disrupt the dynamic equilibrium of stream channels, resulting in a decline in the quality and quantity of amphibian and anadromous fish habitat, water quality, or stream ecology.

Mass wasting events are able to alter stream environments by increasing bed and suspended sediment loads, modifying the grain-size distribution of channel sediment, introducing woody debris, altering channel morphology by aggradation, damming and obstructing the channel, and in extreme cases scouring the channel to bedrock. Stream systems ultimately adjust to major alterations downstream, as well as upstream of individual mass wasting events. However, the consequences may last for a long while.

In the Pacific Northwest where anadromous fish are present, mass wasting can have both beneficial and adverse effects on salmonid habitat. Beneficial effects include formation of new spawning, rearing, and over-wintering habitat due to addition of coarse gravels to the channel.

The introduction of woody debris and boulders from landslides can increase cover and improve pool:riffle ratios. Adverse effects include filling of pools and scouring of riffles, blockage of fish access, disturbing side-channel rearing areas, and siltation of spawning gravels. The magnitude of these effects are dependent on the frequency, location, and intensity of mass wasting events, as well as the sediment transporting capabilities of a particular stream. Beneficial and adverse effects typically occur simultaneously, and the relative relationship between the two will vary, even for individual events. Because of their greater stream powers, larger streams and rivers adjust to mass wasting perturbations faster than smaller streams.

BEDROCK STRUCTURE AND LITHOLOGY IN THE ELK CREEK WAU

The Elk Creek WAU is underlain by bedrock of the Tertiary-Cretaceous Coastal Belt Franciscan, comprised predominately of interbedded sandstone and shale sequences with minor pebble conglomerate and greenstone (Manson, 1984). The Coastal Belt Franciscan is characterized by a relatively chaotic structure with shear zones, folds, and faults often juxtaposed with coherent sections of thin to massive sandstone and shale. Consistent with mass-flow type marine trench and trench-slope deposition, sedimentary structures are typically absent.

Local alluvial deposits are present along the higher order channels within the Elk Creek WAU, and remnant outcrops of relatively cohesionless marine sandstone of the Pliocene Ohlson Ranch Formation are mapped along the ridges in the basin. Remnants of the Ohlson Ranch Formation, and the residual soils that develop on the Ohlson Ranch, have been identified as a unique terrain stability unit based on the relatively high erodibility of the soils when surface water is allowed to concentrate for any significant distance. The Ohlson Ranch deposits are located on the low-gradient ridges in the basin where the likelihood of mass failure is relatively low because slopes are not steep. However, where first order ephemeral watercourses originate in these deposits, and connectivity exists to higher order tributaries, the potential for surface erosion and sediment delivery is relatively high so protections are provided including road run-off and erosion control measures.

The geomorphic expression of Elk Creek suggests structural control as the mainstem and larger tributaries trend consistently northwest-southeast, consistent with many of the larger rivers and creeks draining the Coastal Belt Franciscan. Previous mapping by Manson (1984) identifies an inactive fault with vertical offset trending the valley bottom along the entire length of the mainstem of Elk Creek. The fault is mapped as “inferred”, likely based on the northwest-southeast linear drainage morphology that dominates the drainage. Although subsurface investigation (e.g. trench mapping) was beyond the scope of this report, no evidence of recent movement (e.g. surface rupture) was observed during the field reconnaissance, and the fault is not within an identified fault-rupture hazard zone per the Alquist Priolo fault hazard maps (DMG, 1997).

Based on field reconnaissance, available geologic and hydrologic maps, and published literature, no regional indicators of adverse rock type, structure, or groundwater conditions were identified. Locally, cohesionless deposits of the Ohlson Ranch Formation have been identified as a unique terrain stability unit, acknowledging the erodibility of this particular rock type.

LANDSLIDE TYPES AND PROCESSES IN THE ELK CREEK WAU

Landslide features are widespread over the Elk Creek WAU, owing to the relatively rapid down-cutting of Elk Creek in response to global sea level fluctuations and regional uplift. The terminology used to describe landslides in this report closely follows the definitions of Cruden and Varnes (1996). This terminology is based on two nouns, the first describing the material that the landslide is composed of and the second describing the type of movement. Landslides identified in the Elk Creek WAU were described using the following names: debris slides, debris torrents, debris flows, and rockslides. These names are described in Cruden and Varnes (1996) with the exception of our use of debris torrent.

Shallow-Seated Landslides

Debris slides, debris flows, and debris torrents are terms used throughout Mendocino Redwood Company's ownership to identify shallow-seated landslide processes. The material composition of debris slides, flows, or torrents is considered to be soil with a significant proportion of coarse material; 20 to 80 percent of the particles are larger than 2 mm (Cruden and Varnes, 1996). Shallow-seated slides generally move quickly downslope and commonly break apart during failure. Shallow-seated slides commonly occur in converging topography where colluvial materials accumulate and subsurface drainage concentrates. Susceptibility of a slope to fail by shallow-seated landslides is affected by slope steepness, saturation of soil, soil strength (friction angle and cohesion), and root strength. Due to the shallow depth and fact that debris slides, flows, or torrents involve the soil mantle, these are landslide types that can be significantly influenced by forest practices.

Debris slides are the most common landslide type observed in the WAU. The landslide mass typically fails along a surface of rupture or along relatively thin zones of intense shear strain located near the base of the soil profile. The landslide deposit commonly slides a distance beyond the toe of the surface of rupture and onto the ground surface below the failure; it generally does not slide more than the distance equal to the length of the failure scar. Landslides with deposits that traveled a longer distance below the failure scar would likely be defined as a debris flow or debris torrent. Debris slides commonly occur on steep planar slopes, convergent slopes, along forest roads and on steep slopes adjacent to watercourses. They usually fail by translational movement along an undulating or planar surface of failure. By definition debris slides do not continue downstream upon reaching a watercourse.

A debris flow is similar to a debris slide with the exception that the landslide mass continues to "flow" down the slope below the failure a considerable distance on top of the ground surface. A debris flow is characterized as a mobile, potentially rapid, slurry of soil, rock, vegetation, and water. High water content is needed for this process to occur. Debris flows generally occur on both steep, planar hillslopes and confined, convergent hillslopes. Often a failure will initiate as a debris slide, but will change as its moves downslope to a debris flow.

Debris torrents have the greatest potential to destroy stream habitat and deliver large amounts of sediment. The main characteristic distinguishing a debris torrent is that the mass of failed soil and debris "torrents" downstream in a confined channel and erodes the channel. As the debris torrent moves downslope and scours the channel, the liquefied landslide material increases in mass. Highly saturated soil or run-off in a channel is required for this process to occur. Debris torrents move rapidly and can potentially run down a channel for great distances. They typically initiate in headwall swales and torrent down intermittent watercourses. Often a failure will initiate as a debris slide, but will develop into a debris torrent upon reaching a channel. While actually a combination of two processes, these features were considered debris torrents.

Deep-Seated Landslides

Rockslides and earthflows are terms used throughout Mendocino Redwood Company's ownership to identify deep-seated landslide processes. The failure dates of the deep-seated landslides could not be estimated with any confidence, they are likely to be of varying age with some potentially being over 10,000 years old. Many of the deep-seated landslides are considered "dormant", but the importance of identifying them lies in the fact that if reactivated, they have the potential to deliver large amounts of sediment and impair stream habitat. Accelerated or episodic movement is likely to have occurred over time in response to seismic shaking or high rainfall events.

Rockslides are deep-seated landslides with movement involving a relatively intact mass of rock and overlying earth materials. The failure plane is below the colluvial layer and involves the underlying bedrock. Mode of rock sliding generally is not strictly rotational or translational, but involves some component of each. Rotational slides typically fail along a concave surface, while translational slides typically fail on a planar or undulating surface of rupture. Rockslides commonly create a flat, or back-tilted, bench below the crown of the scarp. A prominent bench is usually preserved over time and can be indicative of a rockslide. Rockslides fail in response to triggering mechanisms such as seismic shaking, adverse local structural geology, high rainfall, offloading or loading material on the slide, or channel incision (Wieczorek, 1996). The stream itself can be the cause of chronic movement, if it periodically undercuts the toe of a rockslide.

Earth flows are deep-seated landslides composed of fine-grained materials and soils derived from clay-bearing rocks. Earth flow materials typically consist of 80% or more of particles smaller than 2mm (Cruden and Varnes, 1996). Materials in an earth flow also commonly contain boulders, some very large, which move down slope in the clay matrix. Failure in earth flows is characterized by spatially differential rates of movement on discontinuous failure surfaces that are not preserved. The "flow" type of movement creates a landslide that can be very irregularly shaped. Some earth flow surfaces are dominantly grassland, while some are partially or completely forested. The areas of grassy vegetation are likely due to the inability of the unstable, clay-rich soils to support forest vegetation. The surface of an earth flow is characteristically hummocky with locally variable slope forms and relatively abundant gullies. The inherently weak materials within earth flows are not able to support steep slopes, therefore slope gradients are low to moderate. The rates of movement vary over time and can be accelerated by persistent high groundwater conditions. Timber harvesting can have the effect of increasing the amount of subsurface water, which can accelerate movement in an earth flow (Swanston et al, 1988).

Use of SHALSTAB by Mendocino Redwood Company for the Elk Creek WAU

MRC uses SHALSTAB—a coupled steady state runoff infinite slope stability model—to assist with the mapping of the hazard potential of shallow-seated landslides (Dietrich and Montgomery, 1998). William Dietrich of the University of California (Berkeley) and David Montgomery of the University of Washington (Seattle) have published a validation study of the SHALSTAB model. Generally, they found that the SHALSTAB model correctly distinguishes areas more prone to shallow landslide instability. In mass wasting studies conducted in seven basins in northern California, they concluded that a log (q/T) threshold of less than -2.8 identifies the portion of the basin within which on average 57% of the shallow landslides mapped from aerial photographs are found. However, they also found that the performance of SHALSTAB depends strongly on the quality of the topographic data. The best readily available topographic data (10-m grid data from digitized USGS 7.5' quad maps) do not represent the fine scale topography that dictates the convergence of subsurface flow and the locations where shallow landslides are likely to occur. In our watershed analysis, we assess mass wasting hazards apart from SHALSTAB as well, using aerial photographs and field reconnaissance. However, we still use SHALSTAB output as one tool to assist with the interpretation of the landscape into terrain stability units.

METHODS

Landslide Inventory

The mass wasting assessment relies on an inventory of mass wasting features collected through the use of aerial photographs and field observations. MRC owned photographs from 2004 (color, 1:12,000), 2000 (color, 1:12,000), 1987 (black-and-white, 1:12,000), 1978 (color, 1:15,840), and 1967 (black and white, 1:15,840) were used, as were 1964 (black-and-white, 1:20,000), and 1947 (black-and-white, 1:20,000) photos on file at the Mendocino County Museum in Willits.

MRC collected data regarding characteristics and measurements of the identified landslides. We acknowledge that some landslides may have been missed, particularly small ones that may be obscured by vegetation. A brief description of select parameters inventoried for each landslide observed in the field and during aerial photograph interpretation is presented in Figure A-1. A detailed discussion of these parameters follows.

Figure A-1. Description of Select Parameters used to Describe Mass Wasting in the Mass Wasting Inventory.

- Slide Identification: Each landslide is assigned a unique identification number, a two letter code (see below) that denotes which planning watershed (PWS) the slide is located, and a number which indicates the USGS designated map section number the slide is mapped in.
  - Planning Watershed Codes:
  - CL – Lower Elk Creek
  - CE – Upper Elk Creek
- TSU # – Terrain Stability Unit in which landslide is located.
- Landslide Type:
  - DS – debris slide
  - DF – debris flow
  - DT – debris torrent
  - RS – rockslide
  - EF – earthflow
- Certainty: The certainty of identification is recorded.
  - D – Definite
  - P – Probable
  - Q – Questionable
- Physical Characteristics: Includes average length, width, depth, and volume of individual slides. Length of torrent, if present, is recorded as a comment.
- Sediment Routing: Denotes the type of stream the sediment was routed into.
  - P – Perennial
  - I – Intermittent or Ephemeral
  - N – no sediment delivered
- Sediment Delivery: Quantification of the relative percentage of the landslide that delivered to the stream.
- Slope: Percent slope angle is recorded for all shallow-seated landslides observed in the field.

- Age: Relative age of the observed slide is estimated.
  - N – new (<5 years old)
  - R – recent (5-10 years old)
  - O – old (>10 years old)
- Slope Form: Denotes morphology of the slope where the landslide originated
  - C – concave
  - D – divergent
  - P – planar
- Slide Location: Interpretation of the location where the landslide originated
  - H – Headwall Swale
  - S – Steep Streamside Slopes
  - I – Inner Gorge
  - N – Neither
- Road Association: Denotes the association of the landslide to land-use practices.
  - R – Road
  - S – Skid Trail
  - L – Landing
  - N – Neither
  - I – Indeterminate
- Contributing Area: Categorical description of the area interpreted to concentrate surface and/or subsurface flow to the point of failure for non-road related slide points.
  - S – Small, <0.5 acres
  - M – Medium, 0.5 – 3.0 acres
  - L – Large, >3.0 acres
- Aspect: Categorical description of the predominant cardinal direction the hillslope is facing for all slide points.
  - NE – Northeast, 0°-89°
  - NW – Northwest, 270°-359°
  - NE – Southeast aspect, 90°-179°
  - NE – Southwest aspect, 180°-269°
- Soil Type: County soil survey is used to attribute a soil type to each slide point. Soil types are grouped into similar grain size distributions based on the Unified Soil Classification System rating provided in the county survey.
  - C – Coarse, soils consisting of gravel-sand-silt mixture (GM-GC, USCS Class.)
  - F – Fine, soils consisting mainly of silt-clay (CL-ML, USCS Class.)
  - M – Mixed, soils with coarse and fine material (GC-CL)
- MRC Structure Class: 24 forest stand classes are used to describe the forest conditions across the MRC timberland. In this assessment this information is used to build a database of forest conditions upslope of recent (2001-2004 time period) non-road related failures. Structure classes are generated by classifying the following stand attributes:
  - Dominant Species
  - Dominant Diameter
  - Canopy Cover (%)
- Deep-seated landslides morphologic descriptions: toe, body, lateral scarps, and main scarp (see section below on Systematic Description of Deep-seated Landslide Features).

Landslides identified in the field and from aerial photograph observations are plotted on a landslide inventory map (Map A-1). All shallow-seated landslides are identified as a point plotted on the map at the interpreted head scarp of the failure. Deep-seated landslides are represented as a polygon representing the interpreted perimeter of the landslide body. Physical and geomorphic characteristics of all inventoried landslides are categorized in a database in Appendix A. Landslide dimensions and depths can be quite variable, therefore length, width, and depth values that are recorded are considered to be the average dimension of that feature. When converting landslide volumes to mass (tons), we assume a soil bulk density of 1.35 grams/cubic centimeter.

The certainty of landslide identification is assessed for each landslide. Three designations are used: definite, probable, and questionable. Definite means the landslide definitely exists. Probable means the landslide probably is there, but there is some doubt in the analyst's interpretation. Questionable means that the interpretation of the landslide identification may be inaccurate; the analyst has the least amount of confidence in the interpretation. Accuracy in identifying landslides on aerial photographs is dependent on the size of the slide, scale of the photographs, thickness of canopy, and logging history. Landslides mapped in areas recently logged or through a thin canopy are identified with the highest level of confidence. Characteristics of the particular aerial photographs used affects confidence in identifying landslides. For example, sun angle creates shadows which may obscure landslides, the print quality of some photo sets varies, and photographs taken at small scale makes identifying small landslides difficult. The landslide inventory results are considered a minimum estimate of sediment production. This is because landslides that were too small to identify on aerial photographs may have been missed, landslide surfaces could have reactivated in subsequent years and not been quantified, and secondary erosion by rills and gullies on slide surfaces is difficult to assess.

The technique employed to extrapolate a sediment volume delivery percentage to landslides not visited in the field relied on an average of those that were visited in the field. While this averaging technique is an oversimplification of actual on the ground sediment delivery measurements, it provides a means for estimating sediment delivery from the slides not visited in the field.

Landslides were classified based on the likelihood that a road associated land use practice was associated with the landslide. In this analysis, the effects of silvicultural techniques were not observed. The Elk Creek WAU has been managed, recently and historically, for timber production. Therefore, it was determined that the effect of silvicultural practices was too difficult to confidently assign to landslides. There have been too many different silvicultural activities over time for reasonable confidence in a landslide evaluation based on silviculture. The land use practices that were assigned to landslides were associations with roads, skid trails, or landings. It was assumed that a landslide adjacent to a road, skid trail, or landing was triggered either directly or indirectly by that land use practice. If a landslide appeared to be influenced by more than one land use practice, the more causative one was noted. If a cutslope failure did not cross the road prism, it was assumed that the failure would remain perched on the road, landing, or skid trail and would not deliver to a watercourse. Some surface erosion could result from a cutslope failure and is assumed to be addressed in the road surface erosion estimates (Surface and Fluvial Erosion Module).

Sediment Input from Shallow-Seated Landslides

The overall time period used for mass wasting interpretation and sediment budget analysis is sixty-seven years. Sediment input to stream channels by mass wasting is quantified for seven time periods (1938-1947, 1948-1964, 1965-1967, 1968-1978, 1979-1987, 1988-2000, 2001-2004). The evaluation assumes that approximately the last 10 years of mass wasting can be observed in the aerial photograph. This is due to landslide surfaces revegetating quickly, making small mass wasting features older than about 10 years difficult to see. We acknowledge that we have likely missed an unknown quantity of small mass wasting events during the aerial photograph interpretation. However, we assume we have captured the majority of the larger mass wasting events in this analysis.

Sediment delivery estimates from mapped shallow-seated landslides were used to produce the total mass wasting sediment input. In order to extrapolate depth to the shallow-seated landslides not visited in the field, an average was taken from the measured depths of landslides visited in the field. Field measurements revealed a similar distribution of depths for management associated (which includes roads, skid trails, and landings), and non-management associated shallow-seated landslides. Therefore, the shallow-seated landslides not verified in the field were assigned the average depth from field verified landslides. In order to extrapolate sediment delivery percentage to landslides not verified in the field, an average was taken from the estimated delivery percentage of field verified landslides.

Delivery statistics were not calculated for deep-seated landslides, however, some of the sediment delivery from shallow-seated landslides is the result of conditions created by deep-seated landslides. For example, a deep-seated failure could result in a debris slide or torrent, which could deliver sediment. Furthermore, over-steepened scarps or toes of deep-seated landslides may have shallow failures associated with them. These types of sediment delivery from shallow-seated landslides associated with deep-seated landslides are accounted for in the delivery estimates.

Sediment Input from Deep-Seated Landslides

Large, active, deep-seated landslides can potentially deliver large volumes of sediment. Delivery generally occurs over long time periods compared to shallow-seated landslides, with movement delivering earth materials into the channel, resulting in an increased sediment load downstream of the failure. Actual delivery can occur by over-steepening of the toe of the slide and subsequent failure into the creek, or by the slide pushing out into the creek. It is very important not to confuse normal stream bank erosion at the toe of a slide as an indicator of movement of that slide. Before making such a connection, the slide surface should be carefully explored for evidence of significant movement, such as wide ground cracks. Sediment delivery could also occur in a catastrophic manner. In such a situation, large portions of the landslide essentially fail and move into the watercourse “instantaneously”. These types of deep-seated failures are relatively rare on MRC property and usually occur in response to unusual storm events or seismic ground shaking.

Movement of deep-seated landslides has definitely resulted in some sediment delivery in the Elk Creek WAU. Quantification of the sediment delivery from deep-seated landslides was not determined in this watershed analysis. Factors such as rate of movement, or depth to the slide plane, are difficult to determine without subsurface geotechnical investigations that were not conducted in this analysis. Sediment delivery to watercourses from deep-seated landslides (landslides typically ≥10 feet thick) can occur by several processes. Such processes can include surface erosion and shallow-or deep-seated movement of a portion or all of the deep-seated landslide deposit.

The ground surface of a deep-seated landslide, like any other hillside surface, is subject to surface erosion processes such as rain drop impact, sheet wash (overland flow), and gully/rill erosion. Under these conditions the sediment delivery from surficial processes is assumed the same as adjacent hillside slopes not underlain by landslide deposits. The materials within the landslide are disturbed and can be arguably somewhat weaker. However, once a soil has developed, the fact that the slope is underlain by a deep-seated landslide should make little difference regarding sediment delivery generated by erosional processes that act at the ground surface. Although fresh, unprotected surfaces that develop in response to recent or active movement could become a source of sediment until the bare surface becomes covered with leaf litter, re-vegetated, or soils developed.

Clearly, movement of a portion or all of a deep-seated landslide can result in delivery of sediment to a watercourse. This determination is made by exploring for any evidence of movement. However, movement would need to be on slopes immediately adjacent to or in close proximity to a watercourse and of sufficient magnitude to push the toe of the slide into the watercourse. A deep-seated slide that toes out on a slope far from a creek or moves only a short distance downslope will generally deliver little to a watercourse. It is also important to realize that often only a portion of a deep-seated slide may become active, though the portion could be quite variable in size. Ground cracking at the head of a large, deep-seated landslide does not necessarily equate to immediate sediment delivery at the toe of the landslide. Movement of large deep-seated landslides can create void spaces within the slide mass. Though movement can be clearly indicated by the ground cracks, many times the toe may not respond or show indications of movement until some of the void space is "closed up". This would be particularly true in the case of very large deep-seated landslides that exhibit ground cracks that are only a few inches to a couple of feet wide. Compared to the entire length of the slide, the amount of movement implied by the ground crack could be very small. This combined with the closing up or "bulking up" of the slide, would not generate much movement, if any, at the toe of the slide. Significant movement, represented by large wide ground cracks, would need to occur to result in significant movement and sediment delivery at the toe of the slide.

Systematic Description of Deep-seated Landslide Features

The characteristics of deep-seated landslides received less attention in the landslide inventory than shallow-seated landslides mainly due to the fact that subsurface analyses would have to be conducted to estimate attributes such as depth, volume, failure date, current activity, and sediment delivery. Subsurface investigation was beyond the scope of this report. Few of the mapped deep-seated landslides were observed to have recent movement associated with them, mainly due to oversteepening of the slope at the toe or scarp. Further assessment of deep-seated landslides will occur on a site-by-site basis in the Elk Creek WAU, likely during timber harvest plan preparation and review.

Deep-seated landslides were mainly interpreted by reconnaissance techniques (aerial photograph interpretation complemented by limited field observations). Reconnaissance mapping criteria consist of observations of four morphologic features of deep seated landslides – toe, internal morphology, lateral flanks, main scarp, and vegetation (after McCalpin 1984 as presented by Keaton and DeGraff, 1996, p. 186, Table 9-1). The mapping and classification criteria for each feature are presented in detail below.

Aerial photo interpretation of deep seated landslide features in the Elk Creek WAU suggests that the first three morphologic features above are the most useful for inferring the presence of deep-seated landslides. The presence of tension cracks and/or sharply defined and topographically offset scarps are probably a more accurate indicator of recent or active landslide movement. These features, however, are rarely visible on aerial photos.

Sets of five descriptions have been developed to classify each deep-seated landslide morphologic feature or vegetation influence. The five descriptions are ranked in descending order from characteristics more typical of active landslides to dormant to relict landslides. One description should characterize the feature most accurately. Nevertheless, some overlap between classifications is neither unusual nor unexpected. We recognize that some deep-seated landslides may lack evidence with respect to one or more of the observable features, but show strong evidence of another feature. If there is no expression of a particular geomorphic feature (e.g. lateral flanks), the classification of that feature is considered "undetermined". If a deep-seated landslide is associated with other deep-seated landslides, it may also be classified as a landslide complex.

In addition to the classification criteria specific to the deep-seated landslide features, more general classification of the strength of the interpretation of the deep-seated landslide is conducted. Some landslides are obscured by vegetation to varying degrees, with areas that are clearly visible and areas that are poorly visible. In addition, weathering and erosion processes may also obscure geomorphic features over time. The quality of different aerial photograph sets varies and can sometimes make interpretations difficult. Owing to these circumstances, each inferred deep-seated landslide feature is classified according to the strength of the evidence as definite, probable or questionable as defined with respect to interpretation of shallow landslides.

At the project scale (THP development and planning), field observations of deep-seated landslide morphology and other indicators by qualified professionals are expected to be used to reduce uncertainty of interpretation inherent in reconnaissance mapping. Field criteria for mapping deep-seated landslides and assessment of activity are presented elsewhere.

Deep Seated Landslide Morphologic Classification Criteria:

I. Toe Activity

1. Steep streamside slopes with extensive unvegetated to sparsely vegetated debris slide scars. Debris slides occur on both sides of stream channel, but more prominently on side containing the deep-seated landslide. Stream channel in toe region may contain coarser sediment than adjacent channel. Stream channel may be pushed out by toe. Toe may be eroding, sharp topography/geomorphology.
2. Steep streamside slopes with few unvegetated to sparsely vegetated debris slide scars. Debris slides generally are distinguishable only on streamside slope containing the deep-seated landslide. Stream channel may be pushed out by toe. Sharp edges becoming subdued.
3. Steep streamside slopes that are predominantly vegetated with little to no debris slide activity. Topography/geomorphology subdued.
4. Gently sloping stream banks that are vegetated and lack debris slide activity. Topography/geomorphology very subdued.
5. Undetermined

II. Internal Morphology

1. Multiple, well defined scarps and associated angular benches. Some benches may be rotated against scarps so that their surfaces slope back into the hill causing ponded water, which can be identified by different vegetation than adjacent areas. Hummocky topography with ground cracks. Jack-strawed trees may be present. No drainage to chaotic drainage/disrupted drainage.
2. Hummocky topography with identifiable scarps and benches, but those features have been smoothed. Undrained to drained but somewhat subdued depressions may exist. Poorly established drainage.
3. Slight benches can be identified, but are subtle and not prominent. Undrained depressions have since been drained. Moderately developed drainage to established drainage but not strongly incised. Subdued depressions but are being filled.
4. Smooth topography. Body of slide typically appears to have failed as one large coherent mass, rather than broken and fragmented. Developed drainage well established, incised. Essentially only large undrained depressions preserved and would be very subdued. Could have standing water. May appear as amphitheater slope where slide deposit is mostly or all removed.
5. Undetermined

III. Lateral Flanks

1. Sharp, well defined. Debris slides on lateral scarps fail onto body of slide. Gullies/drainage may begin to form at boundary between lateral scarps and sides of slide deposit. Bare spots are common or partially unvegetated.
2. Sharp to somewhat subdued, rounded, essentially continuous, might have small breaks; gullies/drainage may be developing down lateral edges of slide body. May have debris slide activity, but less prominent. Few bare spots.
3. Smooth, subdued, but can be discontinuous and vegetated. Drainage may begin to develop along boundary between lateral scarp and slide body. Tributaries to drainage extend onto body of slide.
4. Subtle, well subdued to indistinguishable, discontinuous. Vegetation is identical to adjacent areas. Watercourses could be well incised, may have developed along boundary between lateral scarp and slide body. Tributaries to drainage developed on slide body.
5. Undetermined

IV. Main Scarp

1. Sharp, continuous geomorphic expression, usually arcuate break in slope with bare spots to unvegetated; often has debris slide activity.
2. Distinct, essentially continuous break in slope that may be smooth to slightly subdued in parts and sharp in others, apparent lack of debris slide activity. Bare spots may exist, but are few.
3. Smooth, subdued, less distinct break in slope with generally similar vegetation relative to adjacent areas. Bare spots are essentially non-existent.
4. Very subtle to subdued, well vegetated, can be discontinuous and deeply incised, dissected; feature may be indistinct.
5. Undetermined

V. Vegetation

1. Less dense vegetation than adjacent areas. Recent slide scarps and deposits leave many bare areas. Bare areas also due to lack of vegetative ability to root in unstable soils. Open canopy, may have jack-strawed trees; can have large openings.
2. Bare areas exist with some regrowth. Regrowth or successional patterns related to scarps and deposits. May have some openings in canopy or young broad-leaf vegetation with similar age.
3. Subtle differences from surrounding areas. Slightly less dense and different type vegetation. Essentially closed canopy; may have moderately aged to old trees.
4. Same size, type, and density as surrounding areas.
5. Undetermined

Terrain Stability Units

Terrain Stability Units (TSUs) are delineated by partitioning the landscape into zones characterized by similar geomorphic attributes, shallow-seated landslide potential, and sediment delivery to stream channels. A combination of aerial photograph interpretation, field investigation, and SHALSTAB output were utilized to delineate TSUs. The TSU designations for the Elk Creek WAU are only meant to be general characterizations of similar geomorphic and terrain characteristics related to shallow seated landslides. Deep-seated landslides are also shown on the TSU map (Map A-2). The deep-seated landslides have been included to provide land managers with supplemental information to guide evaluation of harvest planning and subsequent needs for geologic review. The landscape and geomorphic setting in the Elk Creek WAU is certainly more complex than generalized TSUs delineated for this evaluation. The TSUs are only meant to be a starting point for gauging the need for site-specific field assessments.

The delineation of each TSU described is based on landforms present, the mass wasting processes, sensitivity to forest practices, mass wasting hazard, delivery potential, and forest management related trigger mechanisms for shallow seated landslides. The landform section of the TSU description defines the terrain found within the TSU. The mass wasting process section is a summary of landslide types found in the TSU. Sensitivity to forest practice and mass wasting hazard is, in part, a subjective call by the analyst based on the relative landslide hazard and influence of forest practices. Delivery potential is based on proximity of TSU to watercourses and the likelihood of mass wasting in the unit to reach a watercourse. The hazard potential is based on a combination of the mass wasting hazard and delivery potential (Table A-1). The trigger mechanisms are a list of forest management practices that may have the potential to create mass wasting in the TSU.

Table A-1. Ratings for Potential Hazard of Delivery of Debris and Sediment to Streams by Mass Wasting (L= low hazard, M= moderate hazard, H = high hazard)(from Version 4.0, Washington Forest Practices Board, 1995).

		Mass Wasting Potential		
		Low	Moderate	High
Delivery Potential	Low	**L**	**L**	**M**
	Moderate	**L**	**M**	**H**
	High	**L**	**M**	**H**

RESULTS

Mass Wasting Inventory

A Landslide Inventory Data Sheet (Appendix A) was used to record attributes associated with each landslide. The spatial distribution and location of landslides is shown on Map A-1.

A total of 399 shallow-seated landslides (debris slides, torrents, or flows) were identified and characterized in the Elk Creek WAU. A total of 68 deep-seated landslides (rockslides and earthflows) were mapped in the Elk Creek WAU. A considerable effort was made to field verify as many landslides as possible to insure greater confidence in the results. Approximately 27% (106/399) of the identified shallow-seated landslides were field verified. From this level of field observations, extrapolation of landslide depth and sediment delivery is assumed to be performed with a reasonable level of confidence.

The temporal distribution of the 399 shallow-seated landslides observed in the Elk Creek WAU is listed in Table A-2. The distribution by landslide type is shown in Table A-3.

Table A-2. Shallow-Seated Landslide Summary for Elk Creek WAU by Time Periods.

Planning Watershed	1938 - 1947	1948 - 1964	1965 - 1967	1968 - 1978	1979 - 1987	1988 - 2000	2001 - 2004
Lower Elk Creek	8	5	53	35	48	19	5
Upper Elk Creek	18	19	56	56	48	19	10
Elk Creek WAU	26	24	109	91	96	38	15

Table A-3. Landslide Summary by Type and Planning Watershed for Elk Creek WAU.

Planning Watershed	Debris Slides	Debris Flows	Debris Torrents	Rock-slides	Earth-flows	Total	Road[a] Assoc.
Lower Elk Creek	161	9	3	29	1	203	130
Upper Elk Creek	198	25	3	30	8	264	107
Elk Creek WAU	359	34	6	59	9	467	237

a – Includes roads, skid trails, and landings

The majority of the landslides observed in the Elk Creek WAU are debris slides. Of the 399 shallow-seated landslides in the Elk Creek WAU, 237 are determined to be road associated (includes roads, skid trails, or landings). This is approximately 60% of the total number of shallow-seated landslides. There were 40 debris torrents and flows observed in the Elk Creek WAU. This is approximately 10% of the total shallow-seated landslides observed in the Elk Creek WAU.

Of the 46 field observed shallow-seated landslides across the MRC Ownership in Lower Elk Creek, 91% (42/46) were initiated on slopes of 70% gradient or higher (Chart A-1). Of the 60 field observed shallow-seated landslides across the MRC Ownership in Upper Elk Creek, 85% (51/60) were initiated on slopes of 70% gradient or higher (Chart A-2). Of the 106 field observed shallow-seated landslides across the Elk Creek WAU, 88% (93/106) were initiated on slopes of 70% gradient or higher (Chart A-3).

Chart A-1. Slope Gradient Histogram for Shallow-Seated Landslides Occurring on MRC Ownership in Lower Elk Creek.

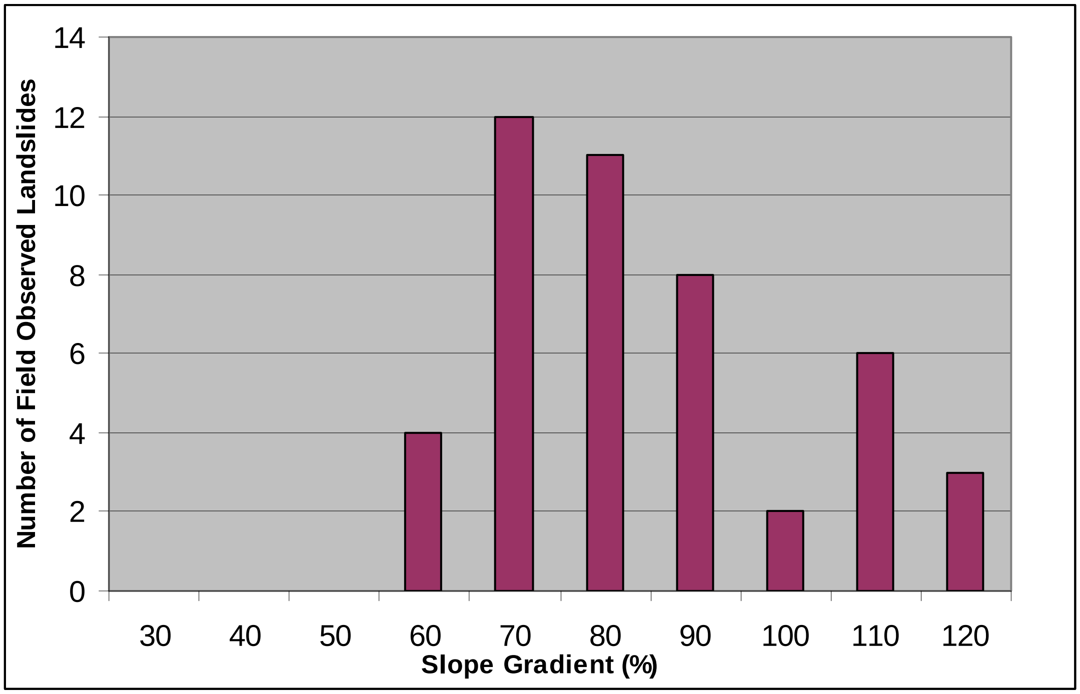


Chart A-2. Slope Gradient Histogram for Shallow-Seated Landslides Occurring on MRC Ownership in Lower Elk Creek.

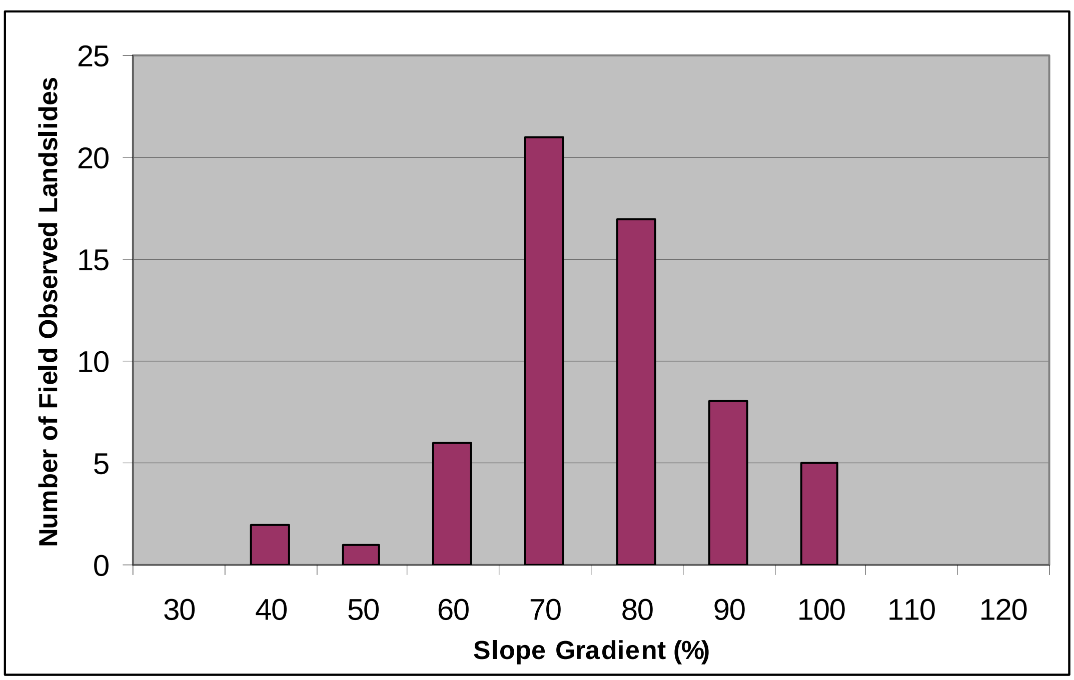
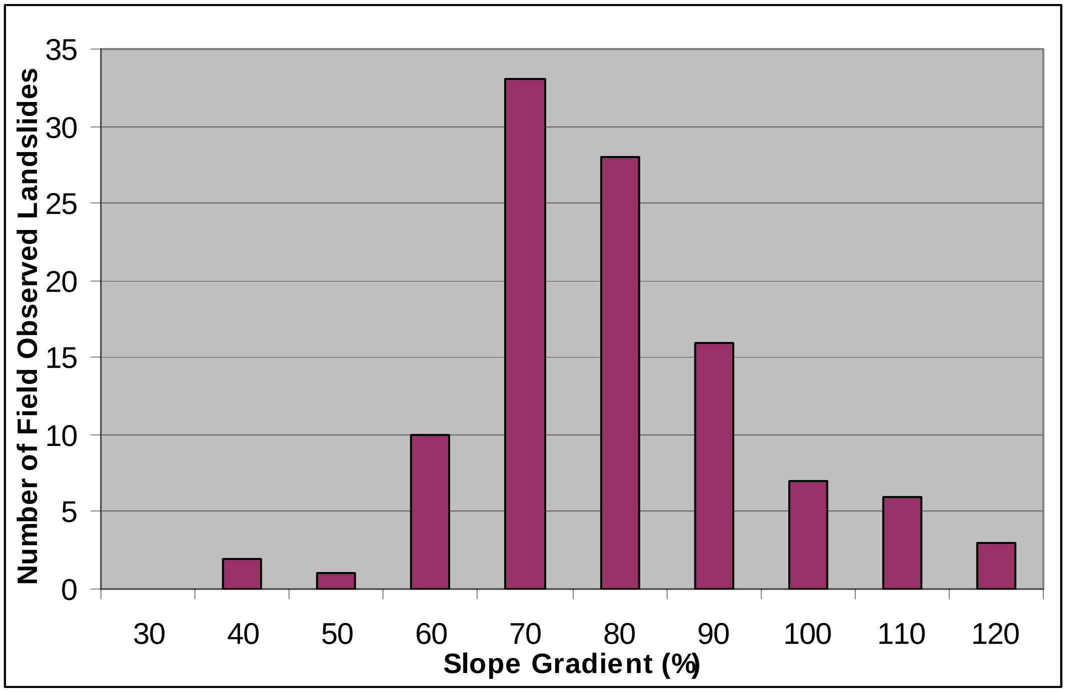
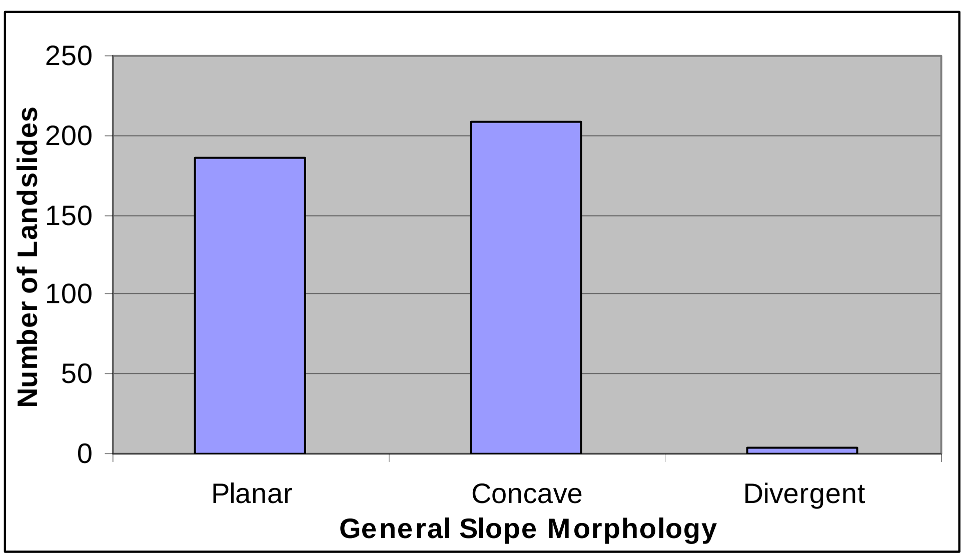


Chart A-3. Slope Gradient Histogram for Shallow-Seated Landslides Occurring on MRC Ownership in the Elk Creek WAU.



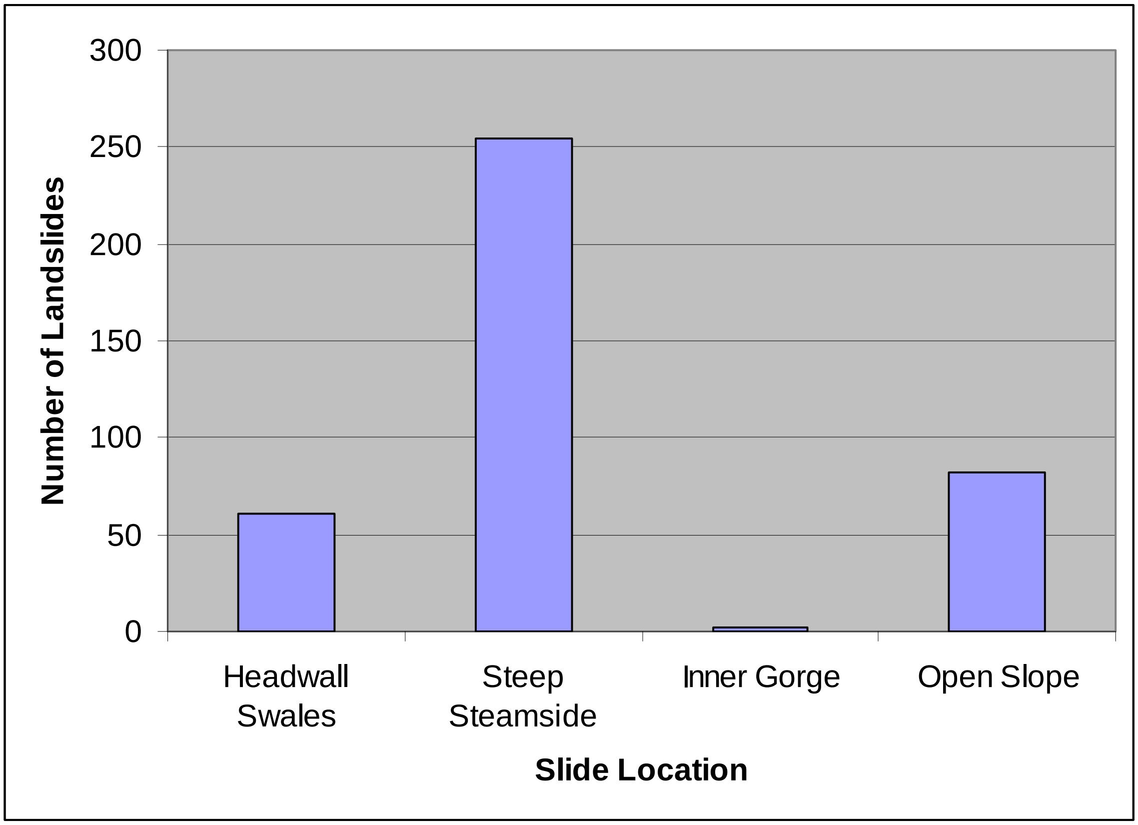
The majority of inventoried landslides originated in convergent topography (209/399, or 52%) where subsurface water tends to concentrate, or on steep, planar topography (186/399, or 47%), where sub-surface water can be concentrated at the base of slopes, in localized topographic depressions, or by local geologic structure. Few landslides originated in divergent topography (4/399, or 1%), where subsurface water is typically routed to the sides of ridges (Chart A-4).

Chart A-4. Slope Morphology Summary for Shallow-Seated Landslides Occurring on MRC Ownership in the Elk Creek WAU.



A majority of the inventoried landslides were discovered along steep streamside slopes (254/399, or 64%), with fewer found in headwall swales (61/399, or 15%) and inner gorge slopes (2/399, or 1%) observed along the outside edge of meander bends. A significant portion (82/399, or 21%) of the inventoried landslides were observed on open slopes away from any inner gorge, steep streamside slopes, or headwall swales, however, a majority of these slides originated in fill material along the outside edge of roads and skid trails (Chart A-5). Such observations were, in part, the basis for the delineation of the WAU into Terrain Stability Units.

Chart A-5. Slide Location Summary for Shallow-Seated Landslides Occurring on MRC Ownership in the Elk Creek WAU.



Terrain Stability Units

The landscape was partitioned into seven Terrain Stability Units representing general areas of similar geomorphology, landslide processes, and sediment delivery potential for shallow-seated landslides (Map A-2). The units are to be used by forest managers to assist in making decisions that will minimize future mass wasting sediment input to watercourses. The delineation for the TSUs was based on qualitative observations and interpretations from aerial photographs, field evaluation, and SHALSTAB output. Deep-seated landslides are also shown on the TSU map (Map A-2). The deep-seated landslides have been included to provide land managers with supplemental information to guide evaluation of harvest planning and subsequent needs for geologic review.

Shallow-seated landslide characteristics considered in determination of map units are size, frequency, delivery to watercourses, and spatial distribution. Hillslope characteristics considered are slope form (convergence, divergence, planar), slope gradient, relative magnitude of stream incision, and overall geomorphology. The range of slope gradients was determined from USGS 1:24,000 topographic maps and field observations. Hillslope and landslide morphology vary within each individual TSU and the boundaries are not exact. This evaluation is not intended to be a substitute for site-specific field assessments. Site-specific field assessments will still be required in TSUs and at deep-seated landslides or specific areas of some TSUs to assess the risk and likelihood of mass wasting impacts from a proposed management action. The TSUs are compiled on the entitled Terrain Stability Unit Map (Map A-2).

TSU Number:	1
Description:	Inner Gorge or Steep Streamside Slopes adjacent to Low Gradient Watercourses
Materials:	Shallow soils formed on weathered marine sedimentary rocks. Maybe composed of toe sediment of deep-seated landslide deposit.
Landform:	Characterized by steep streamside slopes or inner gorge topography along low gradient watercourses (typically less than 6-7%). An inner gorge is a geomorphic feature created from down cutting of the stream, generally in response to tectonic uplift. Inner gorge slopes extend from either one or both sides of the stream channel to the first break in slope. Inner gorge slope gradients typically exceed 70%, although slopes with lower inclination are locally present. Inner gorge slopes commonly contain areas of multiple, coalescing shallow seated landslide scars of varying age. Steep streamside slopes are characterized by their lack of a prominent break in slope. Slopes are generally planar in form with slope gradients typically exceeding 70%. The upper extent of TSU 1 is variable. Where there is not a break in slope, the unit may extend 300 feet upslope (based on the range of lengths of landslides observed, 20-300 feet). Landslides in this unit generally deposit sediment directly into Class I and II streams. Small areas of incised terraces may be locally present.
Slope:	Typically >70 %, (mean slope of observed mass wasting events is 88%, range is 60%-120%)
Total Area:	917 acres; 7% of the total WAU area.
MW Processes:	74 *road-associated landslides* • 74 Debris slides • 0 Debris flows • 0 Debris torrents 47 *non-road associated landslides* • 45 Debris slides • 2 Debris flows • 0 Debris torrents
Non Road-related Landslide Density:	0.05 landslides per acre for the past 67 years.
Forest Practices Sensitivity:	High sensitivity to road construction due to proximity to watercourses, high sensitivity to harvesting and forest management practices due to steep slopes with localized colluvial or alluvial soil deposits adjacent to watercourses.
Mass Wasting Potential:	High localized potential for landslides in both unmanaged and managed conditions.

Delivery Potential: High

Delivery Criteria Used: Steep slopes adjacent to stream channels, a majority of the observed landslides delivered sediment into streams.

Hazard-Potential Rating: **High**

Forest Management Related Trigger Mechanisms:

- Sidecast fill material placed on steep slopes can initiate debris slides or flows in this unit.
- Concentrated drainage from roads onto unstable areas can initiate debris slides or flows in this unit.
- Poorly sized culvert or excessive debris at watercourse crossings can initiate failure of the fill material creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Sidecast fill material created from skid trail construction placed on steep slopes can initiate debris slides or flows in this unit.
- Concentrated drainage from skid trails onto unstable areas can initiate debris slides or flows in this unit.
- Cut-slope of skid trails can remove support of slope creating debris slides, torrents or flows in this unit.
- Cut-slope of skid trails can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Concentrated drainage from roads can increase groundwater, accelerating movement of rockslides or earth flows and over-steepening TSU 1 slopes.
- Removal of vegetation from these slopes can result in loss of evapotranspiration and thus increase pore water pressures that could initiate slope failure in this unit.
- Post timber harvest root decay of hardwood or non-redwood conifer species can be a contributing factor in the initiation of debris slides, torrents or flows in this unit.

Confidence: High confidence for susceptibility of landslides and sediment delivery in this unit. Moderate confidence in placement of the unit boundary. This unit is locally variable and exact boundaries are best determined during field observations. Within this unit there are likely areas of low gradient slopes that are less susceptible to mass wasting.

TSU Number: 2

Description: Inner gorge or Steep Streamside Slopes adjacent to high gradient intermittent or ephemeral watercourses.

Materials: Shallow soils formed from weathered marine sedimentary rocks with localized areas of thin to thick colluvial deposits.

Landforms: Characterized by steep streamside slopes or inner gorge topography along low gradient watercourses (typically greater than 6-7%). An inner gorge is a geomorphic feature created from down cutting of the stream, generally in response to tectonic uplift. Inner gorge slopes extend from either one or both sides of the stream channel to the first break in slope. Inner gorge slope gradients typically exceed 70%, although slopes with lower inclination are locally present. Inner gorge slopes commonly contain areas of multiple, coalescing shallow seated landslide scars of varying age. Steep streamside slopes are characterized by their lack of a prominent break in slope. Slopes are generally planar in form with slope gradients typically exceeding 70%. The upper extent of TSU 2 is variable. Where there is not a break in slope, the unit may extend 300 feet upslope (based on the range of lengths of landslides observed, 25-300 feet). Landslides in this unit generally deposit sediment directly into Class I and II streams.

Slope: Typically >70% (mean slope of observed mass wasting events is 80%, range is 60%-100%).

Total Area: 1654 acres; 12% of total WAU area

MW Processes: 98 *road-associated landslides*

- 92 Debris slides
- 4 Debris flows
- 2 Debris torrents

48 *non-road associated landslides*

- 44 Debris slides
- 3 Debris flows
- 1 Debris torrent

Non Road-related Landslide Density: 0.03 landslides per acre for the past 67 years.

Forest Practices Sensitivity: High sensitivity to roads due to steep slopes adjacent to watercourses, high to moderate sensitivity to harvesting and forest management due to steep slopes next to watercourses. Localized areas of steeper and/or convergent slopes may have an even higher sensitivity to forest practices.

Mass Wasting Potential: High in both unmanaged and managed conditions due to the steep morphology of the slope.

Delivery Potential: High

Delivery Criteria Used: Steep slopes adjacent to stream channels, a majority of the observed landslides delivered sediment into streams.

Hazard-Potential Rating: **High**

Forest Management Related Trigger Mechanisms:

- Sidecast fill material placed on steep slopes can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads onto unstable areas can initiate debris slides, torrents or flows in this unit.
- Poorly sized culvert or excessive debris at watercourse crossings can initiate failure of the fill material creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Sidecast fill material created from skid trail construction placed on steep slopes can initiate debris slides, torrents or flows.
- Concentrated drainage from skid trails onto unstable areas can initiate debris slides, torrents or flows.
- Cut-slope of skid trails can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of skid trails can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Removal of vegetation from these slopes can result in loss of evapotranspiration and thus increase pore water pressures that could initiate slope failure in this unit.
- Post timber harvest root decay of hardwood or non-redwood conifer species can be a contributing factor in the initiation of debris slides, torrents or flows in this unit.

Confidence: High confidence for susceptibility of unit to landslides and sediment delivery. Moderate confidence in the placement of this unit. This unit is highly localized and exact boundaries are better determined from field observations. Within this unit there are likely areas of low gradient slopes that are less susceptible to mass wasting.

TSU Number: 3

Description: Dissected and convergent topography

Materials: Shallow soils formed from weathered marine sedimentary rocks with localized thin to thick colluvial deposits.

Landforms: These areas have steep slopes (typically greater than 65%) that have been sculpted over geologic time by repeated debris slide events. The area is characterized primarily by 1) steep convergent and dissected topography located within steep gradient collivial hollows or headwall swales and small high gradient watercourses, and 2) locally steep planar slopes where there is strong evidence of past landsliding. MRC intends this unit to represent areas with a high hazard potential for shallow landsliding, while not constituting a continuous streamside unit (otherwise it would classify as TSU 1 or 2). The mapped unit may represent isolated individual “high hazard” areas or areas where there is a concentration of “high hazard” areas. Boundaries between higher hazard areas and other more stable areas (i.e. divergent and lower gradient slopes) within the unit should be keyed out as necessary based on field observation of landslide features.

Slope: Typically >70%, (mean slope of observed mass wasting events is 78%, range is 60%-100%)

Total Area: 541 ac., 4% of the total WAU

MW Processes: 21 *road associated landslides*

- 19 Debris slides
- 2 Debris flows
- 0 Debris torrents

33 *non-road associated landslides*

- 25 Debris slides
- 8 Debris flows
- 0 debris torrents

Non Road-related Landslide Density: 0.06 landslides per acre for the past 67 years.

Forest Practices Sensitivity: Moderate to high sensitivity to road building, moderate to high sensitivity to harvesting and forest management practices due to moderate to steep slopes within this unit. Localized areas of steeper and/or convergent slopes have even higher sensitivity to forest practices.

Mass Wasting Potential: High

Delivery Potential: Moderate

Delivery Criteria Used: The converging topography directs mass wasting down slopes toward watercourses. Delivery potential may be high based on relatively high number of debris slides. Landslides in headwater swales often torrent or flow down watercourses. Approximately 80% of landslides in this unit delivered sediment.

Hazard-Potential Rating: **High**

Forest Management Related Trigger Mechanisms:

- Sidecast fill material placed on steep slopes can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads onto unstable areas can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads can increase groundwater, accelerating movement of rockslides or earth flows in this unit.
- Poorly sized culvert or excessive debris at watercourse crossings can initiate failure of the fill material creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Concentrated drainage from skid trails onto unstable areas can initiate debris slides, torrents or flows.
- Cut-slope of skid trails can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of skid trails can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Sidecast fill material created from skid trail construction placed on steep slopes can initiate debris slides, torrents or flows.
- Removal of vegetation from these slopes can result in loss of evapotranspiration and thus increase pore water pressures that could initiate slope failure in this unit.
- Post timber harvest root decay of hardwood or non-redwood conifer species can be a contributing factor in the initiation of debris slides, torrents or flows in this unit.

Confidence: Moderate confidence in placement of unit. This unit is locally variable and exact boundaries are best determined from field observations. Some areas within this unit could have higher susceptibility to landslides and higher delivery rates due to localized areas of steep slopes, weak earth materials, and/or adverse ground water conditions.

TSU Number: 4

Description: Non-dissected topography

Materials: Shallow to moderately deep soils formed from weathered marine sedimentary rocks.

Landforms: Moderate to moderately steep hillslopes with planar, divergent, or broadly convergent slope forms with isolated areas of steep topography or strongly convergent slope forms. TSU 4 is generally a midslope region of lesser slope gradient and more variable slope form than TSU 3.

Slope: Typically 40% - 65%, (mean slope of observed mass wasting events is 77%, range is 40% - 100%)

Total Area: 9399 acres, 67% of the total WAU

MW Processes: 43 *road-associated landslides*

- 39 Debris slides
- 2 Debris flows
- 2 Debris torrents

29 *non-road associated landslides*

- 20 Debris slides
- 8 Debris flows
- 1 Debris torrent

Non Road-related Landslide Density: 0.003 landslides per acre for the past 67 years.

Forest Practices Sensitivity: Moderate sensitivity to road building, moderate to low sensitivity to harvesting and forest management practices due to moderate slope gradients and non-converging topography within this unit. Localized areas of steeper slopes have higher sensitivity to forest practices.

Mass Wasting Potential: Moderate

Delivery Potential: High

Delivery Criteria Used: This unit constitutes a majority of the WAU, which accounts for it having the highest number of landslides. This unit has a low non-road related landslide density, and therefore has a moderate mass wasting hazard. Although landslides in this unit are localized, when landslides occur, the landslide has a high potential to deliver. Approximately 90% of the landslides in this unit delivered sediment. This unit has a moderate sensitivity to road building due to low road landslide density.

Hazard-Potential Rating: **Moderate**

Forest Management Related Trigger Mechanisms:

- Sidecast fill material placed on steep slopes can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads onto unstable areas can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads can increase groundwater, accelerating movement of rockslides or earth flows in this unit.
- Poorly sized culvert or excessive debris at watercourse crossings can initiate failure of the fill material creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Concentrated drainage from skid trails onto unstable areas can initiate debris slides, torrents or flows.
- Cut-slope of skid trails can expose potential failure planes creating debris slides, torrents or flows in this unit.
- Cut-slope of skid trails can remove support of the toe or expose potential failure planes of rockslides or earth flows.
- Sidecast fill material created from skid trail construction placed on steep slopes can initiate debris slides, torrents or flows.
- Removal of vegetation from these slopes can result in loss of evapotranspiration and thus increase pore water pressures that could initiate slope failure in this unit.
- Post timber harvest root decay of hardwood or non-redwood conifer species can be a contributing factor in the initiation of debris slides, torrents or flows in this unit.

Confidence: High confidence in placement of unit, however, this unit is locally variable and exact boundaries are best determined from field observations. Some areas within this unit could have higher susceptibility to landslides and higher delivery rates due to localized areas of steep slopes, weak earth materials, and/or adverse ground water conditions.

TSU Number:	5
Description:	Low relief topography
Material:	Moderately deep to deep soils, derived from weathered marine sedimentary rocks.
Landforms:	Characterized by low gradient slopes generally less than 40%, although in some places slopes may be steeper. This unit occurs on ridge crests, low gradient side slopes, and well-developed terraces. Shallow-seated landslides seldom occur and usually do not deliver sediment to stream channels.
Slope:	Typically <40% (based on field observations)
Total Area:	126 acres, 1% of WAU area
MW Processes:	0 *landslides*
Non Road-related Landslide Density:	0 landslides per acre for past 67 years.
Forest Practices Sensitivity:	Low sensitivity to road building and forest management practices due to low gradient slopes
Mass Wasting Potential:	Low
Delivery Potential:	Low
Delivery Criteria Used:	Sediment delivery in this unit is low.
Hazard-Potential Rating:	**Low**
Forest Management Related Trigger Mechanisms:	•Poorly sized culvert or excessive debris at watercourse crossings can initiate failure of the fill material creating debris slides, torrents or flows in this unit. •Concentrated drainage from roads and skid trails can initiate or accelerate gully erosion, which can increase the potential for mass wasting processes.
Confidence:	High confidence in placement of unit in areas of obviously stable topography. High confidence in mass wasting potential and sediment delivery potential ratings.

TSU Number:	6
Description:	Earth Flow Topography
Materials:	Fine-grained soils and clays of highly weathered and sheared marine sedimentary rocks. Soils contain >80% particles less than 2mm in size with boulders, some very large, within the soil matrix.
Landforms:	Boundaries of this unit correspond to the mapped, deep-seated earth flows from mass wasting inventory, regardless of state of activity. Characterized by hummocky slopes with localized areas of steep, and areas of flat topography. Slopes commonly contain areas of backtilted topography, creating ponded water. Ground surfaces in this unit commonly contain areas of grassy vegetation, which may be attributed to the inability of the clay-rich soil to support dense forests. Gullies are common in this unit. Rate of movement within earth flows typically is variable and likely fluctuates seasonally according to groundwater conditions. Most of unit 6 is earth flow complexes with many scarps and benches that create a step-like profile.
Slope:	Typically <50%
Total Area:	259 acres; 2% of the total WAU.
MW Processes:	1 *road-associated landslide* • 1 Debris slide • 0 Debris flows • 0 Debris torrents 5 *non-road associated landslides* • 0 Debris slides • 5 Debris flows • 0 Debris torrents
Non Road-related Landslide Density:	0.02 landslides per acre for past 67 years.
Forest Practices Sensitivity:	High sensitivity to roads, harvesting, and forest management practices on active earth flow surfaces. Potential forest practices in this unit should be assessed on a site-specific basis due to variable topography and differing states of activity and rates of movement within an earth flow.
Mass Wasting Potential:	High
Delivery Potential:	High

Delivery Criteria Used: Many of the earth flows in the Elk Creek WAU have the toe or lateral edges along watercourses. If earth flow movement occurs the landslides will deliver sediment.

Hazard Potential Rating: **High**

Forest Management Related Trigger Mechanisms:

- Sidecast fill material placed on locally steep slopes can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads onto unstable areas can initiate debris slides, torrents or flows in this unit.
- Concentrated drainage from roads can increase groundwater, accelerating movement of earth flows of this unit.
- Poorly sized culvert or excessive debris at watercourse crossings can initiate failure of the fill material creating debris slides, torrents or flows in this unit.
- Cut-slope of roads can over-steepen the slope creating debris slides in this unit.
- Concentrated drainage from skid trails onto unstable areas can initiate debris slides, torrents or flows in this unit.
- Loss of evapotranspiration from forest harvest can increase groundwater levels initiating or accelerating movement of earth flows of this unit or aid in initiation of debris slides, torrents or flows.
- Concentrated drainage from roads and skid trails can initiate or accelerate gully erosion, which can increase the potential for mass wasting processes.
- Cut-slope of skid trails can remove support of the toe or expose potential failure planes of earth flows.
- Sidecast fill material created from skid trail construction placed on locally steep slopes can initiate debris slides, torrents or flows.
- Root decay of hardwood or non-redwood conifer species can be a contributing factor in the initiation of debris slides, torrents or flows in this unit.

Confidence: Confidence in delineation of unit is consistent with confidence level in mass wasting inventory mapping of deep-seated earth flows. High confidence in hazard potential rating due to relatively low hazard for shallow-seated landslides

TSU Number: 8

Description: Ohlson Ranch Formation

Materials: Fine-grained, relatively cohesionless, sandy material.

Landforms: Boundaries of this unit correspond to the mapped outcrops of the Ohlson Ranch Formation (Manson, 1984). Slopes are characterized by relatively low gradient slopes found along broad wave cut ridge-tops. Ground surfaces in this unit contain areas of vegetation similar to the surrounding forest. Rills and gullies are common in this unit, particularly where roads and skid trails concentrate water for any significant distance.

Slope: Typically <30%

Total Area: 1181 acres; 8% of the total WAU.

MW Processes: 0 *landslides*

Non Road-related Landslide Density: 0 landslides per acre for past 67 years.

Forest Practices Sensitivity: High sensitivity to roads and skid trails, low sensitivity to harvesting of trees. However, slopes underlain by this unit are not steep and therefore usually harvested using ground based yarding where skid trails

Mass Wasting Potential: Low

Delivery Potential: Moderate

Delivery Criteria Used: All mapped exposures of the Ohlson Ranch Formation, and overlying residual soils, typically occur on low gradient ridge-tops where run-off is generated through subsurface processes. However, where first order ephemeral watercourses originate in these deposits, and connectivity exists to higher order tributaries, the potential for surface erosion and sediment delivery is relatively high if roads and/or skid trails are not properly constructed and/or drained after operations.

Hazard Potential Rating: **Low**

Forest Management Related Trigger Mechanisms:

- Concentrated drainage from roads and skid trails can initiate or accelerate gully erosion, which can increase the potential for sediment delivery.

Confidence: High confidence in placement of unit in areas of obviously erodible cohesionless sandy earth materials. High confidence in mass wasting potential and sediment delivery potential ratings.

Sediment Input from Mass Wasting

Sediment delivery was estimated for shallow-seated landslides in the Elk Creek WAU. Depth values were estimated to facilitate approximation of mass for the landslides not observed in the field. In order to extrapolate depth to the shallow-seated landslides not visited in the field, an average was taken from the measured depths of landslides visited in the field. The mean depth of all shallow-seated landslides interpreted as being unrelated to road systems was 4 feet. The mean depth of all shallow seated landslides interpreted as being associated with road systems was also 4 feet. Due to the relative lack of debris flows and torrents, no effort was made to differentiate landslide depths among different shallow landslide types. The mean depth of 4 feet was assigned to all landslides not verified in the field.

The mean sediment delivery percentage assigned to shallow landslides determined to deliver sediment, but not field verified, is 63%. Of the 399 shallow-seated landslides mapped by MRC in this watershed analysis, 373 of the landslides delivered some amount of sediment (Table A-4).

Table A-4. Total Shallow-Seated Landslides Mapped for each PWS in Elk Creek WAU.

Planning Watershed	Total Landslides	Landslides with Sediment Delivery	Landslides with No Sediment Delivery
Lower Elk	173	164	9
Upper Elk	226	209	17
sum	***399***	***373***	***26***
Percentage	***100%***	***93%***	***7%***

Sediment input to stream channels by mass wasting is quantified for seven time periods (1938-1947, 1948-1964, 1965-1967, 1968-1978, 1979-1987, 1988-2000, 2001-2004). The dates for each of the time periods are based on the date of aerial photographs used to interpret landslides (1947, 1964, 1967, 1978, 1987, 2000, and 2004) and field observations (2005). The available aerial photography did not correspond exactly to ten year time periods for mass wasting assessment, however the time periods and the aerial photographs analyzed approximate decadal intervals and bracket major disturbance events (e.g. intensive tractor logging in the 1965-1967 time period). These time periods allow for a general evaluation of the relative magnitude of sediment delivery rate estimates across the Elk Creek WAU.

A total of approximately 447,672 tons of mass wasting sediment delivery was estimated for the time period 1938-2004 in the Elk Creek WAU. This equates to approximately 305 tons/sq. mi./yr. Of the total estimated amount, 31% delivered from 1938-1947, 6% delivered from 1948-1964, 26% delivered from 1965-1967, 14% delivered from 1968-1978, 14% delivered from 1979-1987, 7% delivered from 1988-2000, and 2% delivered in the 2001-2004 time period (Table A-5).

Table A-5. Sediment Delivery (in tons) by Time Period for Elk Creek WAU[a].

PWS	1938 - 1947		1948 – 1964		1965 – 1967	
	RR[a]	NRR[b]	RR	NRR	RR	NRR
CL	0	30,594	4,500	3,811	53,777	15,120
CE	0	106,591	0	20,161	15,689	29,608
Elk WAU	***0***	***137,185***	***4,500***	***23,972***	***69,466***	***44,728***
Total	***137,185***		***28,472***		***114,194***	

a – Road related (including roads, skid trails, and landings) b – Non-road related

Table A-5 (continued). Sediment Delivery (in tons) by Time Period for Elk Creek WAU[a].

PWS	1968 - 1978		1979 – 1987		1988 – 2000		2001-2004	
	RR	NRR	RR	NRR	RR	NRR	RR	NRR
CL	29,052	2,284	22,833	9,585	8,894	9,462	3,323	30
CE	19,833	13,695	24,585	7,186	7,503	4,623	1,755	3,178
Elk WAU	***48,885***	***15,979***	***47,418***	***16,771***	***16,397***	***14,085***	***5,078***	***3,208***
Total	***64,864***		***64,189***		***30,482***		***8,286***	

Relatively large amounts of sediment delivered from 1938-1947, particularly in Upper Elk Creek, is the result of a few discrete relatively large debris slides observed on the 1947 photos. Relatively large amounts of sediment delivered from 1965-1967 is mainly attributed to intensive ground based yarding. Ground based yarding during this era of forest management included the practice of sidecasting excavated fill material on steep slopes adjacent to watercourses. Additionally, according to local rainfall data, the December 1964 storm event produced the wettest days on record at 80 precipitation stations on the northwest coast (Goodridge, 1997). Although the 1964 storm was most intensely focused in Humboldt County, a large portion of Mendocino County was subjected to a 100 year recurrence interval precipitation event. Numerous studies reveal there is a pronounced effect of pore water pressure changes on factor of safety for shallow-seated landslides (Sidle et al., 1985). It appears that the 1964 storm event triggered many landslides, not only where sidecast fills were constructed on steep slopes, but also along watercourses apart from any road building activity.

The sediment delivery estimates were normalized by time (years) and area (square miles) for the purposes of relative comparison between time intervals and planning watershed. The resulting sediment delivery rates in the Elk Creek WAU change dramatically over the time period investigated (Chart A-4).

Chart A-4. Mass Wasting Sediment Delivery Rate (tons/sq.mi./year) from Landslides for MRC Ownership in Lower Elk Creek Shown by Time Period.

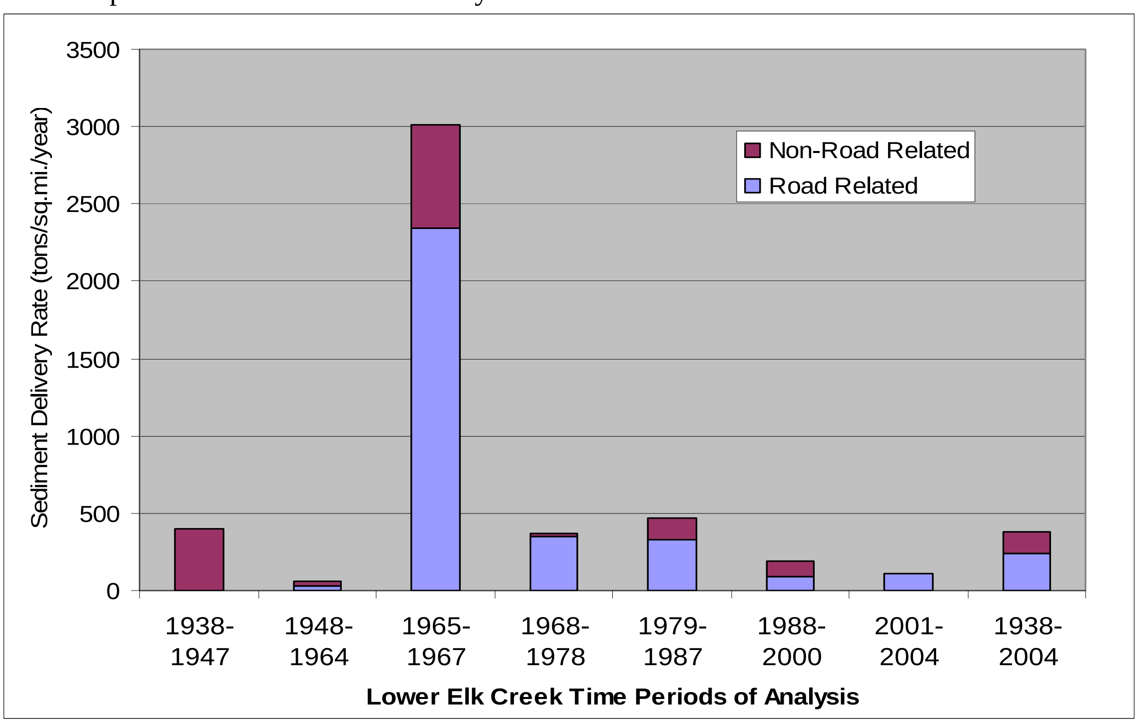


Chart A-5. Mass Wasting Sediment Delivery Rate (tons/sq.mi./year) from Landslides for MRC Ownership in Upper Elk Creek Shown by Time Period.

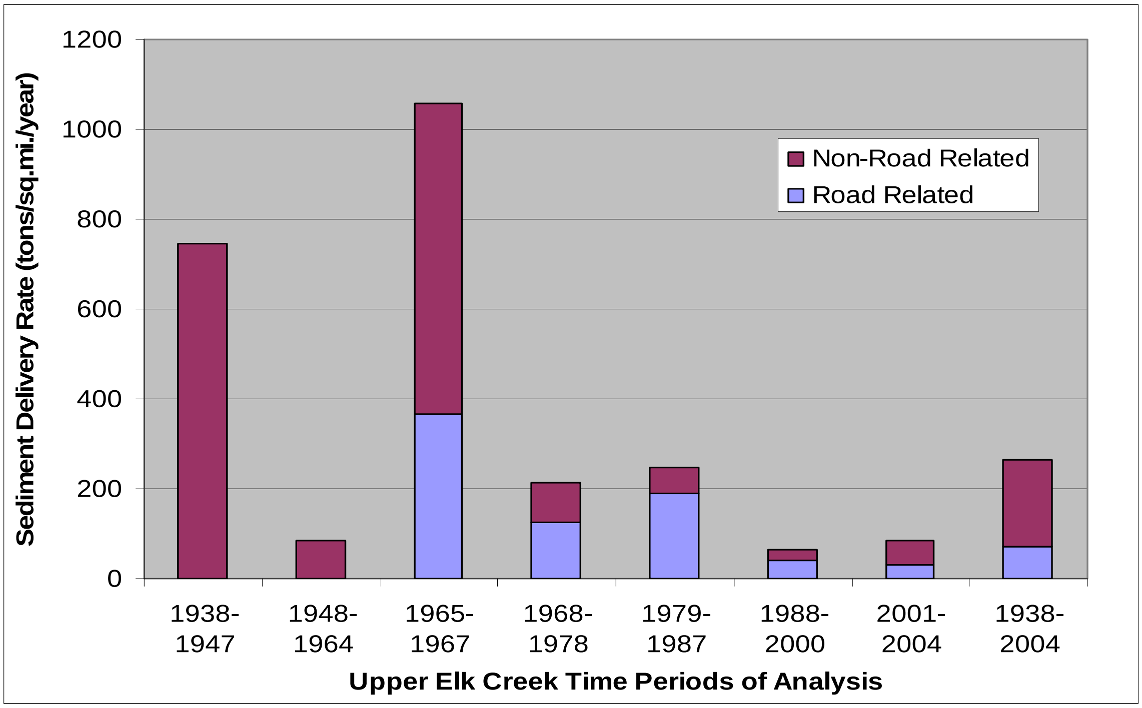
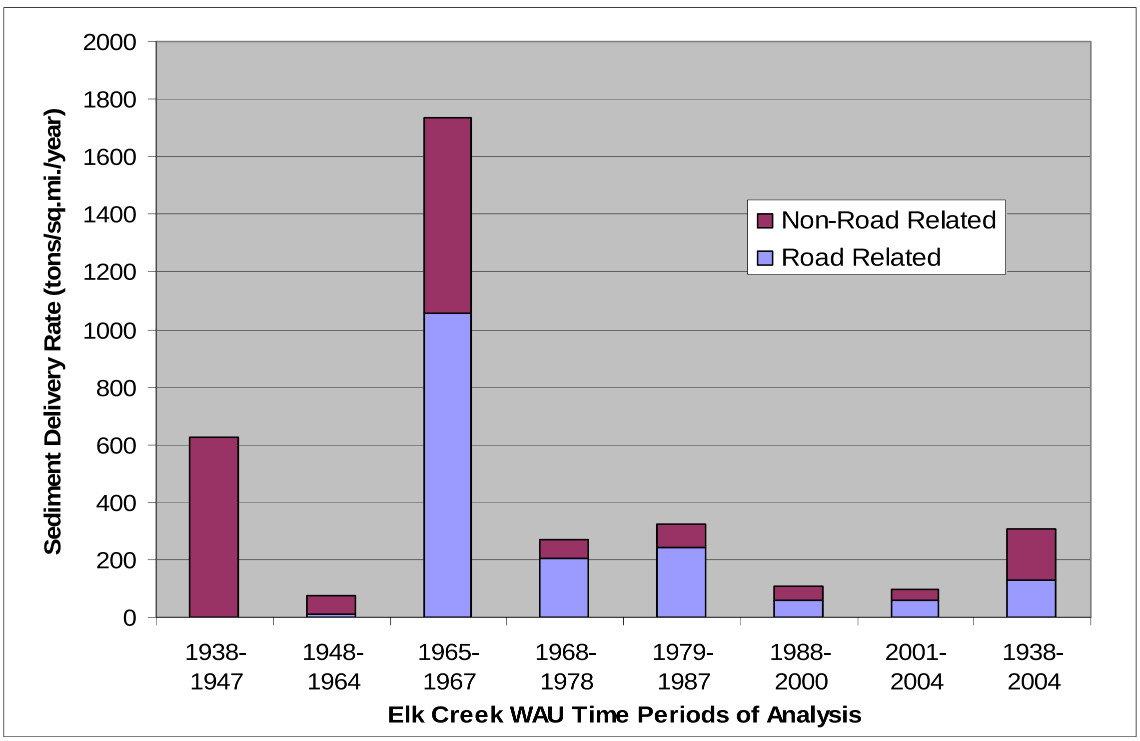


Chart A-6. Mass Wasting Sediment Delivery Rate (tons/sq.mi./year) from Landslides for MRC Ownership in Upper Elk Creek Shown by Time Period.



Road associated mass wasting (including roads, skid trails, and landings) was found to have contributed 191,744 tons (131 tons/sq. mi./yr) of sediment over the 67 years analyzed in the Elk Creek WAU (Table A-6). This represents approximately 43% of the total mass wasting inputs for the Elk Creek WAU for 1938-2004. The road related sediment delivery rates for both Lower and Upper Elk Creek planning watersheds are quite different. A review of the aerial photo record reveals a majority of Lower Elk Creek had been intensively tractor yarded in the few years prior to the 1964 storm event. Upper Elk Creek had not been subjected to the same level of disturbance prior to the 1964 storm event, this is revealed in the difference in road related sediment rates for the 1965-1967 time period between Lower Elk Creek (2348 tons/sq. mi./yr) and Upper Elk Creek (366 tons/sq. mi./yr).

Table A-6. Road Associated Sediment Delivery (in tons) for Shallow-Seated Landslides for Elk Creek WAU by Planning Watershed.

Planning Watershed	Road Associated Mass Wasting Sediment Delivery (tons)	Percent of Total Sediment Delivery From Planning Watershed
Lower Elk Creek	122,379	63%
Upper Elk Creek	69,365	27%
Elk Creek WAU	***191,744***	***43%***

Lower Elk Creek has a slightly higher overall sediment delivery rate from mass wasting than Upper Elk Creek over the entire 67 year period (378 tons/sq.mi./yr. versus 266 tons/sq.mi./yr.). The larger sediment delivery rate may be due to generally steeper terrain, and a larger amount of land area disturbed by tractor logging prior to the 1964 storm event.

A categorical description of the land area interpreted to concentrate surface and/or subsurface flow to the point of failure for non-road related shallow-seated failures was conducted. Road related failures were excluded because of the many other variables that influence road failures (e.g. thickness of fill, construction techniques, concentrated road run-off, etc.). In this analysis, categories of contributing area included small areas (<0.5 acres), medium sized areas (0.5-3.0 acres) and large areas (>3.0 acres). Areas were determined by a combination of air photo and GIS analysis and indicate a majority of the sediment delivery is occurring from slides where the contributing area is between 0.5 and 3.0 acres in size (Table A-7).

Table A-7. Sediment Delivery from Landslides for MRC Ownership in Elk Creek Shown by Contributing Area.

Planning Watershed	Small Area <0.5 acres	Medium Area 0.5-3.0 acres	Large Area >3.0 acres
Lower Elk	16,479	31,396	23,011
Upper Elk	31,153	77,484	73,964
Elk Creek WAU	***47,632***	***108,880***	***96,975***

Intuitively, a majority of the sediment delivery is occurring from medium and large contributing areas where pore pressure increases in response to precipitation events would be most significant.

A categorical description of the slope aspect for all shallow-seated failures was conducted. Despite the other variables that influence road related failures, as mentioned above, road related failures were included in this analysis. In this analysis slope aspect is determined as an absolute azimuth in the GIS and then categorically described as NE (0°-89°), SE (90°-179°), SW (180°-269°), or NW (270°-359°). Results are presented below (Table A-8)

Table A-8. Sediment Delivery from Landslides for MRC Ownership in Elk Creek Shown by Hillslope Aspect.

Planning Watershed	NE	SE	SW	NW
Lower Elk	31,191	46,569	80,019	35,486
Upper Elk	31,822	131,097	68,659	22,829
Elk Creek WAU	***63,013***	***177,666***	***148,678***	***58,315***

A majority (73%) of the sediment delivery is occurring on slopes with a predominately south facing aspect. This may be attributed to the south to north direction that rain falls when storm events occur over in the area, resulting in increased pore water pressure increases on south facing slopes.

The distribution of shallow-seated landslides by soil type was analyzed to investigate the relationship between sediment delivery and soil type. The Mendocino County Soil Survey (Rittiman and Thorson, 2001) data includes a classification (USCS, Unified Soil Classification System) that describes the general properties of the soil and allows for a categorical description (Coarse, Fine, or Mixed) based on the distribution of grain size. The GIS was queried for the mapped soil type at the crown of the failure and the USCS soil type was categorically described as either coarse (predominately gravel and sand), fine (predominately silt or clay), or mixed (containing both coarse and fine grain sizes). Criteria for mapping soil types and classifying them based on the USCS are presented elsewhere. A portion of Lower Elk Creek was not made available by previous landowners when soils mapping was conducted, therefore the column “NA” is provided to summarize the amount of sediment that was not classified during this analysis. Results are presented below (Table A-9).

Table A-9. Sediment Delivery from Landslides for MRC Ownership in Elk Creek Shown by Soil Type.

Planning Watershed	Coarse	Fine	Mixed	NA
Lower Elk	89,464	17,752	4,265	81,784
Upper Elk	174,450	44,429	35,528	0
Elk Creek WAU	***263,914***	***62,181***	***39,793***	***81,784***

Results of this analysis reveal a majority of the sediment delivery is occurring from coarse grained soils, however, coarse grained soils also make up a majority of the soils mapped in the Elk Creek WAU.

Historically, research on the influence of timber harvesting on slope stability has focused on clear-cutting, or even-aged management, where hydrologic changes are most pronounced. The effect of partial harvest, or uneven-aged management, on slope stability is less well known. This data should not be misinterpreted as present forest conditions on MRC lands have resulted in a majority of the ownership being in a state of partial harvest. The purpose of this analysis is to begin to generate a long term dataset on the relationship between forest conditions and landslide occurrence. Updates to this watershed analysis over time will build upon this dataset with the intention of identifying any emerging trends in the relationship between forest conditions and sediment delivery from partial harvesting.

The effect that forest stand conditions can have on sediment delivery from shallow-seated landsliding is investigated by attributing recent (2001-2004) non-road related failures with a forest inventory variable titled "structure class." Stands with similar forest attributes (dominant diameter, dominant vegetation, and canopy density) are described by their structure class as a tool for MRC to assess habitat conditions property wide. Generally, in this process vegetation strata are delineated based on an air photo interpretation of individual similar stands, subsequent field sampling generates empirical information on tree species, diameter, and canopy, and similar strata are grouped together to generate structure classes for habitat description purposes. The findings are summarized below (Table A-10).

Table A-10. Forest Stand Attributes for Recent Non-Road Related Landslides on MRC Ownership in Elk Creek.

Slide ID	Structure Class	Dominant Veg.	Dominant Diameter	Canopy Closure
702	21	Conifer	<16"	>60%
703	22	Conifer	16-24"	>60%
705	10	Conifer/Hardwood	>16"	40%-60%
706	21	Conifer	<16"	>60%
707	22	Conifer	16-24"	>60%
708	22	Conifer	16-24"	>60%
711	22	Conifer	16-24"	>60%

Sediment Input by Terrain Stability Unit

Total mass wasting sediment delivery for the Elk Creek WAU was separated into respective Terrain Stability Units. Sediment delivery statistics for each TSU are summarized in Table A-7.

Table A-7. Total Sediment Delivery (in tons) by TSU in the Elk Creek WAU (tons)

Sediment Delivery (tons)	TSU						
	1	2	3	4	5	6	8
Road Related	66,776	78,753	12,136	33,370	0	709	0
% road related	35%	41%	6%	17%	0%	0%	0%
Non-Road Related	50,786	49,935	118,191	34,809	0	2,207	0
% non-road related	20%	20%	46%	14%	0%	1%	0%
Total	117,562	128,688	130,327	68,179	0	2916	0
% of total delivery	26%	29%	29%	15%	0%	1%	0%
Acres	917	1654	541	9399	126	259	1181
% of WAU area	7%	12%	4%	67%	1%	2%	8%
Ratio- delivery %/area %	4.0	2.4	7.6	0.2	0.0	0.4	0.0

The TSU with the largest estimated sediment delivery is TSU 3, which is estimated to deliver 29% of the total sediment input for the Elk Creek WAU. However, a significant portion of this estimate is comprised of sediment from three non-road related sources in Upper Elk Creek in the 1938-1947 time period. These three failures reveal the influence that large mass wasting events can have on a landslide inventory, 16% of the sediment delivered during the entire 67 year period of analysis was delivered by these three slides.

Combining all high hazard units (TSU 1, 2, 3, and 6) would yield 86% of the estimated non-road related sediment input of approximately 24% of the MRC owned acreage. Combining the moderate and low hazard units (TSU 4, 5, and 8) would yield 14% of the estimated non-road related sediment input off the remaining 76% of the property. One measure of the intensity of mass wasting processes in a given TSU is the amount of sediment produced divided by the area in the TSU. The last row in Table A-7 expresses landslide intensity as the ratio of the percentage of total sediment delivered by the percentage of watershed area in the TSU. A ratio of 1.0 would indicate that the map unit is producing a proportion of the sediment delivery equal to the proportion of the map unit area within the WAU. Values of this ratio greater than 1.0 indicate high landslide rates in a relatively concentrated area. The TSUs with the largest ratios were units 1, 2, and 3, with ratios of 4.0, 2.4, and 7.6, respectively. The smallest ratios are found in units 4, 5, 6, and 8; 0.2, 0.0, 0.4, and 0.0, respectively. The ratios suggest that the delineation of the high hazard Terrain Stability Units has captured the majority of the estimated sediment delivery from mass wasting over the past 41 years in the Elk Creek WAU.

CONCLUSIONS

In forest environments of the California Coast Range, mass wasting is a common, natural occurrence. In the Elk Creek WAU this is due to steep slopes, the condition of weathered and intensely sheared and fractured marine sedimentary rocks, seismic activity, locally thick colluvial soils, a history of timber harvest practices, and the occurrence of high intensity rainfall events. Mass wasting events are episodic and many landslides may happen in a short time frame. Mass wasting features of variable age and stability are observed throughout the Elk Creek WAU. A majority of the landslides visited in the field during this assessment occurred on slopes greater than 70%. Seeps and springs were evident in the evacuated cavity at many sites. Particular caution should be exercised when conducting any type of forest management activity in areas with convergent or locally steep topography.

Mass wasting sediment input is estimated to be at least 305 tons/sq.mi./yr. over the 1938-2004 time period for the entire Elk Creek WAU. However, approximately 60% of the shallow-seated landslides inventoried in the Elk Creek WAU are road associated (includes roads, skid trails, and landings). Road associated mass wasting represented 43% of the estimated sediment delivery, or at least 131 tons/sq. mi./yr of sediment over the 67 years analyzed. Road construction is thus a significant factor in the cause of shallow-seated mass wasting events. Improved road construction practices combined with design upgrades of old roads can reduce anthropogenic sediment input rates and mass wasting hazards.

The steep streamside areas of TSU 1, 2, and 3 contribute the highest amount of the sediment per unit area in the watershed. In the moderate and low hazard units of TSU 4 and 5, a large amount of road associated landslides are occurring, suggesting the need to make improvements on roads within the Elk Creek WAU.

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Elk Creek Mass Wasting Inventory
Appendix A

Watershed:		Elk Creek												Shallow-seated landslides											Deep-seated landslides							Mass Wasting Inventory Sheet Mendocino Redwood Company, LLC
Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type	TSU	Certainty	Size Length	Size Width	Size Depth	Slide Vol.	Sed. Routing	Dom. Aspect	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Contrib. Area	Soil Type	Struc. Class	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.	Comments
					DS DF DT EF RS	1 2 3 4 5 6	D P Q	feet	feet	feet	yd^3	P I N	NE SE NW SW	25 50 75 100 (%)	yd^3	tons	(%)	N R O	C D P	H S I N	R S L N I	S M L	USCS	1 to 24	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4	Y N	Y N	
1	CL	17	1947	2_118	DS	3	D	200	250	4	7407.41	P	NW	63	4667	6300		N	P	S	N	L	C									DSL toe slopes
2	CL	20	1947	2_118	DS	2	D	200	150	4	4444	I	SE	63	2800	3780		N	C	S	N	S	C									
3	CL	20	1947	2_118	DS	3	P	250	200	3	5556	P	SW	50	2778	3750	90	N	C	S	N	M	C								Y	
4	CL	7	1947	2_119	DS	1	D	300	200	4	8889	P	SE	25	2222	3000	110	N	P	S	N	S	F								Y	
5	CL	7	1947	2_119	DS	4	D	250	150	5	6944	P	SE	25	1736	2344	100	N	P	S	N	S	NA								Y	
6	CL	8	1947	2_119	DS	2	D	300	150	4	6667	P	SE	63	4200	5670		N	C	N	N	M	NA									
7	CL	6	1947	2_120	DS	3	D	175	150	4	3889	I	SW	50	1944	2625	85	N	C	S	N	L	NA								Y	
8	CE	22	1947	8_87	DS	4	D	100	125	6	2778	P	NW	75	2083	2813	85	N	P	S	N	M	C								Y	DSL toe slopes
9	CE	22	1947	8_87	DS	1	P	75	50	4	556	P	SW	100	556	750	80	N	P	S	N	M	C								Y	
10	CE	27	1947	8_87	DS	1	D	150	75	4	1667	P	NE	63	1050	1418		N	C	S	N	M	C									
11	CE	26	1947	8_87	DS	3	P	150	100	4	2222	I	SW	63	1400	1890		N	P	N	N	M	C									just below break in slope
12	CE	22	1947	8_88	DS	4	D	150	100	4	2222	I	SW	50	1111	1500	70	N	C	H	N	S	C								Y	indistinct in the field
13	CL	15	1947	8_89	DS	1	P	200	125	5	4630	P	SW	50	2315	3125	80	N	P	S	N	S	F								Y	
14	CE	36	1947	10_6	DS	3	Q	300	75	4	3333	P	SW	63	2100	2835		R	P	N	N	S	F									
15	CE	26	1947	10_6	DS	4	Q	150	100	4	2222	P	SW	63	1400	1890		R	P	N	N	S	M									
16	CE	26	1947	10_7	DS	3	P	250	200	4	7407	P	SE	63	4667	6300		N	P	N	N	M	C									
17	CE	19	1947	10_21	DF	4	D	150	50	4	1111	I	SE	63	700	945		N	C	H	N	S	M									
18	CE	19	1947	10_21	DF	3	D	150	50	4	1111	I	SE	63	700	945		N	C	H	N	M	M									
19	CE	19	1947	10_21	DF	4	D	75	50	4	556	I	SE	63	350	473		N	C	H	N	S	M									
20	CE	19	1947	10_21	DF	4	D	100	100	4	1481	I	SE	63	933	1260		N	C	H	N	S	M									
21	CE	32	1947	9_38	DS	3	P	150	75	4	1667	I	SW	63	1050	1418		N	C	H	N	L	C									
22	CE	6	1947	9_39	DS	2	D	100	75	3	833	P	SE	75	625	844	80	N	C	S	N	M	C								Y	
23	CE	30	1947	9_39	DS	3	D	350	250	8	25926	P	SE	50	12963	17500	75	N	C	S	N	M	C								Y	earthflow morphology here
24	CE	30	1947	9_39	DS	3	D	400	250	10	37037	P	SE	75	27778	37500	75	R	P	S	N	L	C								Y	DSL toe slopes
25	CE	30	1947	9_39	DS	3	D	250	200	10	18519	P	SE	75	13889	18750	75	R	P	S	N	L	C								Y	DSL toe slopes
26	CE	30	1947	9_39	DS	3	D	300	200	4	8889	P	SE	63	5600	7560		R	C	S	N	M	C									
100	CL	17	1964	17_103	DS	1	D	75	150	4	1667	P	SW	63	1050	1418		N	P	S	N	L	C									DSL toe slopes
101	CL	20	1964	17_103	DS	2	P	100	50	3	556	I	SW	25	139	188	73	N	C	H	N	M	F								Y	
102	CL	8	1964	17_104	DS	1	D	200	225	4	6667	P	SE	50	3333	4500	85	N	C	S	R		NA								Y	
103	CE	27	1964	6_103	DS	1	P	100	50	4	741	P	NE	63	467	630		R	P	S	N	M	C									
104	CL	15	1964	6_104	DS	1	Q	100	100	4	1481	P	NE	63	933	1260		R	P	S	N	S	C									
105	CE	14	1964	6_104	DS	2	D	150	75	4	1667	I	SW	63	1050	1418		N	P	N	N	S	M									earthflow morphology here
106	CL	15	1964	6_105	DF	2	D	150	50	4	1111	I	SW	63	700	945		N	C	H	N	S	C									800' long runout
107	CE	35	1964	17_58	DS	3	P	175	100	4	2593	I	SE	63	1633	2205		R	C	H	N	M	F									
108	CE	35	1964	17_58	DS	4	D	200	150	4	4444	I	SE	63	2800	3780		N	C	H	N	M	F									
109	CE	36	1964	17_58	DS	3	P	100	100	4	1481	N	SW	0	0	0		N	C	S	N	S	M									
110	CE	36	1964	17_58	DS	4	P	100	50	4	741	N	SW	0	0	0		N	C	S	N	S	M									
111	CE	24	1964	17_60	DF	3	D	200	50	4	1481	I	SW	63	933	1260		N	C	H	N	S	M									
112	CE	24	1964	17_60	DS	3	P	150	100	4	2222	N	SW	0	0	0		N	C	H	S		M									
113	CE	25	1964	17_60	DS	1	Q	50	50	4	370	P	SW	63	233	315		N	C	S	N	M	M									
114	CE	32	1964	4_84	DS	2	Q	100	100	4	1481	I	NW	63	933	1260		N	C	N	N	M	F									
115	CE	29	1964	4_84	DS	2	D	100	75	4	1111	I	SW	63	700	945		N	P	S	N	M	C									
116	CE	32	1964	4_84	DF	4	D	100	75	4	1111	P	NE	63	700	945		N	P	S	N	L	C									
117	CE	32	1964	4_84	DF	2	D	150	75	4	1667	P	SE	63	1050	1418		N	C	S	N	L	F									DSL toe slopes
118	CE	32	1964	4_84	DF	1	D	100	50	4	741	I	SW	63	467	630		N	C	S	N	M	F									DSL toe slopes
119	CE	32	1964	4_84	DF	1	D	100	50	4	741	I	SE	63	467	630		N	C	S	N	M	F									DSL toe slopes
120	CE	32	1964	4_84	DS	1	D	150	100	4	2222	P	SW	63	1400	1890		N	C	S	N	M	F									DSL toe slopes
121	CE	32	1964	4_85	DS	2	P	100	100	4	1481	I	SE	63	933	1260		N	P	N	N	M	M									earthflow morphology here
122	CE	29	1964	4_85	DS	2	D	100	75	4	1111	I	SW	63	700	945		N	P	N	N	M	F									
123	CE	31	1964	4_85	DF	3	P	100	50	4	741	I	SW	63	467	630		N	C	H	N	S	C									
200	CL	7	1967	02_06	DS	2	D	150	100	4	2222	I	NE	63	1400	1890		N	C	H	N	L	NA									
201	CL	8	1967	02_06	DS	1	D	150	150	4	3333	P	NW	63	2100	2835		N	C	S	N	L	NA									
202	CL	8	1967	02_04	DS	4	D	100	50	4	741	P	NE	63	467	630		N	P	N	S		NA									
203	CL	8	1967	02_04	DS	1	D	150	200	4	4444	P	SW	63	2800	3780		N	C	S	R		NA									
204	CL	8	1967	02_04	DS	1	D	200	150	4	4444	P	SW	63	2800	3780		N	C	S	R		NA									
205	CL	7	1967	02_04	DS	1	Q	150	100	4	2222	P	NE	63	1400	1890		N	C	S	N	L	NA									
206	CL	7	1967	02_04	DS	1	D	50	50	4	370	P	SW	100	370	500	75	N	C	S	R		NA								Y	
207	CL	5	1967	02_04	DS	4	D	100	50	4	741	I	NW	63	467	630		N	C	S	S		NA									
208	CL	6	1967	02_04	DS	2	D	50	50	4	370	I	NW	63	233	315		N	C	S	S		NA									
209	CL	6	1967	02_04	DS	4	D	150	100	4	2222	I	NW	63	1400	1890		N	C	S	S		NA									
210	CL	5	1967	02_04	DS	2	D	150	100	4	2222	N	NW	0	0	0		N	P	N	S		NA									
211	CL	6	1967	02_04	DS	2	P	100	100	4	1481	I	SW	63	933	1260		N	P	S	S		NA									
212	CL	6	1967	02_04	DS	4	D	50	50	4	370	P	NE	63	233	315		N	P	S	S		NA									
213	CE	22	1967	03_06	DS	1	D	75	40	4	444	P	SE	25	111	150	72	N	P	S	R		C								Y	
214	CL	22	1967	03_06	DS	1	D	75	100	5	1389	P	SW	75	1042	1406	80	N	C	S	R		C								Y	

Watershed:		Elk Creek												Shallow-seated landslides											Deep-seated landslides							Mass Wasting Inventory Sheet Mendocino Redwood Company, LLC
Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type DS DF DT EF RS	TSU 1 2 3 4 5 6	Certainty D P Q	Size Length feet	Width feet	Depth feet	Slide Vol. yd^3	Sed. Routing P I N	Dom. Aspect NE SE NW SW	Sed. Del. Ratio 25 50 75 100 (%)	Sed. Delivery yd^3	Sed. Delivery tons	Slope (field) (%)	Age N R O	Slope Form C D P	Slide Loc. H S I N	Road Assoc. R S L N I	Contrib. Area S M L	Soil Type USCS	Struc. Class 1 to 24	Toe Activity 1 2 3 4 5	Body Morph. 1 2 3 4 5	Lat. Scarps 1 2 3 4 5	Main Scarps 1 2 3 4 5	DS Veg. 1 2 3 4	Complex Y N	Field Obs. Y N	Comments
215	CE	22	1967	03_06	DS	1	Q	50	50	4	370	P	SE	63	233	315		N	P	S	R		C								Y	Unable to locate in the field
216	CE	22	1967	03_06	DS	1	P	50	75	5	694	P	SW	75	521	703	100	N	C	S	R		C								Y	
217	CE	22	1967	03_06	DS	1	D	60	50	3	333	P	SW	50	167	225	80	N	C	S	R		C								Y	
218	CE	22	1967	03_06	DS	1	P	100	75	4	1111	P	NW	50	556	750	90	N	C	S	S		C								Y	Seepage in skid trail cutslope
219	CE	22	1967	03_06	DS	2	D	50	50	4	370	P	SW	63	233	315		N	P	S	R		C									
220	CE	27	1967	03_06	DS	4	Q	150	100	4	2222	I	NW	63	1400	1890		N	C	H	N	M	C									Possible DSL instability
221	CE	21	1967	03_06	DS	2	D	150	100	4	2222	I	NE	63	1400	1890		N	C	S	R		C									
222	CL	21	1967	03_06	DS	4	Q	100	50	4	741	I	SW	63	467	630		N	C	H	S		F									
223	CL	21	1967	03_06	DS	2	P	50	50	4	370	I	SE	63	233	315		N	P	S	R		C									
224	CL	21	1967	03_06	DS	4	D	100	100	4	1481	N	SE	0	0	0		N	C	H	R		C									
225	CL	21	1967	03_06	DS	2	P	100	50	4	741	I	NW	63	467	630		N	P	S	R		C									
226	CL	21	1967	03_06	DS	4	P	100	50	4	741	P	NW	63	467	630		N	C	S	S		C									
227	CL	21	1967	03_06	DF	3	P	50	50	4	370	I	SW	63	233	315		N	C	S	S		C									
228	CL	21	1967	03_06	DS	3	P	100	50	4	741	I	SW	63	467	630		N	C	S	S		C									
229	CL	21	1967	03_06	DF	2	P	50	50	4	370	I	NW	63	233	315		N	C	S	S		C									
230	CL	21	1967	03_06	DS	4	D	200	250	4	7407	P	NE	63	4667	6300		N	P	S	N	M	C									
231	CL	20	1967	03_06	DS	4	P	50	100	4	741	P	NE	63	467	630		N	P	S	S		C									
232	CL	17	1967	03_06	DS	2	D	125	150	4	2778	P	NE	75	2083	2813	85	N	C	S	R		C								Y	
233	CL	16	1967	03_06	DS	1	D	100	100	4	1481	I	SE	63	933	1260		N	P	N	S		C									
234	CL	21	1967	03_06	DS	1	D	100	50	4	741	I	NW	63	467	630		N	P	S	R		C									
235	CL	21	1967	03_06	DS	1	P	50	150	4	1111	I	NW	63	700	945		N	C	S	S		F									
236	CL	21	1967	03_06	DS	4	P	50	50	4	370	I	NW	63	233	315		N	C	S	S		F									
237	CL	21	1967	03_06	DS	4	Q	250	200	4	7407	I	NW	63	4667	6300		N	P	S	R		C									
238	CL	21	1967	03_06	DS	1	P	100	50	4	741	I	NE	63	467	630		N	C	S	S		C									
239	CL	21	1967	03_06	DS	1	Q	50	50	4	370	N	SW	0	0	0		N	C	S	S		C									
240	CL	16	1967	03_06	DS	1	P	150	150	4	3333	P	SW	63	2100	2835		N	C	S	S		C									
241	CL	16	1967	03_06	DS	1	D	150	100	4	2222	P	SW	63	1400	1890		N	C	S	S		C									
242	CL	15	1967	03_06	DS	1	D	100	150	5	2778	P	SW	100	2778	3750	110	N	P	S	R		C								Y	
243	CL	15	1967	03_06	DS	1	P	100	50	4	741	P	NW	63	467	630		N	C	S	R		C									
244	CL	15	1967	03_06	DS	1	D	100	40	4	593	P	SW	50	296	400	95	N	P	S	R		C								Y	
245	CL	15	1967	03_06	DS	1	D	100	75	4	1111	P	SW	50	556	750	95	N	P	S	R		F								Y	
246	CL	15	1967	03_04	DS	4	D	150	50	4	1111	I	SW	63	700	945		N	C	H	N	S	C									
247	CL	15	1967	03_04	DS	2	P	100	200	4	2963	I	SW	63	1867	2520		N	P	H	R		C									
248	CL	15	1967	03_04	DS	2	D	100	75	4	1111	I	NW	63	700	945		N	P	N	N	M	M									
249	CL	10	1967	03_04	DS	2	D	50	25	4	185	I	SW	63	117	158		N	C	S	S		M									
250	CL	10	1967	03_04	DS	4	D	50	25	4	185	I	SW	63	117	158		N	P	N	S		M									
251	CL	16	1967	03_04	DS	1	Q	75	100	3	833	P	SE	75	625	844	120	N	C	S	R		C								Y	
252	CL	15	1967	03_04	DS	2	Q	150	50	4	1111	I	SE	63	700	945		N	C	N	S		C									
253	CL	16	1967	03_04	DS	2	P	100	100	4	1481	I	SE	63	933	1260		N	P	S	S		F									
254	CL	8	1967	03_04	DS	1	Q	100	150	4	2222	P	NE	63	1400	1890		N	C	S	R		NA									
255	CL	15	1967	03_04	DS	4	D	100	50	4	741	I	NW	63	467	630		N	C	H	R		M									
256	CL	9	1967	03_04	DS	2	D	75	150	4	1667	I	SW	63	1050	1418		N	C	S	S		NA									
257	CL	8	1967	03_04	DS	2	P	75	100	4	1111	I	NW	63	700	945		N	P	S	S		NA									
258	CL	9	1967	03_04	DS	2	P	100	50	4	741	I	NW	63	467	630		N	C	S	S		NA									
259	CL	9	1967	03_04	DS	2	P	50	50	4	370	I	SW	63	233	315		N	P	S	N	L	NA									
260	CE	34	1967	04_07	DS	4	P	200	100	4	2963	I	NE	63	1867	2520		N	C	H	S		C									
261	CE	35	1967	04_07	DS	1	Q	100	50	4	741	I	SW	63	467	630		N	C	S	N	M	C									
262	CE	26	1967	04_07	DS	1	Q	200	150	4	4444	P	SW	63	2800	3780		N	P	S	N	S	C									
263	CE	26	1967	04_07	DS	4	D	50	50	4	370	I	SW	63	233	315		N	C	H	N	M	M									toe of DSL
264	CE	23	1967	04_07	DS	4	P	100	50	4	741	I	SW	63	467	630		N	C	H	N	L	F									
265	CE	26	1967	04_05	DS	1	Q	50	100	4	741	P	SW	63	467	630		N	P	S	N	L	C									
266	CE	23	1967	04_05	DS	1	P	100	50	4	741	P	SW	63	467	630		N	C	S	N	M	C									
267	CE	23	1967	04_05	DS	1	P	100	50	4	741	P	SW	63	467	630		N	C	S	N	L	C									
268	CE	23	1967	04_05	DS	1	P	50	50	4	370	N	NE	0	0	0		R	C	S	N	L	C									
269	CE	22	1967	04_05	DS	1	Q	50	75	6	833	P	SW	25	208	281	75	N	P	S	N	L	C								Y	
270	CE	22	1967	04_05	DS	1	P	100	40	3	444	P	SW	50	222	300	70	N	C	S	N	L	C								Y	
271	CL	15	1967	04_05	DS	1	D	100	50	4	741	P	SW	63	467	630		N	C	S	S		C									
272	CE	14	1967	04_05	DS	3	D	100	50	4	741	N	SW	0	0	0		N	C	H	N	M	M									Possible DSL (earthflow) instability
273	CE	14	1967	04_05	DS	2	D	150	75	4	1667	I	SW	63	1050	1418		N	C	S	N	M	C									
274	CE	23	1967	04_05	DS	2	D	50	50	3	278	I	SE	75	208	281	90	N	C	S	N	S	C								Y	
275	CE	23	1967	04_05	DS	2	P	50	50	4	370	I	SW	63	233	315		N	P	S	N	M	C								Y	Unable to locate in the field
276	CE	23	1967	04_05	DS	3	P	100	50	4	741	I	SW	63	467	630		N	C	N	N	M	C									
277	CE	23	1967	04_05	DS	2	Q	50	100	4	741	I	SW	63	467	630		N	P	N	N	L	C									
278	CE	23	1967	04_05	DS	3	D	100	50	4	741	I	SW	63	467	630		N	C	H	N	S	C									
279	CE	36	1967	05_06	DS	3	D	50	50	4	370	I	SE	63	233	315		N	C	H	N	M	M									

Watershed: Elk Creek

Shallow-seated landslides | *Deep-seated landslides*

Mass Wasting Inventory Sheet
Mendocino Redwood Company, LLC

Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type	TSU	Certainty	Size Length	Width	Depth	Slide Vol.	Sed. Routing	Dom. Aspect	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Contrib. Area	Soil Type	Struc. Class	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.	Comments
					DS DF DT EF RS	1 2 3 4 5 6	D P Q	feet	feet	feet	yd^3	P I N	NE SE NW SW	25 50 75 100 (%)	yd^3	tons	(%)	N R O	C D P	H S I N	R S L N I	S M L	USCS	1 to 24	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4	Y N	Y N	
280	CE	31	1967	05_06	DS	2	Q	50	50	4	370	I	NE	63	233	315		N	P	N	N	S	M									
281	CE	31	1967	05_06	DS	4	P	100	50	4	741	I	NE	63	467	630		N	C	H	N	M	M								Y	Unable to locate in the field
282	CE	30	1967	05_06	DS	3	D	100	50	4	741	I	SW	63	467	630		N	P	H	R		C									
283	CE	24	1967	05_04	DS	3	P	75	75	4	833	N	NE	0	0	0		N	C	H	N	M	C									
284	CE	24	1967	05_04	DS	3	P	150	100	4	2222	N	SE	0	0	0		N	C	H	N	M	C									
285	CE	24	1967	05_04	DS	2	P	50	75	4	556	I	SW	63	350	473		N	C	S	N	M	C									
286	CE	25	1967	05_04	DS	3	Q	75	75	4	833	I	SE	63	525	709		N	C	S	N	M	C									
287	CE	19	1967	05_04	DS	3	P	50	25	4	185	I	SW	63	117	158		N	C	H	N	M	C									
288	CE	19	1967	05_04	DS	2	Q	150	100	4	2222	P	NW	63	1400	1890		N	P	S	I		F									
289	CE	19	1967	06_03	DS	4	D	100	50	4	741	I	SE	63	467	630		N	C	H	N	S	M									Possible DSL (earthflow) instability
290	CE	20	1967	06_03	DS	2	D	50	25	4	185	I	SW	63	117	158		N	C	N	R		F									
291	CE	19	1967	06_03	DS	2	D	100	75	4	1111	I	NE	63	700	945		N	P	N	S		F									
292	CE	20	1967	06_03	DS	3	Q	100	50	4	741	I	SW	63	467	630		N	C	N	S		F									
293	CE	20	1967	06_03	DS	4	D	50	50	4	370	N	SW	0	0	0		N	C	H	N	S	C									
294	CE	29	1967	06_03	DS	3	D	50	25	4	185	N	SW	0	0	0		N	C	H	N	S	C									
295	CE	29	1967	06_03	DS	4	P	100	50	4	741	P	SE	63	467	630		N	P	S	N	M	F									
296	CE	29	1967	06_05	DS	4	Q	100	50	4	741	I	SW	63	467	630		N	C	H	R		C									
297	CE	29	1967	06_05	DS	2	P	100	100	4	1481	I	SW	63	933	1260		N	P	S	I		C									
298	CE	33	1967	06_05	DS	2	P	100	50	4	741	I	SW	63	467	630		N	P	S	N	L	F									
299	CE	33	1967	06_05	DS	2	Q	50	50	4	370	I	SW	63	233	315		N	P	S	N	L	F									
300	CE	32	1967	06_05	DS	2	D	50	75	4	556	P	SE	63	350	473		N	P	S	R		F									
301	CE	32	1967	06_05	DS	2	P	100	50	4	741	P	SE	63	467	630		N	P	S	R		C									
302	CE	32	1967	06_05	DS	2	D	250	150	4	5556	P	NW	63	3500	4725		N	P	S	R		F									
303	CE	32	1967	06_05	DS	1	P	50	25	4	185	P	SW	63	117	158		N	C	H	N	L	F									
304	CE	32	1967	06_05	DS	1	P	150	100	4	2222	P	SE	63	1400	1890		N	P	S	N	L	F									
305	CE	32	1967	06_05	DS	1	D	100	50	4	741	P	SW	63	467	630		N	P	S	N	L	C									
306	CE	32	1967	06_05	DS	2	D	100	50	4	741	I	SW	63	467	630		N	P	H	N	M	M									
307	CE	32	1967	06_05	DS	1	P	200	150	4	4444	P	SE	63	2800	3780		N	P	S	N	S	M									
308	CE	6	1967	06_05	DS	2	P	100	75	4	1111	I	SW	63	700	945		N	P	N	N	S	M									
400	CL	18	1978	2_12	DS	1	D	100	50	4	741	P	SE	63	467	630		N	C	S	R		NA									
401	CL	18	1978	2_12	DS	4	D	75	25	4	278	N	NE	0	0	0		N	D	N	R		NA									
402	CL	18	1978	2_12	DS	4	D	100	50	4	741	I	SE	63	467	630		N	C	S	S		NA									
403	CL	18	1978	2_12	DS	1	D	75	50	4	556	I	SE	63	350	473		N	C	S	S		NA									
404	CL	18	1978	2_12	DS	1	D	75	50	4	556	I	SE	63	350	473		N	P	S	S		NA									
405	CL	18	1978	2_12	DS	4	D	100	50	4	741	I	SE	63	467	630		N	P	S	S		NA									
406	CL	18	1978	2_12	DS	1	Q	100	100	4	1481	I	SE	63	933	1260		N	P	S	S		NA									
407	CL	18	1978	2_12	DS	1	P	50	50	4	370	P	SW	63	233	315		N	C	S	R		NA									
408	CL	18	1978	2_12	DS	1	D	75	35	4	389	P	NE	63	245	331		N	C	S	R		NA									
409	CL	18	1978	2_12	DS	1	P	75	75	4	833	P	NE	63	525	709		N	C	S	N	L	NA									
410	CL	18	1978	2_12	DS	1	P	50	50	4	370	P	NE	63	233	315		N	C	S	N	L	NA									
411	CL	17	1978	2_12	DS	1	P	25	25	4	93	P	NE	63	58	79		N	P	S	R		C									
412	CL	17	1978	2_12	DS	3	D	50	50	4	370	P	NE	63	233	315		N	P	S	R		C									
413	CL	17	1978	2_12	DF	4	D	75	50	4	556	P	SW	63	350	473		N	C	H	S		C									
414	CL	20	1978	2_12	DS	3	D	80	60	4	711	P	SW	50	356	480	80	N	C	H	S		F								Y	
415	CL	20	1978	2_12	DT	2	D	200	150	4	4444	P	NE	63	2800	3780		N	C	N	S		C									500' torrent track
416	CE	27	1978	3_8	DS	1	P	50	50	4	370	I	SW	63	233	315		N	C	S	R		C									
417	CE	27	1978	3_8	DF	2	D	75	50	4	556	I	SW	63	350	473		N	C	N	R		C									
418	CE	27	1978	3_8	DS	1	D	100	50	4	741	I	SW	63	467	630		N	P	S	R		C									
419	CE	27	1978	3_8	DS	1	Q	100	75	4	1111	I	SE	63	700	945		R	C	N	S		C									
420	CE	27	1978	3_8	DS	1	D	50	25	4	185	P	NW	63	117	158		N	C	S	R		C									
421	CE	22	1978	3_10	DS	1	D	70	50	4	519	P	SW	25	130	175	70	N	C	S	R		C								Y	
422	CE	27	1978	3_10	DS	1	D	100	75	4	1111	P	SW	63	700	945		N	C	S	R		C									
423	CE	27	1978	3_10	DS	2	D	25	25	4	93	I	SE	63	58	79		N	C	N	S		C									
424	CE	21	1978	3_10	DS	2	P	75	50	4	556	I	NE	63	350	473		N	P	N	S		C									
425	CE	21	1978	3_10	DS	2	D	100	50	4	741	N	NE	0	0	0		N	P	N	S		C									
426	CE	21	1978	3_10	DS	2	D	75	50	4	556	N	NE	0	0	0		N	D	N	S		C									
427	CE	21	1978	3_10	DS	2	D	50	50	4	370	I	NE	63	233	315		N	P	S	S		C									
428	CL	15	1978	3_10	DS	1	D	100	50	4	741	P	NE	63	467	630		N	C	S	N	M	C									
429	CL	15	1978	3_12	DS	2	D	50	150	4	1111	P	NW	50	556	750	70	N	P	N	R		C								Y	
430	CL	15	1978	3_12	DS	2	D	100	75	4	1111	I	NW	50	556	750	85	N	D	N	R		C								Y	
431	CL	15	1978	3_12	DS	2	P	50	25	4	185	I	SW	63	117	158		N	C	S	S		C									
432	CL	15	1978	3_12	DS	2	Q	100	50	4	741	I	SE	63	467	630		N	P	S	S		C									
433	CL	15	1978	3_12	DS	3	D	100	100	4	1481	I	NW	63	933	1260		N	P	N	S		C									
434	CL	15	1978	3_12	DS	3	D	100	50	4	741	N	NW	0	0	0		N	C	N	S		C									
435	CL	15	1978	3_12	DS	2	Q	100	50	4	741	I	NW	63	467	630		N	C	N	R		C									Possible gully erosion

Watershed:		Elk Creek												Shallow-seated landslides											Deep-seated landslides							Mass Wasting Inventory Sheet Mendocino Redwood Company, LLC
Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type	TSU	Certainty	Length	Size Width	Depth	Slide Vol.	Sed. Routing	Dom. Aspect	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Contrib. Area	Soil Type	Struc. Class	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.	Comments
					DS DF DT EF RS	1 2 3 4 5 6	D P Q	feet	feet	feet	yd^3	P I N	NE SE NW SW	25 50 75 100 (%)	yd^3	tons	(%)	N R O	C D P	H S I N	R S L N I	S M L	USCS	1 to 24	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4	Y N	Y N	
436	CL	15	1978	3_12	DS	2	D	25	25	4	93	I	SE	63	58	79		N	C	N	S		C									
437	CL	15	1978	3_12	DS	2	D	150	150	4	3333	I	SE	63	2100	2835		N	P	N	S		C									
438	CL	10	1978	3_12	DS	4	P	100	150	4	2222	I	SW	63	1400	1890		N	P	H	R		NA									
439	CL	9	1978	3_12	DS	2	D	300	150	4	6667	I	SW	63	4200	5670		N	C	H	S		NA									
440	CL	9	1978	3_12	DS	2	D	100	50	4	741	I	SE	63	467	630		N	C	H	S		NA									
441	CL	9	1978	3_12	DS	2	P	75	50	4	556	I	SW	63	350	473		N	P	S	R		NA									
442	CL	16	1978	3_12	DS	1	D	100	50	4	741	P	NW	63	467	630		N	C	S	N	M	C									
443	CL	16	1978	3_12	DS	4	D	100	50	4	741	P	NE	63	467	630		N	C	S	R		C									
444	CL	16	1978	3_12	DS	1	D	100	50	4	741	P	SE	63	467	630		N	C	S	R		C									
445	CL	16	1978	3_12	DS	1	D	150	75	4	1667	P	SE	63	1050	1418		N	C	S	R		C									
446	CE	35	1978	4_6	DS	2	P	100	50	4	741	I	NE	63	467	630		N	C	H	S		F									
447	CE	35	1978	4_6	DT	2	P	150	100	4	2222	P	NE	63	1400	1890		N	C	H	S		C									500' torrent track
448	CE	35	1978	4_6	DS	2	P	50	50	4	370	I	NE	63	233	315		N	C	S	S		C									
449	CE	26	1978	4_6	DS	1	D	50	75	4	556	P	NE	63	350	473		N	C	S	N	M	C									
450	CE	26	1978	4_6	DS	3	Q	50	50	4	370	N	NE	0	0	0		R	P	N	N	M	C									
451	CE	26	1978	4_6	DS	3	P	75	75	4	833	I	NE	63	525	709		N	C	N	S		C									
452	CE	23	1978	4_6	DS	1	P	75	75	4	833	P	SW	63	525	709		N	C	S	R		C									Toe of DSL
453	CE	23	1978	4_6	DS	2	D	150	75	4	1667	I	SW	63	1050	1418		N	C	S	N	M	F									
454	CE	25	1978	4_6	DS	2	P	25	25	4	93	I	SW	63	58	79		N	P	S	N	S	C									
455	CE	24	1978	4_8	DS	3	D	100	150	4	2222	I	SW	63	1400	1890		N	P	H	R		C									cutslope failure, possible DSL
456	CE	24	1978	4_8	DS	4	P	75	75	2	417	I	SE	25	104	141	80	N	P	S	R		C								Y	
457	CE	23	1978	4_8	DS	2	D	100	50	3	556	I	SW	75	417	563	90	N	P	S	R		M								Y	
458	CE	23	1978	4_8	DF	3	D	75	30	2	167	I	SE	100	167	225	65	N	C	H	N	S	M								Y	open grassland
459	CE	23	1978	4_8	DF	4	D	75	25	3	208	I	SE	100	208	281	65	N	C	H	N	S	M								Y	open grassland
460	CE	23	1978	4_8	DF	4	D	100	50	4	741	I	SE	75	556	750	65	N	C	H	N	S	M								Y	open grassland
461	CE	23	1978	4_8	DF	4	D	100	50	4	741	I	NW	25	185	250	90	N	P	S	R		C								Y	250' runout
462	CE	24	1978	4_8	DS	4	D	100	50	4	741	I	SW	75	556	750	70	N	C	N	R		M								Y	
463	CE	6	1978	5_4	DS	2	Q	150	50	4	1111	I	NE	63	700	945		R	C	N	S		M									anomolous vegetation
464	CE	6	1978	5_4	DS	4	D	75	45	3	375	N	SW	0	0	0	75	N	P	N	R		M								Y	
465	CE	6	1978	5_4	DS	2	D	50	60	4	444	P	NW	50	222	300	70	N	P	S	S		M								Y	
466	CE	6	1978	5_4	DS	2	D	50	35	3	194	P	SW	75	146	197	70	N	P	S	S		M								Y	
467	CE	6	1978	5_4	DS	2	D	50	45	3	250	P	SE	100	250	338	85	N	P	S	S		M								Y	cutslope failure
468	CE	30	1978	5_5	DS	4	P	200	100	4	2963	P	SE	50	1481	2000	80	N	P	S	N	M	C								Y	
469	CE	30	1978	5_5	DT	4	D	100	75	4	1111	I	SW	63	700	945		N	C	H	R		C									750' torrent track
470	CE	30	1978	5_5	DS	3	Q	50	50	4	370	I	SW	63	233	315		N	C	H	R		C									
471	CE	19	1978	5_7	DS	2	P	100	75	4	1111	I	NW	63	700	945		N	C	N	S		F									Disrupted Ground
472	CE	19	1978	5_7	DS	2	D	200	100	4	2963	P	NW	63	1867	2520		N	P	S	N	S	F									
473	CE	25	1978	5_7	DF	3	P	150	75	4	1667	I	SE	63	1050	1418		N	C	H	N	M	C									
474	CE	20	1978	5_7	DS	2	D	50	50	4	370	I	SW	63	233	315		N	P	S	S		F									
475	CE	19	1978	5_7	DS	4	P	75	50	4	556	I	SW	63	350	473		N	P	S	S		M									
476	CE	24	1978	5_7	DF	2	P	150	75	3	1250	I	NE	50	625	844	80	N	C	S	S		C								Y	Assoc. w/ DSL#863
477	CE	19	1978	5_7	DS	3	D	100	75	4	1111	N	SW	0	0	0		N	P	N	R		F									
478	CE	20	1978	5_7	DS	2	P	100	50	4	741	I	SW	63	467	630		R	P	S	N	S	M									
479	CE	20	1978	5_7	DS	2	P	75	50	4	556	I	SW	63	350	473		R	P	S	N	M	F									
480	CE	33	1978	6_4	DS	2	D	100	100	4	1481	I	NW	63	933	1260		N	P	S	R		F									cutslope failure
481	CE	33	1978	6_4	DS	4	D	100	50	4	741	N	SW	0	0	0		N	P	N	N	L	C									
482	CE	33	1978	6_4	DS	2	D	75	50	4	556	P	SW	63	350	473		N	P	S	N	L	F									
483	CE	32	1978	6_4	DS	4	D	100	50	4	741	P	SE	63	467	630		N	P	S	N	L	F									
484	CL	6	1978	field obs	DS	2	D	100	50	4	741	I	SE	75	556	750	90	O	P	S	S		NA								Y	
485	CE	24	1978	field obs	DS	2	D	50	50	5	463	I	SE	25	116	156	80	O	C	S	R		C								Y	Assoc. w/ DSL#863
486	CE	30	1978	field obs	DF	2	D	200	30	4	889	P	SE	100	889	1200	82	O	C	S	N	L	C								Y	Toe failure off #24
487	CE	30	1978	field obs	DS	2	D	150	40	5	1111	P	SE	75	833	1125	90	O	C	S	N	L	C								Y	Toe failure off #24
488	CE	6	1978	field obs	DS	4	D	50	30	4	222	P	NW	75	167	225	70	O	P	S	S		M								Y	
489	CE	6	1978	field obs	DS	2	D	30	15	3	50	P	NW	75	38	51	70	O	P	S	S		M								Y	
490	CE	22	1978	field obs	DS	1	D	50	30	3	167	P	SE	75	125	169	80	O	P	S	R		C								Y	
500	CL	20	1987	M16_19	DS	1	D	75	60	4	667	P	NW	25	167	225	75	N	P	S	S		C								Y	
501	CL	20	1987	M16_19	DS	1	D	50	40	4	296	I	SW	75	222	300	75	N	C	S	S		C								Y	
502	CL	20	1987	M16_19	DS	1	D	50	50	4	370	I	NW	63	233	315		N	P	S	S		C									
503	CL	20	1987	M16_19	DS	1	D	50	75	4	556	I	NW	63	350	473		N	P	S	S		C									
504	CL	20	1987	M16_19	DS	1	D	50	25	4	185	I	NW	63	117	158		N	P	S	S		C									
505	CL	18	1987	M16_21	DS	1	P	50	50	4	370	P	SW	63	233	315		N	P	S	R		NA									
506	CL	17	1987	M16_21	DS	1	D	75	50	4	556	P	SW	63	350	473		N	C	S	R		C									
507	CL	7	1987	M16_21	DS	1	D	75	75	4	833	P	SW	63	525	709		N	P	S	R		NA									Cutslope failure
508	CL	7	1987	M16_21	DS	2	D	50	50	4	370	P	SE	63	233	315		N	P	S	N	L	NA									
509	CL	7	1987	M16_21	DF	3	Q	100	50	4	741	P	NE	63	467	630		N	C	H	N	L	NA									

Watershed:		Elk Creek												Shallow-seated landslides											Deep-seated landslides							Mass Wasting Inventory Sheet Mendocino Redwood Company, LLC
Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type DS DF DT EF RS	TSU 1 2 3 4 5 6	Certainty D P Q	Size Length feet	Width feet	Depth feet	Slide Vol. yd^3	Sed. Routing P I N	Dom. Aspect NE SE NW SW	Sed. Del. Ratio 25 50 75 100 (%)	Sed. Delivery yd^3	Sed. Delivery tons	Slope (field) (%)	Age N R O	Slope Form C D P	Slide Loc. H S I N	Road Assoc. R S L N I	Contrib. Area S M L	Soil Type USCS	Struc. Class 1 to 24	Toe Activity 1 2 3 4 5	Body Morph. 1 2 3 4 5	Lat. Scarps 1 2 3 4 5	Main Scarps 1 2 3 4 5	DS Veg. 1 2 3 4	Complex Y N	Field Obs. Y N	Comments
510	CL	7	1987	M16_21	DS	3	D	100	50	5	926	N	SW	0	0	0	75	N	P	N	R		NA								Y	
511	CL	7	1987	M16_21	DS	3	D	100	50	4	741	N	SW	0	0	0	75	N	C	N	S		NA								Y	
512	CL	8	1987	M16_21	DS	1	P	50	25	4	185	P	SE	63	117	158		N	P	S	N	L	NA									
513	CL	7	1987	M16_21	DS	1	D	100	100	6	2222	P	SE	50	1111	1500	90	N	P	S	R		NA								Y	toe failure of DSL#807
514	CL	7	1987	M16_21	DS	1	D	100	100	3	1111	P	NE	75	833	1125	110	R	C	S	N	L	NA								Y	
515	CL	7	1987	M16_21	DS	1	D	100	125	3	1389	P	NE	75	1042	1406	110	R	P	S	N	L	NA								Y	
516	CL	7	1987	M16_23	DS	4	D	75	50	4	556	I	NE	63	350	473		N	C	S	S		NA									
517	CL	6	1987	M16_23	DS	1	P	50	75	4	556	I	NW	63	350	473		R	C	N	S		NA									
518	CL	6	1987	M16_23	DS	2	D	75	100	4	1111	I	SW	63	700	945		N	P	S	S		NA									
519	CL	5	1987	M16_23	DS	2	P	50	50	4	370	I	SW	63	233	315		N	P	S	S		NA									
520	CL	20	1987	M17_22	DT	4	D	200	125	4	3704	I	SE	63	2333	3150		N	P	N	N	M	F									enlargement of 415, 500' torrent track
521	CL	21	1987	M17_22	DS	2	D	40	75	6	667	P	SW	50	333	450	90	N	P	N	S		C								Y	
522	CL	21	1987	M17_22	DS	2	D	100	200	4	2963	I	SW	63	1867	2520		N	P	N	S		C									
523	CL	21	1987	M17_22	DS	2	D	50	100	4	741	I	SW	63	467	630		N	P	N	S		C									
524	CE	21	1987	M17_22	DS	2	D	75	100	4	1111	I	NW	63	700	945		N	P	S	N	M	C									
525	CL	16	1987	M17_24	DS	1	D	75	75	4	833	P	NW	63	525	709		R	C	S	R		C									
526	CL	16	1987	M17_24	DS	1	P	100	200	3	2222	P	SW	75	1667	2250	120	N	P	S	N	M	F								Y	bedrock controlled trib junction
527	CL	16	1987	M17_24	DS	1	D	75	50	3	417	P	SW	100	417	563	120	N	P	S	S		C								Y	
528	CL	9	1987	M17_24	DS	2	D	75	100	4	1111	I	SW	63	700	945		N	P	S	S		NA									
529	CL	9	1987	M17_26	DS	2	P	50	100	4	741	I	SW	63	467	630		N	P	S	S		NA									
530	CL	9	1987	M17_26	DS	2	D	75	125	4	1389	I	NW	63	875	1181		N	P	S	S		NA									
531	CL	9	1987	M17_26	DS	2	D	75	75	4	833	I	SW	63	525	709		N	P	S	S		NA									
532	CL	9	1987	M17_26	DF	4	D	100	25	4	370	N	SE	0	0	0		N	C	N	N	S	NA									possible earthflow at this site
533	CL	8	1987	M17_26	DS	2	D	100	125	4	1852	I	SW	63	1167	1575		N	C	N	S		NA									cutslope failure at watercourse crossing
534	CL	8	1987	M17_26	DS	4	D	100	50	4	741	I	SE	25	185	250	75	N	C	H	R		NA								Y	
535	CE	27	1987	M18_23	DS	1	D	100	75	4	1111	I	SW	63	700	945		N	C	S	S		C									possible gully erosion
536	CE	21	1987	M18_23	DS	2	D	100	50	4	741	P	NW	63	467	630		N	P	S	S		C									
537	CE	27	1987	M18_23	DS	4	D	75	75	4	833	I	NE	63	525	709		N	P	S	R		M									
538	CE	27	1987	M18_23	DS	1	D	75	75	4	833	I	SW	63	525	709		N	P	S	S		C									
539	CE	22	1987	M18_25	DS	1	D	60	40	4	356	P	SW	75	267	360	80	N	P	S	R		C								Y	
540	CE	22	1987	M18_25	DS	1	D	65	60	4	578	P	SW	50	289	390	90	N	P	S	R		C								Y	
541	CE	22	1987	M18_25	DS	1	D	120	60	5	1333	P	SW	75	1000	1350	100	N	C	S	S		C								Y	
542	CL	15	1987	M18_25	DS	4	D	100	50	3	556	P	SW	25	139	188	65	N	P	S	R		F								Y	
543	CL	15	1987	M18_25	DS	4	D	100	75	3	833	P	SE	75	625	844	90	N	D	S	R		C								Y	
544	CL	15	1987	M18_25	DS	2	D	75	50	4	556	P	SW	63	350	473		N	P	S	S		C									
545	CL	15	1987	M18_25	DS	2	D	25	50	4	185	I	NW	63	117	158		N	P	S	S		C									
546	CL	15	1987	M18_25	DS	4	P	75	100	4	1111	I	SW	63	700	945		N	P	S	S		F									
547	CL	14	1987	M18_25	DS	2	D	50	50	4	370	I	SW	63	233	315		N	P	S	S		F									
548	CL	15	1987	M18_25	DS	2	D	50	40	5	370	I	NW	75	278	375	80	N	C	S	S		M								Y	
549	CL	14	1987	M18_25	DS	2	D	50	50	4	370	I	SW	63	233	315		N	P	S	S		M									
550	CL	10	1987	M18_27	DF	4	D	100	25	4	370	I	SE	63	233	315		N	C	H	N	M	M									possible gully erosion
551	CL	10	1987	M18_27	DF	4	D	75	25	4	278	I	SE	63	175	236		R	C	H	N	S	C									open grassland
552	CE	27	1987	M19_24	DS	2	D	100	75	4	1111	P	NE	63	700	945		N	P	S	S		C									
553	CE	22	1987	M19_24	DS	1	D	100	50	4	741	P	SW	63	467	630		N	C	S	R		C									cutslope failure
554	CE	22	1987	M19_24	DS	1	D	60	70	4	622	P	SE	50	311	420	80	N	C	S	R		C								Y	
555	CE	22	1987	M19_24	DS	1	D	50	50	4	370	P	SE	63	233	315		N	C	S	N	L	C									
556	CE	23	1987	M19_26	DS	2	D	75	50	4	556	P	SW	50	278	375	80	N	P	S	R		F								Y	
557	CE	22	1987	M19_26	DS	1	Q	100	50	4	741	I	SW	63	467	630		N	P	N	R		C									toe of DSL
558	CL	15	1987	M19_28	DS	2	D	125	75	4	1389	I	NW	63	875	1181		N	P	S	S		M									
559	CE	1	1987	M20_24	DS	2	Q	50	50	4	370	I	NE	63	233	315		N	C	N	R		C									
560	CE	1	1987	M20_24	DS	2	P	50	50	4	370	I	NE	63	233	315		N	P	N	S		C									
561	CE	36	1987	M20_24	DS	2	Q	50	50	4	370	I	SW	63	233	315		N	P	N	S		C									
562	CE	36	1987	M20_24	DS	2	Q	50	50	4	370	I	SE	63	233	315		N	P	N	S		M									
563	CE	2	1987	M20_24	DS	3	Q	50	50	4	370	I	NE	63	233	315		N	P	S	S		C									
564	CE	2	1987	M20_24	DS	2	D	50	75	4	556	I	SE	63	350	473		N	P	S	S		C									
565	CE	36	1987	M20_24	DS	1	D	100	75	4	1111	I	SW	63	700	945		N	C	S	S		C									possible DSL upslope of here
566	CE	35	1987	M20_26	DS	2	D	50	75	4	556	I	NE	63	350	473		N	P	N	S		C									
567	CE	26	1987	M20_26	DS	4	D	100	50	4	741	I	NE	63	467	630		N	C	S	S		C									
568	CE	26	1987	M20_26	DS	2	P	100	100	4	1481	I	SE	63	933	1260		N	P	S	S		C									
569	CE	26	1987	M20_26	DS	3	Q	75	75	4	833	I	SE	63	525	709		N	P	S	R		C									
570	CE	26	1987	M20_26	DS	2	Q	50	50	4	370	I	SE	63	233	315		N	P	N	S		C									
571	CE	23	1987	M20_28	DS	2	P	50	25	4	185	I	SE	63	117	158		N	P	N	S		C									
572	CE	23	1987	M20_28	DS	2	D	75	50	4	556	I	SE	63	350	473		N	C	N	S		C									
573	CE	23	1987	M20_28	DS	2	D	50	50	4	370	I	SW	63	233	315		N	P	S	N	L	F									
574	CE	23	1987	M20_28	DS	3	D	75	25	2	139	I	SW	100	139	188	65	N	C	H	N	S	M								Y	possible earthflow in here

Watershed:							Elk Creek							Shallow-seated landslides											Deep-seated landslides							Mass Wasting Inventory Sheet Mendocino Redwood Company, LLC
Unique	PWS	T & R	Air Photo	Air Photo	Landslide	TSU	Certainty		Size		Slide	Sed.	Dom.	Sed. Del.	Sed.	Sed.	Slope	Age	Slope	Slide	Road	Contrib.	Soil	Struc.	Toe	Body	Lat.	Main	DS	Complex	Field	
ID#		Sec. #	year	frame	Type			Length	Width	Depth	Vol.	Routing	Aspect	Ratio	Delivery	Delivery	(field)		Form	Loc.	Assoc.	Area	Type	Class	Activity	Morph.	Scarps	Scarps	Veg.		Obs.	Comments
					DS DF DT	1 2 3	D P Q	feet	feet	feet	yd^3	P I N	NE SE	25 50 75	yd^3	tons	(%)	N R O	C D P	H S I N	R S L	S M L	USCS	1 to	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3 4	Y N	Y N	
					EF RS	4 5 6							NW SW	100 (%)							N I			24	4 5	4 5	4 5	4 5				
575	CE	23	1987	M20_28	DS	2	D	75	50	4	556	I	NW	75	417	563	100	N	P	S	N	S	F								Y	lateral scarp of DSL
576	CE	31	1987	M21_21	DF	3	P	100	50	4	741	I	SE	63	467	630		N	C	H	S		C									
577	CE	36	1987	M21_21	DS	3	D	150	100	4	2222	I	NE	63	1400	1890		N	P	N	R		M									
578	CE	30	1987	M21_23	DS	1	P	150	75	4	1667	P	SE	63	1050	1418		N	C	S	N	M	M									
579	CE	30	1987	M21_23	DS	2	D	100	75	4	1111	I	SW	63	700	945		N	P	S	R		M									
580	CE	30	1987	M21_23	DS	2	P	50	50	4	370	I	NE	63	233	315		N	C	S	N	M	M									cutslope failure
581	CE	36	1987	M21_23	DS	1	D	100	100	5	1852	P	NE	75	1389	1875	75	N	C	S	L		M								Y	
582	CE	25	1987	M21_23	DS	1	D	75	50	4	556	P	NE	63	350	473		N	C	S	R		C									
583	CE	24	1987	M21_25	DS	3	D	150	100	4	2222	N	NE	0	0	0		N	P	S	R		C									
584	CE	24	1987	M21_25	DF	4	D	150	25	4	556	I	SE	63	350	473		N	C	N	N	M	M									open grassland
585	CE	19	1987	M21_25	DF	3	D	100	25	4	370	I	SE	63	233	315		N	C	N	N	S	M									
586	CE	19	1987	M21_25	DF	4	D	150	25	4	556	I	SW	63	350	473		N	C	N	N	M	M									
587	CE	19	1987	M21_25	DF	4	D	100	25	4	370	I	SW	63	233	315		N	C	N	N	M	M									
588	CE	19	1987	M21_25	DF	4	D	150	25	4	556	I	SW	63	350	473		N	C	N	N	S	M									
589	CE	23	1987	field obs	DS	2	D	150	75	8	3333	P	SW	50	1667	2250	80	O	P	S	S		F								Y	
590	CL	8	1987	field obs	DS	4	D	50	35	4	259	I	SE	100	259	350	75	O	C	N	S		NA								Y	
591	CL	9	1987	field obs	DS	1	D	75	40	4	444	I	SW	25	111	150	75	O	P	S	S		C									
592	CE	23	1987	field obs	DS	2	D	50	40	3	222	I	NW	100	222	300	100	O	P	S	N	S	F									
593	CE	24	1987	M21_25	DS	4	D	75	75	4	833	I	SE	63	525	709		N	C	N	R		C									
594	CL	20	1987	field obs	DS	1	D	75	50	5	694	P	NW	75	521	703	80	O	P	S	S		C								Y	
595	CE	22	1987	field obs	DS	1	D	50	75	5	694	P	NE	75	521	703	85	O	C	S	N	M	C								Y	
600	CL	17	2000	7B_11	DS	4	Q	150	50	4	1111	P	NE	63	700	945		N	C	S	R		C									
601	CL	17	2000	7B_11	DS	4	Q	100	75	4	1111	N	NE	0	0	0		N	C	N	N	M	C									
602	CL	7	2000	7B_11	DS	3	D	150	75	4	1667	P	SW	63	1050	1418		R	P	N	R		NA									
603	CL	7	2000	7B_11	DS	1	D	120	50	5	1111	I	SW	100	1111	1500	60	N	C	S	R		NA								Y	
604	CL	5	2000	7B_13	DS	2	P	75	50	4	556	I	SE	63	350	473		N	C	S	N	M	NA									
605	CL	5	2000	7B_13	DS	4	D	150	125	4	2778	I	SE	63	1750	2363		N	P	S	R		NA									
606	CL	16	2000	8B_15	DS	1	P	75	100	4	1111	P	NE	63	700	945		R	C	S	N	L	C									
607	CL	9	2000	8B_17	DT	2	D	250	100	4	3704	P	SW	63	2333	3150		N	C	H	N	M	NA									4000' torrent track
608	CL	9	2000	8B_17	DS	2	D	50	50	4	370	I	SW	63	233	315		N	P	S	R		NA									
609	CE	22	2000	9B_12	DS	1	D	100	75	3	833	P	SW	75	625	844	100	N	C	S	N	M	C								Y	
610	CE	21	2000	9B_12	DS	2	D	75	25	4	278	P	SE	63	175	236		N	P	S	S		C									
611	CE	22	2000	9B_12	DS	1	D	85	40	3	378	P	NE	75	283	383	85	N	C	S	N	M	C								Y	
612	CE	22	2000	9B_12	DS	1	D	100	50	4	741	P	SW	63	467	630		N	C	S	R		C									
613	CL	15	2000	9B_14	DS	1	P	100	50	4	741	P	NE	63	467	630		N	P	S	N	M	C									
614	CL	15	2000	9B_14	DS	2	D	75	50	4	556	I	SE	63	350	473		N	P	S	S		C									
615	CL	15	2000	9B_14	DS	2	D	50	50	4	370	I	SE	63	233	315		N	P	S	N	M	C									
616	CE	26	2000	10B_9	DS	1	D	75	50	4	556	P	SW	63	350	473		N	P	S	R		C									
617	CE	23	2000	10B_9	DT	4	D	150	75	4	1667	P	NE	63	1050	1418		N	C	H	S		C									300' torrent track
618	CE	23	2000	10B_11	DF	3	D	100	50	2	370	I	SW	100	370	500	60	N	C	H	N	S	M								Y	grassland
619	CE	36	2000	11B_11	DS	1	D	150	50	4	1111	P	NE	50	556	750	65	N	C	S	R		C								Y	toe failure off DSL#643
620	CE	36	2000	11B_11	DS	1	D	100	75	6	1667	P	NE	75	1250	1688	75	N	C	S	S		C								Y	toe failure off DSL#643
621	CE	24	2000	11B_13	DS	2	D	150	75	4	1667	I	NE	63	1050	1418		N	P	S	N	L	C									
622	CE	29	2000	12C_6	DS	2	D	150	75	4	1667	I	SW	63	1050	1418		N	C	H	N	L	F									
623	CE	20	2000	12C_8	DS	4	D	50	50	4	370	N	SW	0	0	0		N	P	N	N	M	M									grassland
624	CL	8	2000	field obs	DS	2	D	100	50	4	741	I	SW	75	556	750	85	N	P	S	R		NA								Y	
625	CE	22	2000	field obs	DS	2	D	50	30	3	167	P	SE	50	83	113	75	R	C	S	S		F								Y	
626	CL	8	2000	field obs	DS	4	D	50	30	4	222	I	SW	25	56	75	70	R	C	N	R		NA								Y	
627	CL	15	2000	field obs	DS	2	D	75	45	5	625	P	SE	25	156	211	70	R	P	S	R		F								Y	
628	CL	15	2000	field obs	DS	2	D	35	20	3	78	P	SW	100	78	105	60	R	P	N	N	L	C								Y	toe failure off DSL#818
629	CL	15	2000	field obs	DS	1	D	100	75	3	833	P	SW	75	625	844	110	R	C	S	N	S	C								Y	
630	CL	15	2000	field obs	DS	1	D	200	100	6	4444	P	SW	50	2222	3000	110	R	C	S	N	M	C								Y	toe failure off DSL#818
631	CL	15	2000	field obs	DS	1	D	100	75	3	833	P	SW	75	625	844	100	O	P	S	R		C								Y	R/R grade failure
632	CE	23	2000	field obs	DS	4	D	100	75	4	1111	P	SE	25	278	375	55	R	C	N	R		M								Y	likely DSL instability at this site
633	CE	23	2000	field obs	DS	4	D	100	50	4	741	P	SE	50	370	500	60	R	C	N	R		M								Y	
634	CE	31	2000	field obs	DS	1	D	20	20	3	44	P	NE	100	44	60	70	R	P	S	N	M	M								Y	
635	CE	31	2000	field obs	DS	1	D	50	100	6	1111	P	SW	25	278	375	75	R	C	S	R		M								Y	
636	CE	6	2000	field obs	DS	2	D	40	45	5	333	P	NW	50	167	225	95	R	P	S	S		M								Y	
637	CE	22	2000	field obs	DS	2	D	30	80	8	711	P	NW	75	533	720	70	R	P	S	R		F								Y	toe failure off DSL#867
700	CL	7	2004	16_24	DS	1	D	100	100	5	1852	P	SW	75	1389	1875	75	N	C	N	R		NA								Y	
701	CL	15	2004	18_90	DS	2	P	100	50	4	741	P	SW	63	467	630		N	P	S	S		C									
702	CE	25	2004	20_229	DS	3	Q	100	50	4	741	I	NE	63	467	630		N	P	H	N	M	C	21								
703	CE	27	2004	18_86	DS	2	D	50	50	4	370	I	NE	63	233	315		N	P	S	N	M	C	22								
704	CE	27	2004	18_86	DS	2	Q	100	100	4	1481	I	SE	63	933	1260		N	C	S	R		C									
705	CE	26	2004	19_38	DS	1	P	75	50	4	556	P	SW	63	350	473		N	C	S	N	S	C	10								

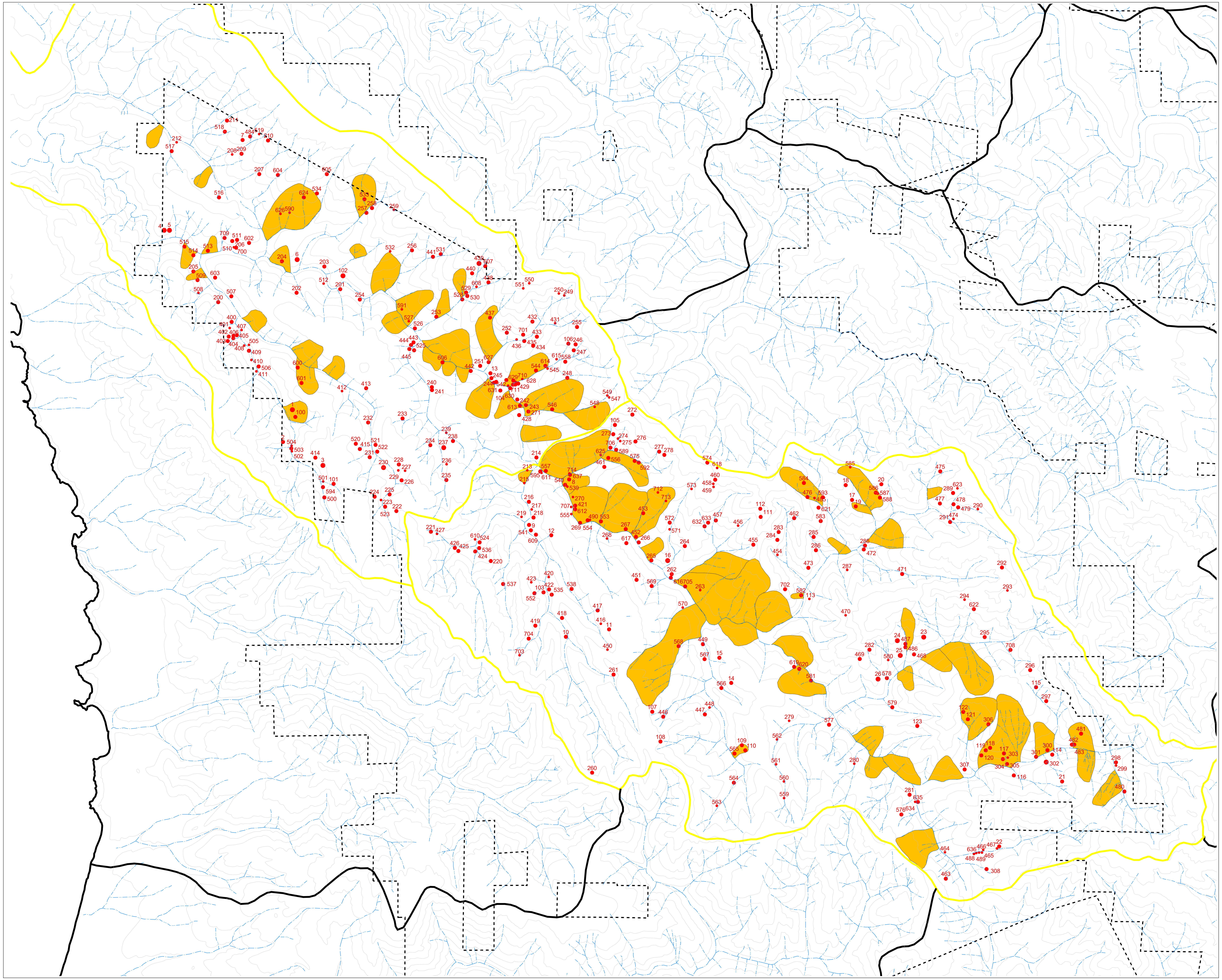
Watershed:		Elk Creek												Shallow-seated landslides											Deep-seated landslides							Mass Wasting Inventory Sheet Mendocino Redwood Company, LLC
Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type	TSU	Certainty	Size Length	Width	Depth	Slide Vol.	Sed. Routing	Dom. Aspect	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Contrib. Area	Soil Type	Struc. Class	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.	Comments
					DS DF DT EF RS	1 2 3 4 5 6	D P Q	feet	feet	feet	yd^3	P I N	NE SE NW SW	25 50 75 100 (%)	yd^3	tons	(%)	N R O	C D P	H S I N	R S L N I	S M L	USCS	1 to 24	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4	Y N	Y N	
706	CE	23	2004	19_40	DS	2	P	100	50	4	741	I	SW	50	370	500	90	N	P	S	N	S	F	21							Y	
707	CE	22	2004	19_40	DS	1	D	50	50	4	370	P	NE	63	233	315		N	C	S	N	L	C	22								
708	CE	29	2004	22_114	DS	2	P	75	100	4	1111	I	SW	63	700	945		N	C	S	N	M	C	22								
709	CL	7	2004	field obs	DF	2	D	70	60	4	622	P	SE	75	467	630	80	N	C	S	R		NA								Y	several large trees delivered
710	CL	15	2004	field obs	DS	2	D	50	25	4	185	P	SW	75	139	188	60	R	P	I	R		M								Y	toe failure off DSL#818
711	CL	15	2004	field obs	DS	1	D	30	10	2	22	P	SW	100	22	30	90	N	P	I	N	L	C	22							Y	toe failure off DSL#818
712	CE	23	2004	field obs	DS	4	D	30	20	2	44	I	SW	100	44	60	40	N	C	N	R		M								Y	on head of DSL#830
713	CE	23	2004	field obs	DS	4	D	50	40	3	222	I	SW	100	222	300	45	N	C	N	R		M								Y	on head of DSL#830
714	CE	22	2004	field obs	DS	2	D	30	30	4	133	I	SW	75	100	135	75	N	P	S	R		F								Y	
800	CL		1987	M16_21	RS		D	800	800			P													2	3	2	3	4	N		DSL's mapped from '87 and '00 photos
801	CL		1987	M16_21	RS		P	700	700			P													3	3	3	4	4	N		
802	CL		1987	M16_21	RS		D	700	400			P													2	2	2	2	4	N		
803	CL		1987	M16_21	RS		D	800	600			P													1	2	2	4	4	N		
804	CL		1987	M16_21	RS		P	800	600			P													3	3	3	3	4	N		
805	CL		1987	M16_21	RS		P	700	500			P													3	3	3	4	4	N		
806	CL		1987	M16_21	RS		D	800	400			P													2	3	4	4	4	N		
807	CL		1987	M16_21	RS		D	500	300			P													3	3	4	4	4	N		
808	CL		1987	M16_21	RS		Q	600	600			P													4	3	4	4	4	N		
809	CL		1987	M16_23	RS		Q	800	500			P													4	4	4	3	4	N		
810	CL		1987	M16_23	RS		P	700	400			P													4	3	3	4	4	N		
811	CL		1987	M17_24	RS		D	1500	1000			P													2	2	3	3	4	N		
812	CL		1987	M17_24	RS		P	800	1100			P													4	4	4	4	4	N		
813	CL		1987	M17_24	RS		D	1000	400			P													2	2	4	3	4	N		
814	CL		1987	M17_26	RS		P	900	400			P													2	3	4	3	4	Y	Y	
815	CL		1987	M17_26	RS		P	800	700			I													3	2	3	3	4	N		
816	CL		1987	M18_25	RS		P	100	500			P													4	3	4	3	4	N		
817	CL		1987	M18_25	RS		P	1300	1000			P													3	4	4	4	4	N	Y	
818	CL		1987	M18_25	RS		D	700	300			I													2	2	3	3	4	Y	Y	
819	CL		1987	M18_25	RS		D	1500	600			P													3	3	3	3	4	N		
820	CL		1987	M18_25	RS		D	2200	1000			P													2	2	3	3	4	N	Y	
821	CL		1987	M18_25	RS		P	1500	900			P													3	2	3	4	4	N	Y	
822	CL		1987	M18_25	RS		P	2000	700			P													2	2	2	3	4	N	Y	
823	CL		1987	M18_25	RS		D	1200	1500			P													3	2	3	3	4	N	Y	
824	CL		1987	M18_27	RS		P	900	400			I													3	3	4	3	4	N		
825	CL		1987	M18_25	RS		Q	600	500			P													3	3	4	3	4	N		
826	CL		1987	M18_25	RS		Q	600	500			P													3	4	4	3	4	N		
827	CE		1987	M19_26	RS		P	1200	1000			P													3	2	4	2	2	Y		
828	CE		1987	M19_26	RS		P	1800	1500			P													3	2	3	2	2	Y		
829	CE		1987	M19_26	RS		D	2000	500			P													3	3	2	2	2	N	Y	
830	CE		1987	M19_26	RS		P	2000	700			P													4	2	3	3	2	Y		
831	CE		1987	M19_26	RS		P	700	500			P													4	2	4	3	2	N		
832	CE		1987	M20_26	RS		P	1400	1000			P													4	3	3	3	2	N		
833	CE		1987	M20_26	RS		D	2000	2800			P													4	3	4	3	2	N	Y	
834	CE		1987	M20_26	RS		P	1500	1000			P													4	3	3	3	2	N		
835	CE		1987	M20_26	RS		P	400	200			P													3	3	2	3	4	N		
836	CE		1987	M20_26	RS		Q	600	400			I													4	3	3	3	4	N		
837	CE		1987	M21_21	RS		P	1400	1000			P													4	3	4	3	4	N		
838	CE		1987	M21_21	RS		Q	1000	1000			P													3	3	4	3	4	N		
839	CE		1987	M21_25	RS		P	1300	1200			P													4	3	3	3	4	N		
840	CE		1987	M21_25	EF		P	700	2000			P													4	2	3	4	4	N		
841	CE		1987	M21_25	EF		P	800	400			P													4	4	4	4	4	N		
842	CE		1987	M21_25	RS		D	700	350			P													4	4	4	4	4	N		
843	CE		1987	M21_23	RS		P	1100	1200			P													3	3	4	3	4	N		
844	CE		2000	12C_6	RS		D	2500	1100			P													3	3	4	3	4	N	Y	
845	CE		2000	12C_6	RS		P	1000	700			P													3	4	4	3	4	N		
846	CE		2000	12C_8	RS		Q	600	400			I													4	3	4	4	4	N		
847	CE		2000	13B_5	RS		D	1500	500			P													3	3	4	3	4	N		
848	CE		2000	13B_5	RS		P	1200	800			P													4	4	4	3	4	N		
849	CE		2000	13B_5	RS		P	1200	750			P													3	3	4	3	4	N		
850	CE		2000	13B_5	EF		D	2800	1000			P													2	2	3	2	2	Y	Y	
851	CE		2000	11B_11	RS		P	1000	1200			P													3	3	4	3	2	Y		
852	CE		2000	11B_11	RS		Q	1000	900			P													4	3	4	3	2	N	Y	
853	CL		1987	M18_25	RS		D	450	900			P													2	2	3	3	4	N		
854	CE		2000	10B_9	RS		P	3500	1000			P													3	3	3	3	4	N	Y	
855	CE		2000	10B_9	RS		P	1200	2000			P													3	2	3	3	4	N		

Watershed: Elk Creek

Shallow-seated landslides | *Deep-seated landslides*

Mass Wasting Inventory Sheet
Mendocino Redwood Company, LLC

Unique ID#	PWS	T & R Sec. #	Air Photo year	Air Photo frame	Landslide Type	TSU	Certainty	Size Length	Size Width	Size Depth	Slide Vol.	Sed. Routing	Dom. Aspect	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Contrib. Area	Soil Type	Struc. Class	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.	Comments
					DS DF DT	1 2 3	D P Q	feet	feet	feet	yd^3	P I N	NE SE	25 50 75	yd^3	tons	(%)	N R O	C D P	H S I N	R S L	S M L	USCS	1 to	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3 4	Y N	Y N	
					EF RS	4 5 6							NW SW	100 (%)							N I			24	4 5	4 5	4 5	4 5				
856	CE		2000	9B_13	RS		Q	450	500			P													3	3	3	3	4	N		
857	CE		2000	11B_9	RS		P	900	600			P													3	3	4	3	4	N		
858	CE		2000	12C_7	RS		D	1000	500			P													3	3	3	3	4	N		
859	CE		2000	13B_5	RS		D	1300	550			P													4	3	4	3	4	N		
860	CL		2000	7B_13	RS		D	1800	1500			P													3	2	4	3	4	N	Y	
861	CL		1987	M17_26	EF		D	700	500			P													4	3	4	4	4	N	Y	
862	CE		1987	M19_26	EF		D	1200	3000			P													3	3	4	4	3	Y	Y	
863	CE		1987	M21_25	EF		D	1500	1000			P													2	2	3	2	2	Y	Y	
864	CE		2000	12C_7	EF		D	900	600			P													3	2	3	2	2	Y	Y	
865	CE		2000	11B_9	EF		P	800	1700			P													4	2	4	4	2	Y	Y	
866	CE		2000	13B_5	EF		P	1500	1300			P													3	2	3	2	2	Y	Y	
867	CE		1987	M19_26	RS		D	1100	600			P													2	3	3	2	4	N	Y	



Elk Creek Watershed Analysis Unit

Map A-1
Mass Wasting Inventory

This map presents the location of mass wasting features identified on the MRC land in the Elk Creek watershed. The mass wasting features were developed from an interpretation of aerial photographs from the 1960's-2000 with field observation taken in 2003. All shallow-seated landslides are identified as a point plotted on the map at the interpreted head scarp of the failure. Deep-seated landslides are represented as a polygon representing the interpreted perimeter of the landslide feature. Physical and geomorphic characteristics of the landslides are categorized in a database in the mass wasting section of the Elk Creek watershed analysis.

Deep-Seated Landslides

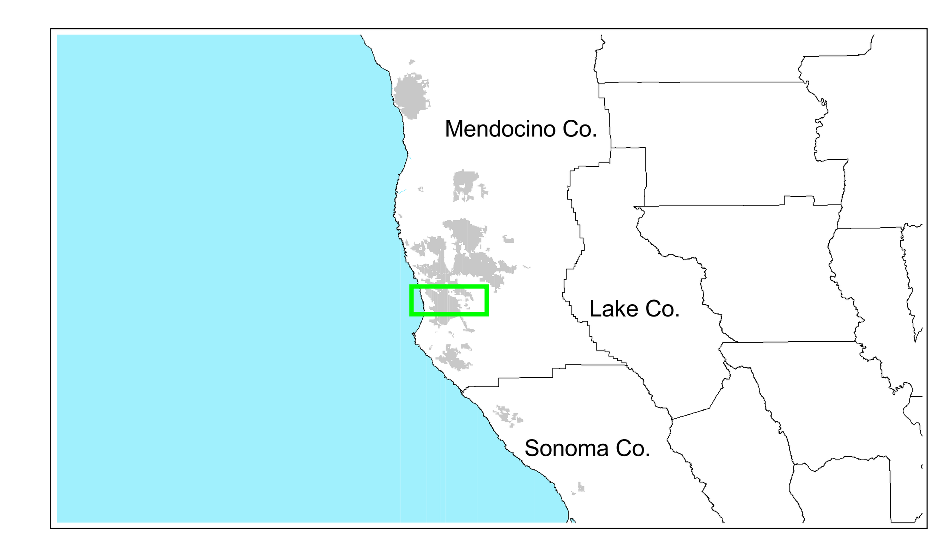
Shallow-Seated Landslides
- < 500 cubic yards
- 500 - 5000 cubic yards
- > 5000 cubic yards

Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse

200ft Elevation Contour

Planning Watershed Boundary
Elk Creek Watershed Boundary

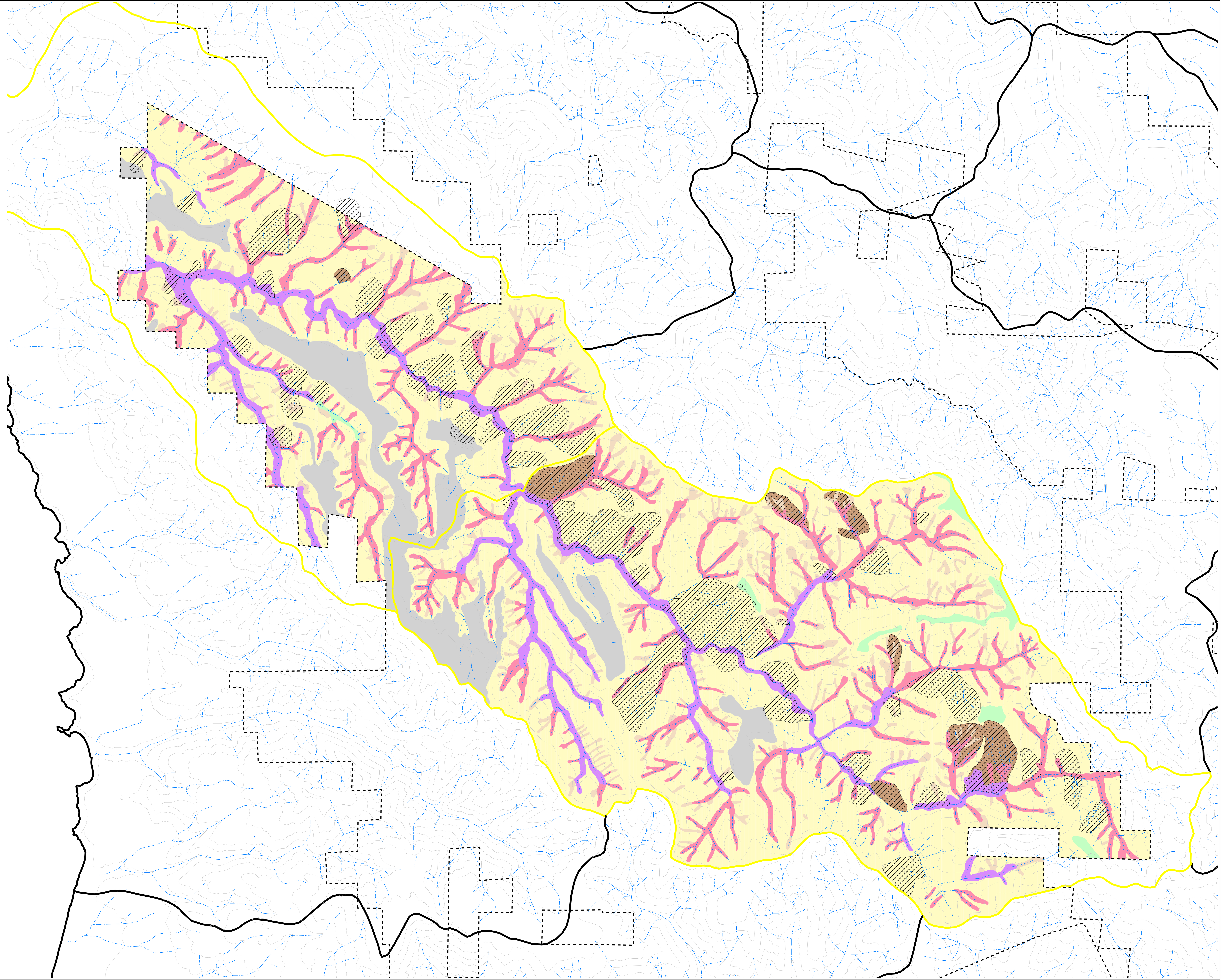
MRC Ownership Boundary



N

0 0.5 1 Miles

November 2007



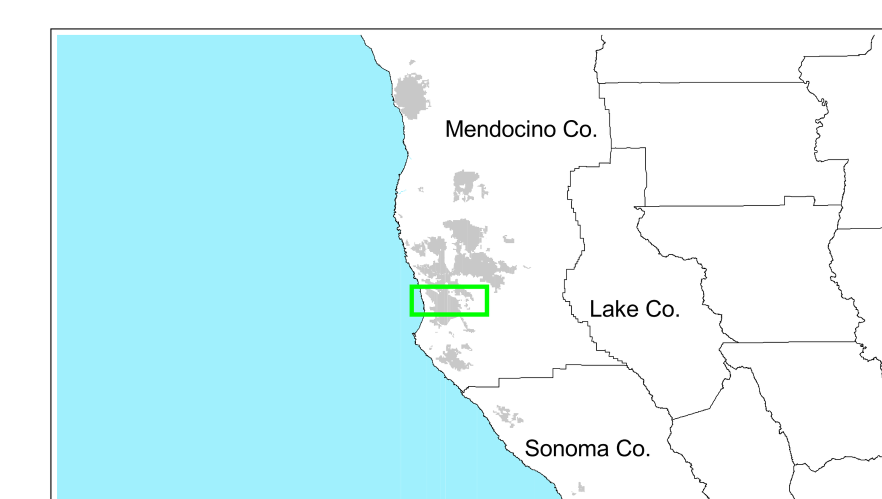
Elk Creek Watershed Analysis Unit

Map A-2
Terrain Stability Units

This map presents an interpretation of the terrain stability units (TSUs) delineated for the Elk WAU. The TSUs characterize the landscape by similiar geomorphic attributes, shallow-seated landslide potential, and sediment delivery potential. The TSU designations for the Elk WAU are only meant to be general characterizations of similiar geomorphic and terrain characteristics related to shallow seated landslides. Deep-seated landslides are also shown on this map. The deep-seated landslides have been included to provide land managers with supplemental information to guide evaluation of harvest planning and subsequent needs for geologic review. The landscape and geomorphic setting in the Elk WAU is more complex than generalized TSUs delineated for this evaluation. The TSUs are only meant to be a starting point for guaging the need for site specific field assessments. Field observations will over-ride unit boundaries of this map.

Unit 1: Inner gorge or steep slopes adjacent to low gradient watercourses
Unit 2: Inner gorge or steep slopes adjacent to high gradient intermittent or ephemeral watercourses
Unit 3: Dissected and convergent topography
Unit 4: Non-dissected topography
Unit 5: Low relief topography
Unit 6: Identified earthflow complexes
Unit 8: Unique geological terrain with low gradient slopes (typically <30%) that have a very high potential for surface erosion.

Deep Seated Landslides
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
200ft Elevation Contour
Planning Watershed Boundary
Elk Creek Watershed Boundary
MRC Ownership Boundary



N
0 0.5 1 Miles

November 2007