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 Garcia River watershed, the Garcia Watershed Analysis Unit (Garcia WAU). California Planning Watersheds included in the Garcia WAU include portions of Rolling Brook (GR), South Fork Garcia (GS), North Fork Garcia (GN), East of Eureka Hill (GB), and Inman Creek (GI). 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 budget for the Garcia WAU, contained in the Sediment Budget section of this watershed analysis (Section 6).

The products of this report are: a landslide inventory map (Map A-1), a mass wasting map unit (MWMU) map (Map A-2), and a mass wasting inventory database (Appendix A). The assembled information will enable forest 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.

LANDSLIDE TYPES AND PROCESSES IN THE GARCIA WAU

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 Garcia 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 in some rockslides is likely to have occurred over time in response to seismic shaking or high rainfall events. Deep-seated landslides can be very large, exceeding tens to hundreds of acres.

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 can 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. 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 consist of 80% or more of the particles smaller than 2mm as stated in Cruden and Varnes (1996). Materials in an earth flow also commonly contain boulders, some very large, which move downslope 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 Garcia WAU

SHALSTAB, a coupled steady state runoff and infinite-slope stability model, is used by MRC as one tool to demonstrate the relative potential for shallow-landslide hazard across the MRC ownership. A detailed description of the model is available in Dietrich and Montgomery (1998). In the watershed analysis, mass wasting hazard is expanded beyond SHALSTAB. Areas of mass wasting and sediment delivery hazards are mapped using field and aerial photograph interpretation techniques. However, SHALSTAB output was used to assist in this interpretation of the landscape and mass wasting map 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. Photographs from 2000 (1:12,000, color), 1996 (1:12,000, color), 1978 (1:15,840, color), 1966 (1:18,000, black and white), and 1952 (1:20,000, black and white) were used to interpret landslides. 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:
  - GR – Rolling Brook
  - GS – South Fork Garcia River
  - GN – North Fork Garcia River
  - GB – East of Eureka Hill
  - GI – Inman Creek
- MWMU # – Mass Wasting Map 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.
- 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 volume and mass 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.
  - A - active (<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

- Deep-seated landslides morphologic descriptions: toe, body, lateral scarps, and main scarp (see below for descriptions).

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 feature (body and scarp). 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 (~100 lbs./cubic foot).

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.

Two techniques were employed in order to extrapolate a sediment volume delivery percentage to landslides not visited in the field. Landslides that were determined to be directly adjacent to a watercourse from topographic maps and aerial photograph interpretation were assigned 100% delivery. Landslides that were determined to deliver, but were not directly adjacent to a watercourse, were assigned the mean delivery percentage from landslides observed 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 Garcia 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, landing, or skid trail 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 58 years. Sediment input to stream channels by mass wasting is quantified for four time periods (1943-1952, 1953-1966, 1967-1978, 1979-2000). The evaluation assumes that approximately the last 10-20 years of mass wasting can be observed in the aerial photograph. Landslide surfaces revegetate quickly, making mass wasting features older than approximately 10-20 years difficult to see. We acknowledge that we have likely missed some 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.

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. 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.

Numerous small inner gorge landslides were discovered during the 1997 field reconnaissance that were not apparent on the aerial photographs. To characterize the contribution of these small shallow-seated failures, volume estimates were tallied along selected reaches within the Garcia WAU and extrapolated to similar areas not visited in the field by using an estimated volume contribution per unit length of the stream channel. A delivery rate was estimated for the 1978-1997 time period and extrapolated back through the previous three time periods to estimate the historic sediment input from these small inner gorge landslides.

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 Garcia 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. To determine this, the slide surface should be carefully explored for 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 Garcia WAU, likely during timber harvest plan preparation and review.

Deep-seated landslides were only interpreted by reconnaissance techniques (aerial photograph interpretation rather than 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 Garcia WAU suggest 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 either 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

Mass Wasting Map Units

Mass Wasting Map Units (MWMUs) 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 MWMUs. The MWMU designations for the Garcia 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 MWMU 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 Garcia WAU is certainly more complex than generalized MWMUs delineated for this evaluation. The MWMUs are only meant to be a starting point for gauging the need for site-specific field assessments.

The delineation of each MWMU 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 MWMU description defines the terrain found within the MWMU. The mass wasting process section is a summary of landslide types found in the MWMU. 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 MWMU 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 MWMU.

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 documents attributes associated with each landslide (Appendix A). The spatial distribution and location of landslides is shown on Map A-1.

A total of 365 shallow-seated landslides (debris slides, torrents, or flows) were identified and characterized in the Garcia WAU. A total of 25 deep-seated landslides (rockslides or earthflows) were mapped in the Garcia WAU. A considerable effort was made to field verify as many landslides as possible to insure greater confidence in the results. A total of 44% 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 365 shallow-seated landslides observed in the Garcia 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 Garcia WAU by Time Periods.

Planning Watershed	1943 - 1952 Landslides	1953 - 1966 Landslides	1967 - 1978 Landslides	1979 – 2000 Landslides
Rolling Brook	19	29	32	54
South Fork Garcia	14	28	50	111
North Fork Garcia	0	0	1	0
East of Eureka Hill	3	0	3	15
Inman Creek	0	0	6	0

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

Planning Watershed	Debris Slides	Debris Flows	Debris Torrents	Rock-Slides	Earth-Flows	Total	Road Assoc.
Rolling Brook	131	2	1	9	0	143	21
South Fork Garcia	200	2	1	8	1	212	81
North Fork Garcia	1	0	0	0	0	1	0
East of Eureka Hill	21	0	0	3	4	28	0
Inman Creek	6	0	0	0	0	6	1

The majority of landslides observed in the Garcia WAU are debris slides and rockslides. Of the 365 shallow-seated landslides in the Garcia WAU, 103 are determined to be road-associated. This is approximately 28% of the total number of shallow-seated landslides. There were 6 debris torrents and flows observed in the Garcia WAU. This is approximately 2% of the total shallow landslides observed in the Garcia WAU.

Of the mapped landslides observed in the field, a total of 97% of the shallow landslides inventoried were initiated on 65% slopes, or greater. Four landslides occurred on slopes with gradients less than 65%; all four were road associated. The majority of inventoried landslides originated in convergent topography where subsurface water tends to concentrate, or on steep, planar topography 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, where subsurface water is routed to the sides of ridges. Such observations were, in part, the basis for the delineation of the WAU into Mass Wasting Map Units.

Mass Wasting Map Units

The landscape was partitioned into six Mass Wasting Map Units (MWMU) 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 MWMUs was based on qualitative observations and interpretations from aerial photographs, field evaluation, and SHALSTAB output. Deep-seated landslides are also shown on the MWMU 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, magnitude of stream incision, and overall geomorphology. The range of slope gradients was determined from USGS 1:24000 topographic maps and field observations. Hillslope and landslide morphology vary within each individual Mass Wasting Map Unit 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 MWMUs and at deep-seated landslides or specific areas of some MWMUs to assess the risk and likelihood of mass wasting impacts from a proposed management action. The Mass Wasting Map Units are compiled on the entitled Mass Wasting Map Unit Map (Map A-2).

MWMU Number: 1

Description: Inner Gorge or Steep Slopes adjacent to Low Gradient Watercourses

Materials: Shallow soils formed on weathered marine sedimentary rocks. May be composed of toe sediment of deep-seated landslide deposit.

Landform: Characterized by steep slopes or steep inner gorge topography along low gradient watercourses (typically less than 6-7%). An inner gorge is considered a geomorphic feature created from down cutting of the stream in response to tectonic uplift. Inner gorge slopes extend from either one side or both sides of the stream channel to the first break in slope. Inner gorge slope gradients typically exceed 70%. Slopes with lower inclination are locally present. Height of inner gorge range from 25 to 300 feet in the Garcia WAU. Slopes commonly contain areas of multiple, coalescing shallow seated landslide scars of varying age. Steep slopes adjacent to low gradient streams are generally planar in form with slope gradients typically exceeding 70%. The upper extent of the unit is variable, and a distinct break in slope is not always present. Where there is not a break in slope, the unit may extend 150 feet upslope (based on the range of lengths of landslides observed 8-1320 feet, mean length of all landslides in the unit is 105 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: 70% to vertical, (mean slope of observed mass wasting events is 89%, range: 50%-120%)

Total Area: 1012 acres; 9% of the total WAU area

MW Processes: 51 road-associated landslides

- 51 Debris slides
- 0 Debris flow
- 0 Debris torrent

154 non-road associated landslides

- 154 Debris slides
- 0 Debris torrent
- 0 Debris flows

Non Road-related Landslide Density: 0.15 landslides per acre for the past 58 years.

Forest Practices Sensitivity: High sensitivity to road construction due to proximity to watercourses, bedrock underlying inner gorge slopes creates increased stability, high sensitivity to harvesting and forest management practices due to steep slopes with localized colluvial or alluvial soil deposits next 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, all 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.
- 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.
- 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.
- Concentrated drainage from roads can increase groundwater, accelerating movement of rockslides or earth flows and over-steepening inner gorge slopes.
- Removal of vegetation above these slopes can result in a reduction of rainfall interception and evapotranspiration and thus increase pore water pressures that could create debris slides in this unit.

Confidence: High confidence for susceptibility of landslides and sediment delivery in this unit. Moderate confidence in placement of this unit. This unit is locally variable and exact boundaries are better determined from field observations.

MWMU Number: 2

Description: Steep slopes or inner gorge topography 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 slopes or inner gorge topography adjacent to high gradient intermittent or ephemeral watercourses. An inner gorge is considered a geomorphic feature created from down cutting of the stream in response to tectonic uplift. Inner gorge slopes extend from either one side or both sides of the stream channel to the first break in slope. Inner gorge slope gradients typically exceed 70%. Slopes with lower inclination are locally present. Steep slope form is largely concave or planar with gradients typically greater than 70%. The break in slope in this unit is typically about 100 feet from the watercourse (based on mean observed debris slide length of 86 feet; maximum observed landslide length is 330 feet). Landslides in this unit commonly are debris slides that deposit sediment directly into Class II and III watercourses. Occasionally the debris slides can form debris torrents that can transport material down the slope through and out of this unit. This unit typically extends upstream from MWMU 1.

Slope: >70% (mean slope of observed mass wasting events is 87%, range: 70%-100%).

Total Area: 665 acres; 6% of total WAU area

MW Processes: 7 road-associated landslides

- 6 Debris slides
- 1 Debris flow
- 0 Debris torrent

35 non-road associated landslides

- 33 Debris slides
- 2 Debris flow
- 0 Debris torrent

Non Road-related Landslide Density: 0.05 landslides per acre for the past 58 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, due to the steep converging topography of the slope in both unmanaged and managed conditions.

Delivery Potential: High

Delivery Criteria Used: Steep slopes adjacent to stream channels, all 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 over-steepen the slope 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 remove support of the toe or expose potential failure planes of rockslides or earth 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.
- Loss of evapotranspiration from forest harvest can increase groundwater levels initiating or accelerating movement in rockslides or earth flows or aid in the initiation of debris slides, torrents or flows.

Confidence: High confidence for susceptibility of unit to landslides and deliver sediment. 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 areas of low gradient slopes that are less susceptible to mass wasting.

MWMU 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 60%) 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) local very steep planar slopes, where there is strong evidence of past shallow landslide failures. MRC intends this unit to represent areas of potential high to moderate high risk for shallow landslides, and that does not constitute a continuous streamside unit (otherwise would classify as MWMU 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 verification of diagnostic landslide form features.
Slope:	>60%, (mean slope of observed mass wasting events is 79% range: 45%-90%)
Total Area:	711 acres, 6% of the total WAU
MW Processes:	10 *road associated landslides* • 9 Debris slides • 0 Debris flow • 1 Debris Torrent *23 non-road associated landslides* • 22 Debris slides • 1 Debris flow • 0 debris torrent
Non Road-related Landslide Density:	0.03 landslides per acre for the past 58 years.
Forest Practices Sensitivity:	Moderate to high sensitivity to road building, moderate to high sensitivity to harvesting and forest management practices due to moderately 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 73% 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 over-steepen the slope creating debris slides in this unit.
- Cut-slope of roads can over-steepen the slope 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 remove support of the toe or expose potential failure planes of rockslides or earth 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.
- Loss of evapotranspiration from forest harvest can increase groundwater levels initiating or accelerating movement in rockslides or earth flows or aid in the initiation of debris slides, torrents or flows.

Confidence: Moderate confidence in placement of unit. This unit is locally variable and exact boundaries are better 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 with weak soils, and unusually adverse ground water conditions.

MWMU 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. Unit is generally a midslope region of lesser slope gradient and more variable slope form than unit 3.

Slope: >40%, (mean slope of observed mass wasting events 79%, range: 60%-120%)

Total Area: 8559 acres, 76% of the total WAU

MW Processes: 36 *road-associated landslides*

- 36 Debris slides
- 0 Debris flow
- 0 Debris torrent

36 non-road associated landslides

- 36 Debris slides
- 0 Debris flow
- 0 Debris Torrents

Non Road-related Landslide Density: 0.004 landslides per acre for the past 58 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 has the largest area, which accounts for it having the highest number of landslides. This unit has a low landslide density, and therefore has a moderate mass wasting hazard. Although the landslides in this unit are highly localized, when landslides occur, the landslide has a high potential to deliver. Approximately 89% of landslides in this unit delivered sediment. This unit has a moderate sensitivity to road building due 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 over-steepen the slope creating debris slides in this unit.
- Cut-slope of roads can over-steepen the slope 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 remove support of the toe or expose potential failure planes of rockslides or earth 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.
- Loss of evapo-transpiration from forest harvest can increase groundwater levels initiating or accelerating movement in rockslides or earth flows or aid in the initiation of debris slides, torrents or flows.

Confidence: High confidence in placement of unit. Some areas within this unit could have higher susceptibility to landslides and higher delivery rates due to localized areas of steep slopes with weak soils, and adverse groundwater conditions.

MWMU Number: 5

Description: Low relief topography

Material: Moderately deep to deep soils, formed from weathered marine sedimentary rocks.

Landforms: Characterized by low gradient slopes generally less than 40%, although in some places slopes can 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: Unknown (no field observations)

Total Area: 245 acres, 2% of WAU area

MW Processes: no shallow landslides

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.

MWMU 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. This unit is 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: Unknown (no field observations)

Total Area: 359 acres; 3% of the total WAU.

MW Processes: 2 *road-associated landslides*

- 2 Debris slides
- 0 Debris flow
- 0 Debris torrent

2 non-road associated landslides

- 2 Debris slides
- 0 Debris flow
- 0 Debris Torrents

Non Road-related Landslide Density: 0.006 landslides per acre for past 58 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 at a site specific basis due to variable topography and differing rates of movement within an earth flow.

Mass Wasting Potential: High

Delivery Potential: High

Delivery Criteria Used: Many of the earth flows in the Garcia 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 six is consistent with confidence level in mass wasting inventory mapping of deep-seated earthflows. High confidence in hazard potential rating due to relatively low hazard for shallow-seated landslides.

Sediment Input from Mass Wasting

Sediment delivery was estimated for shallow-seated landslides in the Garcia 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 5.9 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 for non road related landslides, and 5.9 feet for road related landslides, was assigned to all landslides not verified in the field.

Landslides that were determined to be directly adjacent to a watercourse from topographic maps and aerial photograph interpretation were assigned 100% delivery. The mean sediment delivery percentage assigned to shallow landslides determined to deliver sediment, but not visited in the field, is 76%. Of the 365 shallow-seated landslides mapped by MRC in this watershed analysis, 92% of the landslides delivered some amount of sediment (Table A-4).

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

Planning Watershed	Total Landslides	Landslides with Sediment Delivery	Landslides with No Sediment Delivery
Rolling Brook	134	127	7
South Fork Garcia	203	183	20
North Fork Garcia	1	1	0
East of Eureka Hill	21	18	3
Inman Creek	6	6	0
sum	***365***	***335***	***30***
Percentage	***100%***	***92%***	***8%***

Mass wasting was separated into 4 time periods for analysis: 1943-1952, 1953-1966, 1967-1978, and 1979-2000. The dates for each of the time periods are based on the date of aerial photographs used to interpret landslides (1952, 1966, 1978, 1996, and 2000) and field observations (1997 and 2003). The available aerial photography did not correspond to ten year time periods for mass wasting assessment, however the time periods and the aerial photographs analyzed approximate decadal intervals. These time periods allow for a general evaluation of the relative magnitude of sediment delivery rate estimates across the Garcia WAU.

The sediment contribution from mapped shallow-seated landslides was added to the estimated contribution of small inner gorge landslides to arrive at a total estimated sediment delivery from mass wasting. A total of 768,435 tons of mass wasting sediment delivery was estimated for the time period 1943-2000 in the Garcia WAU. This equates to approximately 752 tons/sq. mi./yr. Of the total estimated amount, 117,512 tons (15% of total) occurred from 1943-1952, 144,461 tons (19% of total) occurred from 1953-1966, 264,628 tons (34% of total) occurred from 1967-1978, and 241,834 tons (32% of total) occurred in the 1979-2000 time period (Table A-5).

Table A-5. Sediment Delivery by Time Period for Garcia WAU (displayed in tons).

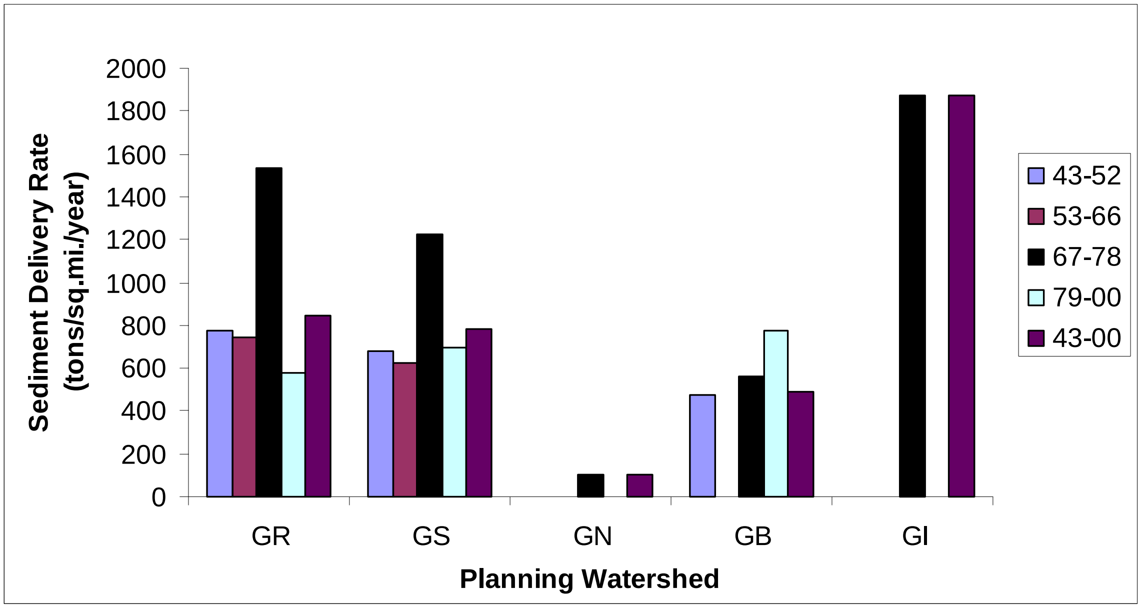
Inputs	Watershed	1943–52	1953–66	1967–78	1979–00	Total
Landslide Sediment Input	Rolling Brook	42163	56054	115645	61455	275317
	South Fork	34279	41753	93853	79165	249050
	North Fork	-	-	752	-	752
	E. Eureka Hill	7746	-	11014	27900	46660
	Inman Creek	-	-	3375	-	3375
Inner Gorge Sediment Input[a]	Rolling Brook	13229	18520	15874	29103	76726
	South Fork	20095	28134	24115	44211	116555
	North Fork	-	-	-	-	-
	E. Eureka Hill	-	-	-	-	-
	Inman Creek	-	-	-	-	-
Total Mass Wasting Sediment Input	Rolling Brook	55392	74574	131519	90558	352043
	South Fork	54374	69887	117968	123376	365605
	North Fork	-	-	752	-	752
	E. Eureka Hill	7746	-	11014	27900	46660
	Inman Creek	-	-	3375	-	3375
	Garcia WAU	***117512***	***144461***	***264628***	***241834***	***768435***

[a] - estimated sediment delivery input from tally of small inner gorge landslides

The highest overall sediment inputs from mass wasting occurred in the South Fork Garcia, and Rolling Brook planning watersheds. The higher sediment delivery appears to be due to two factors. Landslides that occur on roads and skid trails adjacent to watercourses appear to be an ongoing sediment source. Perhaps more importantly, an active inner gorge feature is present along most of the length of the South Fork Garcia and Fleming Creek, the two main tributary streams in the South Fork Planning Watershed, and along Rolling Brook, Lee Creek, and Hutton Gulch, the main tributaries in the Rolling Brook Planning Watershed. The inner gorge feature is being sculpted by shallow-seated landsliding processes as a result of active stream erosion.

The delivery rate in both the South Fork and Rolling Brook planning watersheds changes dramatically over the time period investigated (Chart A-1).

Chart A-1. Mass Wasting Sediment Input Rate (tons/yr/sq. mi.) from Landslides for MRC Ownership in Garcia Shown by Watershed and Time Period.



The sediment delivery rates presented for the North Fork Garcia (GN), East of Eureka Hill (GB), and Inman Creek (GI) planning watersheds, are based on a small number of landslides (one in GN, six in GI, and 18 in GB). The estimated sediment delivery rates presented are greatly influenced by the small amount of MRC ownership in those respective planning watersheds (397 acres in GN, 96 acres in GI, and 1,050 acres in GB). MRC ownership is much greater in the Rolling Brook (4,582 acres) and South Fork Garcia (5,148 acres) planning watersheds, as a result a greater number of slides were used to generate the sediment delivery rate (127 slides in GR, 183 slides in GS)

The highest delivery rates for the Rolling Brook (GR), and South Fork Garcia (GS) planning watersheds occurs in the 1966-1978 time period. The large increase in sediment delivery rate may be largely attributed to an intense rainfall event which occurred in 1974. Another reason for the high amount of mass wasting in the 1966-1978 time period is that roads poorly constructed prior to 1966 may have begun to fail. Mass wasting sediment delivery rates are substantially less in the other two time periods. The smallest sediment delivery rate for the Rolling Brook planning watershed occurred in the 1978-1997 time period in contrast to the 1952-1966 time period in the South Fork planning watershed. This is probably due to better forest practices and road construction standards created from the California Forest Practice rules. This time period also saw a decline in the harvesting activity in the WAU. Mass wasting delivery to stream channels was also assessed for individual hydrologic units. A summary of this data is found in Table A-7.

Table A-7. Estimated Landslide, Small Inner Gorge, and Total Mass Wasting Sediment Delivery Estimates for Hydrologic Units in the Garcia River WAU per Time Period.

Hydrologic Unit	Inputs	1943-1952 (tons)	1952-1966 (tons)	1967-1978 (tons)	1979-2000 (tons)
South Fork	LS[a]	NA	10,100	8,657	13,707
	IG[b]	13,126*	18,377*	15,752*	28,878
	Total	13,126	28,477	24,409	42,585
Fleming Creek	LS	8,198	1,870	17,786	15,185
	IG	5,569*	7,796*	6,682*	12,252
	Total	13,767	9,666	24,468	27,437
Rolling Brook	LS	28,753	11,424	78,598	5,392
	IG	2,494*	3,491*	2,992*	5,486
	Total	31,274	14,915	81,590	10,878
Mill Creek	LS	1,856	17,287	19,374	18,854
	IG	7,114*	9,960*	8,537*	15,651
	Total	8,970	27,247	27,911	34,505
Lee Creek	LS	4,200	4,537	5,628	2,212
	IG	1,282*	1,796*	1,539*	2,821
	Total	5,482	6,333	7,167	5,033
Hutton Gulch	LS	4,406	20,676	11,104	7,495
	IG	778*	1,089*	933*	1,711
	Total	5,184	21,765	12,037	9,206
Garcia R. Main Stem and Tribs	LS	29,028	31,135	79,330	34,850
	IG	8,347*	11,686*	10,017*	18,364
	Total	37,375	42,821	89,347	53,214
Buehler	LS	7,746	NA	NA	29,746
Inman	LS	NA	NA	441	NA

[a] - estimated sediment delivery input from landsliding
[b] - estimated sediment delivery input from tally of small inner gorge landslides
* - extrapolated from field observations from 1979-2000 time period

This data illustrates the fact that inner gorge slides are a major component of sediment delivery to streams. Although inner gorge slides deliver less sediment per event, they are more frequent than other landslides and are a significant contributor of sediment over long time intervals.

The Rolling Brook hydrologic unit and the tributaries of the main stem Garcia River show a much greater amount of sediment delivery in the 1967-1978 time period than the other sub-basins. The South Fork, Fleming, and Mill Creek show more sediment delivery in the 1979-2000 time period. The larger amount of sediment delivery is partly attributed to the longer time frame between aerial photos used in the analysis. Another possible reason is that the lack of field data for the 1943-1952, 1953-1966, and 1967-1978 time periods; this has likely resulted in an underestimate of sediment delivery volume.

Road associated mass wasting was found to have contributed 153,709 tons (150 tons/sq. mi./yr) of sediment over the 58 years analyzed (1943-2000) in the Garcia WAU (Table A-6). This represents approximately 20% of the total mass wasting sediment inputs for the Garcia WAU for 1943-2000. In the South Fork Garcia planning watershed, road associated sediment delivery was a major sediment source, contributing 31% of the sediment delivered from mass wasting. In the

Inman Creek planning watershed, road related mass wasting contributed 80% of the sediment delivered, however, only six landslides had been mapped and inventoried, the largest of which was road related.

Table A-6. Road Associated Sediment Delivery for Shallow-Seated Landslides for Garcia WAU by Planning Watershed.

Planning Watershed	Road Associated Mass Wasting Sediment Delivery (tons)	Percent of Total Sediment Delivery From Planning Watershed
Rolling Brook	37969	11
South Fork Garcia	113027	31
North Fork Garcia	0	0
East of Eureka Hill	0	0
Inman Creek	2713	80
Total	***153709***	***20%***

Sediment Input by Mass Wasting Map Unit

Total mass wasting sediment delivery for the Garcia WAU was separated into respective mass wasting map units. Sediment delivery statistics for each MWMU are summarized in Table A-7. It should be noted that not all planning watersheds contain all six MWMUs.

Table A-7. Total Sediment Delivery by Mass Wasting Map Units in the Garcia WAU

MWMU	1	2	3	4	5	6
Road Related						
Sediment Delivered (tons)	74285	6587	20777	55893	0	956
Non-Road Related						
Sediment Delivered (tons)[a]	445406	37414	39614	55916	0	2932
Total						
Sediment Delivered (tons)	519691	44001	60391	111809	0	3888
% road related delivery for WAU	47	4	13	35	0	1
% non-road related delivery for WAU	77	6	7	10	0	1
% of total delivered for WAU	70	6	8	15	0	1
% of WAU area	9	6	6	73	2	3
% ratio: delivery %/area %	7.8	1.0	1.3	0.2	0.0	0.3

[a] - this combines the landslide sediment delivery with the estimated inner gorge sediment delivery

The mass wasting map unit with the highest sediment delivery is MWMU 1, which is estimated to deliver 68% of the total sediment input for the Garcia WAU. This is due to the large amount of sediment being delivered by landsliding within the inner gorge. An estimated 35% of the road related sediment is being delivered from MWMU 4. This is likely due to the high road density within this unit which makes the actual hazard of the unit appear artificially high. One measure of the intensity of mass wasting processes in a MWMU is the amount of sediment produced divided by the area in the MWMU. 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 MWMU. High values of this ratio indicate high landslide rates in a concentrated area. The MWMU with the highest ratio was unit 1 with a ratio of 7.8. While unit 5 and 4 had the lowest ratio with unit 5 having 0.0 and unit 4 having a ratio of 0.2.

CONCLUSIONS

In forest environments of the California Coast Range, mass wasting is a common, natural occurrence. In the Garcia WAU this is due to steep slopes, the condition of weathered and intensely sheared and fractured marine sedimentary rocks, seismic activity along the San Andreas Fault, 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 Garcia WAU. The vast majority of the landslides visited in the field during this assessment occurred on slopes greater than 60%, in main and side scarps. 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.

The steep streamside areas of MWMU 1 contribute the highest amount of the sediment per unit area in the watershed. In the moderate hazard units (MWMU 4) a large amount of road associated landslides are occurring, suggesting the need to make improvements on roads within the Garcia WAU.

Approximately 28% of the shallow-seated landslides in the Garcia WAU are road associated. Road associated mass wasting represented 20% of the sediment delivery. 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.

In the Garcia WAU, landslides greater than 300 cubic yards in size represented approximately 50% of the sediment delivery estimated. Landslides greater than 200 and 100 cubic yards in size represented approximately 65% and 85%, respectively of the sediment delivery estimated. Mass wasting sediment input is estimated to be at least 752 tons/square miles/year over the 1943-2000 time period for the entire Garcia WAU. Overall in the Garcia WAU, sediment delivery from mass wasting was highest in the South Fork Garcia planning watershed. The large amount of road related landslides adjacent to watercourses, and the actively eroding inner gorge feature, are the predicted reasons for the high sediment delivery.

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Garcia Mass Wasting Inventory
Appendix A

Mass Wasting Inventory Sheet
Mendocino Redwood Company, LLC

Watershed: Garcia

												Shallow-seated landslides								*Deep-seated landslides*						
Unique	PWS	T & R	Air Photo	MWMU	Landslide	Certainty	Size			Slide	Sed.	Sed. Del.	Sed.	Sed.	Slope	Age	Slope	Slide	Road	Toe	Body	Lat.	Main	DS	Complex	Field
ID#		Sec. #	year / number		Type		Length	Width	Depth	Vol.	Routing	Ratio	Delivery	Delivery	(field)		Form	Loc.	Assoc.	Activity	Morph.	Scarps	Scarps	Veg.		Obs.
					DS DF DT	D P Q	feet	feet	feet	yd^3	P I N	25 50 75	yd^3	tons	(%)	A R O	C D P	H S I N	R S L	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3 4	Y N	Y N
					EF RS							100 (%)							N I	4 5	4 5	4 5	4 5			
1	GS	4	1996	4	DS	D	126	45	6	1260	I	60	756	1021	84		P		R							Y
2	GS	4	1996	4	DS	D	70	60	8	1244	P	65	809	1092	60		C		R							Y
3	GS	4	1996	1	DS	Q	42	50	4	311	P	76	236	319			C									
4	GS	4	1996	4	DS	D	80	46	5	681	P	90	613	828	75		C		R							Y
5	GS	4	1996	1	DS	D	130	60	3	867	P	100	867	1170	92		P		R							Y
6	GS	6	1996	4	DS	P	33	33	4	161	N															
7	GS	31	1996	4	DS	Q	117	17	4	295	N						D									
8	GS	4	1996	1	DS	Q	50	8	4	59	P	76	45	61												
9	GS	4	1996	3	DS	Q	33	33	4	161	N						C									
10	GS	4	1996	1	DS	P	25	17	4	63	P	76	48	65												
11	GS	5	1996	1	DS	D	67	50	2	248	P	20	50	67	80		P		R							Y
12	GS	32	1996	1	DS	D	25	33	12	367	P	70	257	347			C		R							
13	GS	3	1996	1	DS	P	41	50	4	304	P	76	231	312			D									
14	GS	3	1996	1	DS	Q	33	25	4	122	P	76	93	125												
15	GS	3	1996	1	DS	Q	50	17	4	126	P	76	96	129												
16	GS	31	1996	4	DS	P	17	50	4	126	P	100	126	170					N							
17	GS	31	1996	1	DS	D	40	60	2	178	P	90	160	216			C		N							
19	GS	32	1996	2	DS	P	33	33	4	161	P	76	123	166			D									
20	GS	32	1978	1	DS	D	167	133	3	2468	P	95	2344	3165	110		C		R							Y
21	GS	32	1978	1	DS	D	150	83	2	922	P	100	922	1245	>100		C		N							Y
22	GS	32	1996	1	DS	Q	150	8	2	89	P	100	89	120	>100		C		N							Y
23	GS	32	1978	1	DS	D	117	67	1	290	P	100	290	392	>100		C		N							Y
24	GS	32	1996	1	DS	Q	167	8	1	49	P	100	49	67	>100		C		N							Y
25	GS	29	1978	1	DS	P	83	66	4	812	P	76	617	833												
26	GS	29	1966	3	DS	D	167	133	2	1645	N						D		I							
27	GR	30	1996	1	DS	D	33	33	4	161	P	76	123	166			C									
28	GR	30	1996	1	DS	D	167	65	3	1206	P	95	1146	1547	110		C		R							Y
29	GR	30	1996	1	DS	D	300	42	3	1400	P	90	1260	1701	110		C		R							Y
30	GR	19	1996	3	DS	D	58	33	4	284	N						C									
31	GR	17	1996	3	DS	D	116	83	4	1426	N						C									
33	GR	18	1966	1	DS	D	100	200	1	741	P	100	741	1000					N							
34	GR	18	1966	1	DS	D	100	167	1	619	P	100	619	835					N							
35	GR	17	1996	3	DS	Q	117	58	4	1005	I	76	764	1031			C									
36	GR	18	1978	1	DS	Q	60	16	4	142	P	76	108	146												
41	GB	15	1996	1	DS	P	25	33	4	122	I	76	93	125												
42	GB	15	1996		DS	P	10	30	4	44	I	76	34	46												
43	GB	15	1996	1	DS	P	200	50	4	1481	P	76	1126	1520												
44	GB	15	1996	1	DS	D	83	66	4	812	P	76	617	833												
45	GB	15	1996	1	DS		17	50	4	126	P	76	96	129												
47	GB	15	1996		DS	P	250	150	4	5556	P	76	4222	5700												
48	GB	10	1996	6	DS	D	167	33	4	816	P	76	620	838												
49	GB	10	1996	6	DS	D	150	167	5.9	5474	N								R							
56	GB	14	1996	4	DS	Q	250	16	4	593	N								N							
57	GB	14	1996		DS	D	67	67	5.9	981	I	76	746	1006					R							
58	GB	10	1996	6	DS	D	533	8	5.9	932	I	76	708	956					R							
59	GB	10	1996	4	DS	D	133	100	4	1970	I	76	1497	2022					N							
60	GB	10	1996	4	DS	D	250	66	4	2444	I	76	1858	2508					N							
61	GB	10	1996	4	DS	P	333	200	4	9867	I	76	7499	10123					N							
62	GB	10	1996		EF	D	1800	500			I								N	4	3	3	3	1	N	
63	GB	15	1996		EF	P	1500	500			P								N	4	3	3	3	1	N	

												Shallow-seated landslides								Deep-seated landslides						
Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type	Certainty	Size Length	Width	Depth	Slide Vol.	Sed. Routing	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.
					DS DF DT EF RS	D P Q	feet	feet	feet	yd^3	P I N	25 50 75 100 (%)	yd^3	tons	(%)	A R O	C D P	H S I N	R S L N I	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
64	GB	10	1996	6	DS	D	166	83	4	2041	I	76	1551	2094					N							
65	GN	9	1978	3	DS	D	150	33	4	733	P	76	557	752												
76	GS	3	1996	4	DS	P	42	83	4	516	P	76	392	530					N							
78	GS	3	1996	1	DS	Q	33	16	3	59	P	20	12	16	65		P		R							Y
79	GS	3	1996	4	DS	D	33	16	4	78	P	76	59	80					N							
80	GS	3	1996	4	DS	D	217	58	5.9	2750	P	76	2090	2822					R							
83	GS	3	1996	2	DS	P	175	42	8	2178	P	100	2178	2940	100		P		N							Y
84	GS	3	1996	4	DS	D	90	31	3	310	N				100		D		R							Y
85	GS	3	1996	4	DS	D	110	33	4	538	P	30	161	218	88		P		R							Y
86	GS	3	1996	4	DS	D	160	60	5	1778	P	50	889	1200	85		P		R							Y
86A	GS	3	1996	2	DS	D	50	20	7	259	P	40	104	140					R							
87	GS	3	1996	4	DS	Q	67	16	5.9	234	P	76	178	240					R							
88	GS	3	1996	4	DS	P	115	68	6	1738	P	20	348	469	90		P		R							Y
89	GS	3	1996	3	DS	D	50	120	7	1556	N				45		D		R							Y
90	GS	3	1996	2	DS	Q	8	8	4	9	P	76	7	10					N							
96	GS	34	1996	4	DS	D	83	33	5.9	599	P	76	455	614					R							
99	GS	33	1996	2	DS	Q	50	50	4	370	P	76	281	380												
100	GS	33	1996	2	DS	D	33	33	4	161	P	76	123	166												
101	GS	33	1996	2	DS	Q	50	66	4	489	P	76	372	502												
102	GS		1978		DS	D	440	264	1	4302	P	76	3270	4414					R							
103	GS	33	1996	4	DS	D	133	42	4	828	P	76	629	849					N							
106	GS	3	1996	3	DS	D	133	25	5.9	727	I	76	552	745					R							
107	GS	3	1996	3	DS	D	117	25	5.9	639	I	76	486	656					R							
108	GS	31	1996	1	DS	Q	83	66	4	812	P	76	617	833												
109	GS	25	1996	3	DS	P	366	88	4	4772	P	76	3626	4896												
110	GR	25	1996	4	DS		67	33	4	328	N															
111	GR	25	1996	2	DS	D	50	33	5.9	361	I	76	274	370					R							
112	GR	25	1996	4	DS	D	45	66	4	440	I	76	334	451												
113	GS	30	1996	1	DS	P	33	13	4	64	P	76	48	65												
114	GS	30	1996	1	DS	D	80	133	2	788	P	76	599	809	>100		P		I							Y
115	GR	30	1978	4	DS	D	235	50	8	3481	P	90	3133	4230	74		C		N							Y
115A	GR	30	1996	1	DS	D	50	50	5	463	P	100	463	625	74				N							Y
115B	GR	30	1996	1	DS	D	210	50	3	1167	P	100	1167	1575	74				N							Y
116	GR	30	1996	1	DS	D	66	100	3	733	P	76	557	752	74		P		I							Y
117	GR	30	1996	1	DS	D	83	50	3	461	P	76	350	473	74		P		I							Y
118	GR	30	1996	1	DS	Q	200	50	4	1481	N															
119	GR	30	1996	1	DS	Q	33	33	4	161	N															
121	GR	19	1996	4	DS	D	76	30	8	676	I	100	676	912	80		C		R							Y
122	GR	19	1996	2	DS	P	33	33	4	161	P	76	123	166												
123	GR	19	1996	4	DS	P	110	60	3	733	P	100	733	990	100		P		I							Y
124	GR	19	1996	1	DS	D	25	50	2	93	P	50	46	63			P		I							
125	GR	19	1996	4	DS	D	116	100	5.9	2535	P	76	1926	2601					R							
126	GR	18	1996	1	DS	D	83	83	4	1021	P	76	776	1047												
127	GR	18	1996	2	DS	P	25	33	4	122	P	76	93	125												
128	GR	24	1978	1	DS	D	132	66	3	968	P	100	968	1307					I							
128A	GR	24	1996	1	DS	D	100	30	9	1000	P	100	1000	1350					I							
129	GR	24	1978	1	DS	D	110	66	3	807	P	100	807	1089					I							
130	GR	24	1996	1	DS	D	83	25	1.5	115	P	80	92	125					I							
131	GR	19	1996	4	DS	D	116	50	4	859	I	76	653	882												
132	GR	18	1996	1	DS	Q	30	30	5.9	197	P	20	39	53	110		D		R							Y
133	GR	13	1996	2	DS	D	25	25	4	93	I	76	70	95												
134	GR	13	1996	2	DS	P	16	16	4	38	I	76	29	39												

												Shallow-seated landslides								Deep-seated landslides						
Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type	Certainty	Size Length	Size Width	Size Depth	Slide Vol.	Sed. Routing	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.
					DS DF DT EF RS	D P Q	feet	feet	feet	yd^3	P I N	25 50 75 100 (%)	yd^3	tons	(%)	A R O	C D P	H S I N	R S L N I	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
136	GR	13	1996	2	DS	D	66	33	4	323	I	76	245	331												
137	GR	13	1996	1	DS	P	100	66	6	1467	P	95	1393	1881	90		D		R							Y
138	GR	12	1996	1	DS	P	16	66	4	156	P	76	119	161												
139	GR	12	1966	1	DS	D	167	88	4	2177	P	76	1655	2234												
140	GR	12	1996	2	DS	P	42	117	4	728	P	76	553	747												
141	GR	12	1996	1	DS	P	16	50	4	119	P	76	90	122												
142	GR	12	1996	1	DS	P	16	33	4	78	P	76	59	80												
143	GR	12	1966	1	DS	D	117	33	4	572	P	76	435	587												
144	GR	12	1978		DS	D	367	83	4	4513	P	76	3430	4630												
145	GR	12	1978	1	DS	D	100	50	4	741	P	76	563	760												
146	GR	12	1978	1	DS	P	50	33	4	244	P	76	186	251												
147	GR	12	1996	1	DS	P	266	67	4	2640	P	76	2007	2709												
148	GR	12	1978	1	DS	D	100	66	4	978	P	76	743	1003												
149	GR	12	1996	1	DS	P	16	16	4	38	P	76	29	39												
150	GR	12	1996	1	DS	P	16	16	4	38	P	76	29	39												
151	GS	31	1996	1	DS	D	83	50	2	307	N				90		D		N							Y
152	GS	31	1996	1	DS	P	50	42	3	233	P	90	210	284	75		P		N							Y
153	GS	31	1996	1	DS	D	133	67	30	9901	P	50	4951	6683	50		C		R							Y
154	GS	31	1996	1	DS	D	60	40	3	267	P	100	267	360	100		C		N							Y
154A	GS	31	1996	1	DS	D	80	40	3	356	P	100	356	480					N							
155B	GR	18	1978	1	DS	D	367	350	12	57089	P	80	45671	61656	80		C									Y
155A	GR	18	1966	4	DS	D	220	110	4	3585	P	80	2868	3872												
156	GS	31	1952	1	DS	D	250	250	4	9259	P	76	7037	9500												
157	GS	4	1952	2			277	42	4	1724	I	76	1310	1768												
158	GS	32	1952	1	DS	D	83	33	2	203	P	20	41	55	>100		P		N							Y
159	GS	29	1952	3	DS	P	28	28	4	116	I	76	88	119												
160	GS	29	1952	3	DS	D	28	28	4	116	I	76	88	119												
161	GS	32	1952	1	DS	P	334	120	4	5938	P	76	4513	6092												
162	GS	32	1952	1	DS	P	55	27	4	220	N															
163	GS	32	1952	3	DS	P	55	42	4	342	N															
164	GS	30	1952	2	DS	D	139	56	4	1153	P	76	876	1183												
165	GS	30	1952	1	DS	D	139	83	4	1709	P	76	1299	1754												
166	GS	30	1952	3	DF	Q	389	28	4	1614	P	70	1130	1525												
167	GR	25	1952	4	DS	D	111	42	4	691	I	76	525	709												
168	GR	29	1952	3	DS	D	222	55	4	1809	I	76	1375	1856												
169A	GR	24	1952	1	DS	D	50	150	5	1389	P	100	1389	1875												
169B	GR	24	1952	1	DS	D	60	40	1	89	P	100	89	120												
169C	GR	24	1952	1	DS	D	30	5	1	6	P	100	6	8												
169D	GR	24	1952	1	DS	D	150	100	2	1111	P	100	1111	1500												
169E	GR	24	1952	1	DS	D	250	250	8	18519	P	100	18519	25000												
169F	GR	24	1952	1	DS	D	50	50	2	185	P	100	185	250												
170	GR	13	1952	1	DS	D	250	56	6	3111	P	100	3111	4200	100		D		N							Y
171	GR	12	1952	1	DS	D	83	56	4	689	P	76	523	706												
172	GR	12	1996	3	DS	D	250	33	4	1222	P	76	929	1254												
173	GR	12	1996	4	DS	P	116	133	4	2286	P	76	1737	2345												
174	GR	12	1952	1	DS	D	111	14	4	230	P	76	175	236												
175	GR	12	1952	3	DS	D	111	28	4	460	P	76	350	472												
176	GR	12	1952	1	DS	D	83	111	4	1365	P	76	1037	1400												
177	GR	12	1952	1	DS	P	55	28	4	228	P	76	173	234												
178	GR	12	1952	1	DS	D	69	56	4	572	P	76	435	587												
179	GR	12	1952	1	DS	D	139	28	4	577	P	76	438	592												
180	GR	12	1952	1	DS	D	28	42	4	174	P	76	132	179												

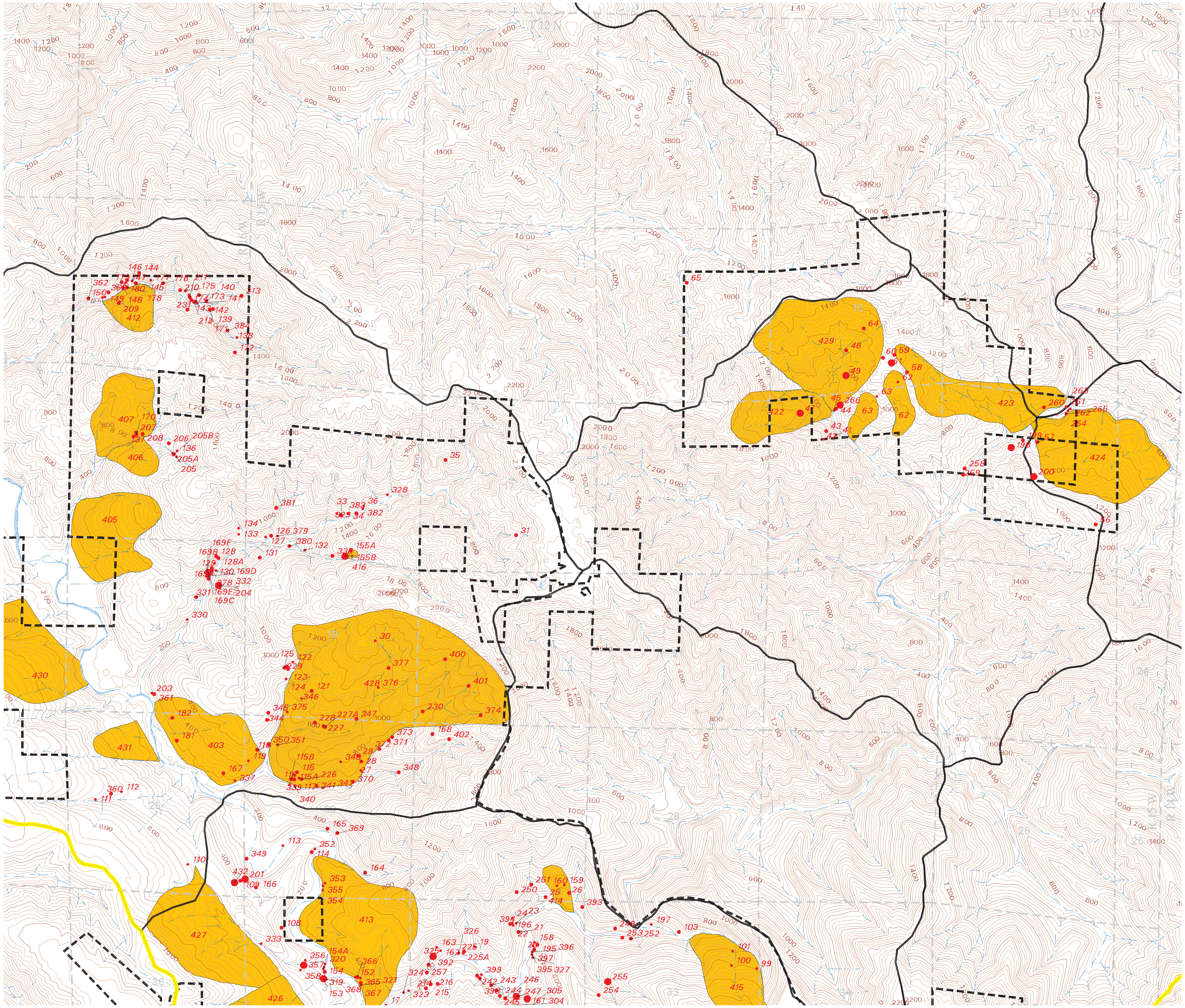
												Shallow-seated landslides								*Deep-seated landslides*						
Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type	Certainty	Size Length	Width	Depth	Slide Vol.	Sed. Routing	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.
					DS DF DT EF RS	D P Q	feet	feet	feet	yd^3	P I N	25 50 75 100 (%)	yd^3	tons	(%)	A R O	C D P	H S I N	R S L N I	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
181	GR	25	1952	4	DS	P	28	138	4	572	I	76	435	587												
182	GR	25	1952	4	DS	D	194	56	4	1609	I	76	1223	1651												
183	GS	3	1952	3	DS	D	278	194	4	7990	I	76	6072	8198												
184	GS	3	1996	1	DS	P	42	83	4	516	I	76	392	530												
185	GS	3	1966	1	DS	D	88	88	4	1147	P	76	872	1177												
186	GS	3	1996	1	DS	P	67	17	4	169	I	76	128	173												
187	GS	3	1996	1	DS	D	50	17	1	31	P	90	28	38												
188	GS	4	1996	1	DS	D	83	55	15	2536	P	95	2409	3253	100		P		N							Y
189	GS	4	1996	1	DS	D	42	17	4	106	P	76	80	109												
190	GS	4	1996	1	DS	D	25	17	4	63	P	76	48	65												
195	GS	32	1952	1	DS	D	222	208	2	3420	P	80	2736	3694	>100		P		N							Y
196	GS	32	1952	1	DS	D	194	28	1	201	P	100	201	272	>100		C		N							Y
197	GS	33	1996	1	DS	D	33	83	4	406	P	76	308	416												
198	GB	14	1952		DS	D	333	111	4	5476	P	76	4162	5618												
199	GB	14	1952		DS	D	250	56	4	2074	P	76	1576	2128												
200	GB	14	1952		DS	P	416	305	4	18797	N															
201	GS	30	1978	3	DS	P	308	220	4	10039	P	90	9035	12197												
203	GR	24	1978	1	DS	D	44	33	4	215	P	76	163	221												
204	GR	24	1978	4	DS	D	330	99	5	6050	P	90	5445	7351	120		P		I							Y
205	GR	13	1978	2	DS	D	100	40	3	444	I	100	444	600	100		C		I							Y
205A	GR	13	1978	2	DF	D	150	5	3	83	I	100	83	113					I							
205B	GR	13	1978	2		D	60	50	30	3333	I	100	3333	4500					R							
206	GR	13	1966	2	DS	D	44	176	4	1147	I	76	872	1177												
207	GR	13	1966	1	DS	D	200	140	3	3111	P	80	2489	3360	100		D		R							Y
208	GR	13	1978	1	DS	D	70	66	3	513	P	60	308	416	100		D		R							Y
209	GR	12	1966	3	DS	D	418	44	5.9	4019	P	76	3054	4123					R							
210	GR	12	1978	1	DS	D	66	66	4	645	P	76	490	662												
211	GR	12	1966	1	DS	D	66	66	4	645	P	76	490	662												
212	GR	12	1966	1	DS	D	66	66	4	645	P	76	490	662												
213	GR	12	1978	3	DT	D	154	110	5.9	3702	P	76	2813	3798					R							
214	GS	32	1978	1	DS	D	132	88	5.9	2538	P	76	1929	2604					R							
215	GS	32	1978	1	DS	D	110	66	5.9	1586	P	76	1206	1628					R							
216	GS	32	1978	4	DS	D	132	88	5.9	2538	P	76	1929	2604					R							
217	GS	32	1978	3	DS	D	44	22	4	143	I	76	109	147												
218	GS	31	1978	3	DS	D	60	28	3	187	N						P		R							
219	GS	32	1978	4	DS	D	66	44	3	323	N															
220	GS	5	1978	1	DS	D	66	110	3	807	P	20	161	218	80		P		R							Y
221	GS	5	1978	1	DS	D	66	66	4	645	P	76	490	662												
222	GS	4	1978	1	DS	D	110	66	4	1076	P	76	817	1104												
223	GS	4	1978	1	DS	P	440	88	4	5736	I	76	4360	5885												
224	GS	4	1978	1	DS	D	88	66	4	860	P	76	654	883												
225	GS	32	1978	1	DS	D	110	60	4	978	P	100	978	1320			P		N							
225A	GS	32	1978	1	DS	D	10	8	1	3	P	100	3	4					N							
226	GR	30	1978	1	DS	D	176	110	4	2868	P	76	2180	2943	74		P									Y
227	GR	30	1978	4	DS	D	264	110	2	2151	P	60	1291	1742	75		P		I							Y
227A	GR	30	1978	4			100	35	4	519	P	20	104	140					I							
228	GR	30	1966	4	DS	D	396	110	2	3227	P	80	2581	3485	75		C		I							Y
229	GR	19	1978	4	DS	D	110	110	5.9	2644	I	76	2009	2713					R							
230	GR	20	1978	2	DS	P	220	110	4	3585	I	76	2725	3678												
231	GR	12	1966	4	DS	P	264	110	4	4302	P	76	3270	4414												
232	GS	3	1978		DT	P	176	88	4	2295	P	76	1744	2354												
233	GS	3	1978	1	DS	D	286	88	4	3729	P	76	2834	3826												

												Shallow-seated landslides								Deep-seated landslides						
Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type	Certainty	Size Length	Width	Depth	Slide Vol.	Sed. Routing	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.
					DS DF DT EF RS	D P Q	feet	feet	feet	yd^3	P I N	25 50 75 100 (%)	yd^3	tons	(%)	A R O	C D P	H S I N	R S L N I	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
234	GS	3	1978	4	DS	P	198	22	4	645	P	76	490	662												
236	GS	3	1966	4	DS	D	220	44	4	1434	P	76	1090	1471												
237	GS	3	1978	1	DS	P	80	22	5	326	P	100	326	440	65		P		R							Y
238	GS	3	1978	1	DS	P	20	40	3	89	N				65		P		R							Y
239	GS	4	1978	3	DS	P	110	44	4	717	I	76	545	736												
241	GS	3	1966	1	DS	D	660	154	1	3764	P	76	2861	3862												
242	GS	32	1978	1	DS	D	132	110	5.9	3173	N								R							
243	GS	32	1978	1	DS	D	154	88	2	1004	P	100	1004	1355			P		R							
244	GS	32	1978	1	DS	D	132	44	3	645	P	100	645	871	>100		P		R							Y
245	GS	32	1978	1	DS	D	198	88	3	1936	P	100	1936	2614	>100		P		R							Y
246	GS	32	1978	1	DS	P	396	99	2	2904	P	100	2904	3920	>100		P		R							Y
247	GS	32	1966	1	DS	D	176	220	4	5736	P	76	4360	5885												
249	GS	33	1966	1	DS	D	110	440	1	1793	P	100	1793	2420	>100		P		N							Y
250	GS	29	1978	4	DS	D	154	110	4	2510	P	76	1907	2575												
251	GS	29	1978	2	DS	D	110	55	4	896	I	76	681	920												
252	GS	33	1978	1	DS	D	66	154	4	1506	P	76	1144	1545												
253	GS	33	1978	1	DS	D	66	66	4	645	P	76	490	662												
254	GS	33	1978	4	DS	D	110	154	5.9	3702	P	76	2813	3798					R							
255	GS	33	1978	4	DS	D	110	220	5.9	5288	P	76	4019	5426					R							
257	GS	32	1966	1	DS	D	175	120	4	3111	P	76	2364	3192	100		P		N							Y
258	GB	14	1978	4	DS	D	154	66	5.9	2221	P	76	1688	2279					R							
259	GB	14	1978		DS	D	187	66	5.9	2697	P	76	2050	2767					R							
260	GI	14	1978	1	DS	D	55	220	5.9	2644	P	76	2009	2713					R							
261	GI	14	1978	1	DS	D	66	22	4	215	P	76	163	221												
262	GI	14	1978	1	DS	D	66	22	4	215	P	76	163	221												
263	GI	14	1978	1	DS	D	44	11	4	72	P	76	54	74												
264	GI	14	1978	1	DS	P	22	22	4	72	P	76	54	74												
265	GI	14	1978	1	DS	P	22	22	4	72	P	76	54	74												
266	GB	15	1978	4	DS	D	242	110	5.9	5817	P	76	4421	5968					R							
267	GS	3	1996	2	DS	D	30	50	3	167	N						D		R							
268	GS	3	1996	4	DS	D	35	58	3	226	I	5	11	15			C		R							
269	GS	3	1996	4	DS	D	130	30	6	867	P	10	87	117	80		D		R							Y
270	GS	3	1996	2		D	10	70	25	648	P	100	648	875	85		P		R							Y
271	GS	3	1978	2	DS	D	40	33	8	391	P	90	352	475	90		P									Y
272	GS	4	1996	4	DS	D	280	36	2	747	P	5	37	50	75		P		R							Y
275	GS	5	1996	4	DS	D	65	39	4	376	P	65	244	330	60		C		R							Y
276	GS	5	1996	4	DS	D	40	30	3	133	N				78		D		R							Y
277	GS	32	1996	1	DS	D	30	20	9	200	P	70	140	189	70				R							Y
278	GS	32	1996	1	DS	D	30	30	6	200	P	70	140	189	70				R							Y
279	GS	5	1996	1	DS	D	10	20	3	22	P	40	9	12	70				R							Y
280	GS	3	1996	1	DS	D	8	10	10	30	P	100	30	40	110		P		R							Y
281	GS	3	1978	1	DS	D				4889	P	100	4889	6600			P		R							
282	GS	4	1978	1	DS	D	80	90	10	2667	P	90	2400	3240	90		C									Y
283	GS	4	1996	1	DS	D	60	70	3	467	P	30	140	189	80		P		R							Y
284	GS	4	1996	1	DS	D	60	30	3	200	P	30	60	81	80		C		R							Y
285	GS	4	1996	2	DS	D	70	70	20	3630	P	95	3448	4655	75		C		N							Y
285A	GS	4	1996	2	DF		100	30	15	1667	P	100	1667	2250					N							
288	GS	4	1996	4	DS	D	10	40	10	148	P	20	30	40	75		P		N							Y
289	GS	4	1996	4	DS	D	100	60	10	2222	P	100	2222	3000	65				R							Y
290	GS	4	1978	4	DS	D	5	15	8	22	P	50	11	15			P		R							
291	GS	4	1978	4	DS	D	20	40	15	444	P	80	356	480			P		R							
292	GS	5	1996	4	DS	D	25	30	10	278	N								R							

												Shallow-seated landslides								*Deep-seated landslides*						
Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type	Certainty	Size Length	Width	Depth	Slide Vol.	Sed. Routing	Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	Field Obs.
					DS DF DT EF RS	D P Q	feet	feet	feet	yd^3	P I N	25 50 75 100 (%)	yd^3	tons	(%)	A R O	C D P	H S I N	R S L N I	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
296	GS	33	1996	3	DS	D	20	30	3	67	I	76	51	68												
297	GS	4	1996	2	DS	D	15	20	2	22	I	80	18	24												
298	GS	33	1996	3	DS	D	20	20	2	30	N															
299	GS	4	1996	4	DS	D	83	25	4	307	I	76	234	315												
300	GS	4	1996	2	DS	D	20	20	4	59	I	76	45	61												
301	GS	3	1996	3	DS	D	100	33	4	489	I	76	372	502												
302	GS	3	1978	4	DS	D	40	25	6	222	I	90	200	270	65		C		R							Y
303	GS	33	1978	3	DS	D	30	35	3	117	I	60	70	95	75		C		R							Y
304	GS	32	1978	1	DS	D	700	48	6	7467	P	100	7467	10080	100		C		R							Y
305	GS	32	1978	1	DS	D	60	40	6	533	N				80		P									Y
306	GS	31	1978	4	DS	D	90	40	4	533	P	100	533	720	70		P		N							Y
307	GS	4	1996	1	DS	D	30	30	15	500	I	20	100	135	110		C		R							Y
308	GS	4	1996	1	DS	D	30	50	1	56	I	10	6	8	110		P		R							Y
309	GS	4	1996	1	DS	D	100	110	7	2852	P	60	1711	2310	80		P		R							Y
310	GS	4	1978	1	DS	D	80	50	5	741	P	60	444	600	80		P		R							Y
311	GS	4	1996	1	DS	D	30	20	6	133	P	40	53	72	95		P		R							Y
312	GS	4	1996	1	DS	D	50	20	2	74	P	20	15	20	75		P		R							Y
313	GS	4	1996	1	DS	D	20	15	2	22	P	10	2	3			D		R							
314	GS	4	1996	1	DS	D	30	30	4	133	P	10	13	18	85		D		R							Y
315	GS	4	1996	1	DS	D	30	20	4	89	P	30	27	36	65		C		N							Y
316	GS	4	1996	1	DS	D	50	30	2	111	P	20	22	30	100		D		R							Y
317	GS	4	1996	1	DS	D	50	30	2	111	N				110		C		N							Y
318	GS	4	1996	1	DS	D	80	50	3	444	P	20	89	120	100		P		R							Y
319	GS	31	1996	1	DS	D	50	140	2	519	P	95	493	665			P		N							
320	GS	31	1996	1	DS	D	10	50	2	37	P	100	37	50	100		D		N							Y
321	GS	31	1996	1	DS	D	30	15	1	17	P	100	17	23	75		P		N							Y
322	GS	31	1996	1	DS	D	35	50	3	194	P	25	49	66	75		C		N							Y
323	GS	31	1978	1	DS	D	30	4	2	9	P	100	9	12												
324	GS	31	1978	1	DS	D	40	4	1	6	P	100	6	8												
325	GS	32	1996	1	DS	D	200	30	3	667	P	100	667	900	110		P		N							Y
326	GS	32	1978	1	DS	D	50	50	2	185	P	100	185	250	110		P		N							Y
327	GS	32	1996	1	DS	D	50	40	2	148	P	70	104	140	110		P		N							Y
328	GR	18	1996	1	DS	D	60	30	3	200	P	100	200	270	85		P		N							Y
329	GR	18	1996	1	DS	D	40	25	2	74	P	60	44	60	110		P		N							Y
330	GR	24	1996	1	DS	D	45	25	7	292	P	80	233	315	75		D		N							Y
331	GR	24	1978	1	DS	D	110	43	7	1226	P	35	429	579	85		D		N							Y
332	GR	24	1978	1	DS	D	50	50	2	185	P	90	167	225	110		P		N							Y
333	GS	31	1996	2	DS	D	80	35	3	311	I	60	187	252			D		R							
334	GS	31	1996	4	DS	D	100	40	4	593	I	20	119	160	80		D		R							Y
335	GS	5	1996	4	DS	D	110	60	6	1467	P	20	293	396												
336	GS	4	1996	2	DS	D	50	100	5	926	I	100	926	1250												
337	GR	25	1996	1	DS	D	50	50	3	278	P	100	278	375	120		P		N							Y
338	GR	18	1978	1	DS	D	100	130	8	3852	P	75	2889	3900	80		C		R							Y
339	GR	30	1996	1	DS	D	70	60	2	311	P	100	311	420	90		P		N							Y
340	GR	30	1996	1	DS	D	40	30	2	89	P	90	80	108	70		P		I							Y
341	GR	30	1996	1	DS	D	100	50	9	1667	P	90	1500	2025	110		P		I							Y
342	GR	30	1996	1	DS	D	40	20	2	59	P	100	59	80	110		P		N							Y
343	GR	30	1996	3	DS	D	30	50	2	111	N				90		P		R							Y
344	GR	30	1996	4	DS	D	93	90	6	1860	I	20	372	502	70		D		R							Y
345	GR	19	1978	4	DS	D	138	78	5	1993	I	50	997	1346	70		C		R							Y
346	GR	19	1996	2	DS	D	100	30	3	333	I	100	333	450	70		C		R							Y
347	GR	19	1996	1	DS	D	50	120	8	1778	P	100	1778	2400	80		C		R							Y

Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type	Certainty	Size			Slide Vol.	Sed. Routing	Shallow-seated landslides								Deep-seated landslides						Field Obs.
							Length	Width	Depth			Sed. Del. Ratio	Sed. Delivery	Sed. Delivery	Slope (field)	Age	Slope Form	Slide Loc.	Road Assoc.	Toe Activity	Body Morph.	Lat. Scarps	Main Scarps	DS Veg.	Complex	
					DS DF DT EF RS	D P Q	feet	feet	feet	yd^3	P I N	25 50 75 100 (%)	yd^3	tons	(%)	A R O	C D P	H S I N	R S L N I	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
348	GR	30	1996	1	DS	D	50	75	4	556	I	90	500	675	75		C		R							Y
349	GS	30	1996	1	DS	D	130	40	3	578	P	100	578	780			P		N							
350	GR	30	1978	1	DS	D	80	100	2	593	P	100	593	800	80		P		I							Y
351	GR	30	1996	1	DS	D	70	25	3	194	P	95	185	249	110		P		I							Y
352	GS	30	1996	1	DS	D	80	30	2	178	P	100	178	240	>100		P		I							Y
353	GS	30	1996	1	DS	D	40	40	5	296	P	100	296	400			P		I							
354	GS	30	1996	1	DS	D	30	50	1	56	P	100	56	75			P		N							
355	GS	30	1996	1	DS	D	30	30	1	33	P	100	33	45			P		N							
356	GS	31	1996	4	DS	D	50	40	1	74	P	100	74	100			P		N							
357	GS	31	1996	4	DS	D	50	200	30	11111	P	60	6667	9000			P		R							
358	GS	31	1996	4	DS	D	70	20	3	156	P	80	124	168			P		R							
359	GS	31	1996	4	DS	D	120	60	7	1867	P	50	933	1260	67		C		R							Y
360	GR	25	1978	4	DS	D	120	30	4	533	P	100	533	720	90		C		R							Y
361	GR	24	1966	1	DS	D	44	242	4	1577	P	100	1577	2130												
362	GR	12	1966	1	DS	D	88	44	4	574	P	76	436	589												
363	GR	12	1966	1	DS	D	110	110	4	1793	P	90	1613	2178												
364	GS	31	1966	3	DS	D	176	100	4	2607	I	50	1304	1760					R							
365	GS	31	1966	1	DS	D	88	22	4	287	P	90	258	348												
366	GS	31	1966	1	DS	D	66	66	4	645	P	90	581	784												
367	GS	31	1966	1	DS	D	88	50	4	652	P	90	587	792												
368	GS	31	1966	1	DS	D	176	44	4	1147	P	60	688	929												
369	GS	30	1966	1	DS	D	154	66	4	1506	P	90	1355	1830					R							
370	GR	30	1966	1	DS	D	44	176	4	1147	P	90	1033	1394												
371	GR	30	1966	2	DS	D	66	220	4	2151	P	90	1936	2614												
372	GR	30	1966	1	DS	D	88	44	4	574	P	90	516	697												
373	GR	30	1966	2	DS	D	176	66	4	1721	P	90	1549	2091												
374	GR	20	1978	3	DS	D	150	66	4	1467	I	90	1320	1782												
375	GR	19	1966	1	DS	D	40	40	4	237	P	90	213	288												
376	GR	19	1966	2	DS	D	66	154	1	376	I	90	339	457												
377	GR	19	1966	2	DS	D	66	572	0.5	699	I	90	629	849												
378	GR	24	1978	1	DS	D	44	88	4	574	P	90	516	697												
379	GR	18	1966	1	DS	D	66	176	1	430	P	80	344	465												
380	GR	18	1978	1	DS	D	110	66	4	1076	P	76	817	1104												
381	GR	18	1966	2	DS	D	176	176	4	4589	I	76	3488	4708												
382	GR	18	1978	1	DS	D	110	110	1	448	P	90	403	545												
383	GR	18	1966	1	DS	D	110	110	1	448	P	90	403	545												
384	GR	12	1966	1	DS	D	1320	88	1	4302	P	90	3872	5227					I							
385	GS	3	1966	2	DS	D	40	40	1	59	I	90	53	72					I							
386	GS	3	1966	2	DS	D	66	88	1	215	I	90	194	261					I							
387	GS	3	1966	4	DS	D	66	33	1	81	I	60	48	65					I							
388	GS	5	1966	4	DS	D	176	88	5.9	3384	P	80	2708	3655					R							
389	GS	4	1966	1	DS	D	220	66	1	538	P	90	484	653												
390	GS	4	1966	4	DS	D	66	44	4	430	I	76	327	441												
391	GS	3	1966	2	DS	D	330	66	1	807	I	100	807	1089												
392	GS	32	1966	1	DS	D	396	110	4	6453	P	80	5163	6970					R							
393	GS	32	1966	1	DS	D	132	110	4	2151	N															
394	GS	32	1966	1	DS	D	154	110	4	2510	P	90	2259	3049												
395	GS	32	1966	1	DS	D	44	44	1	72	P	20	14	19					R							
396	GS	32	1966	1	DS	D	44	22	1	36	P	20	7	10					R							
397	GS	32	1966	1	DS	D	44	22	1	36	P	20	7	10					R							
398	GS	32	1966	1	DS	D	220	44	2	717	P	80	574	774					R							
399	GS	32	1966	1	DS	D	132	44	1	215	P	80	172	232					R							

Unique ID#	PWS	T & R Sec. #	Air Photo year / number	MWMU	Landslide Type DS DF DT EF RS	Certainty D P Q	Size Length feet	Size Width feet	Size Depth feet	Slide Vol. yd^3	Sed. Routing P I N	*Shallow-seated landslides* Sed. Del. Ratio 25 50 75 100 (%)	Sed. Delivery yd^3	Sed. Delivery tons	Slope (field) (%)	Age A R O	Slope Form C D P	Slide Loc. H S I N	Road Assoc. R S L N I	*Deep-seated landslides* 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
400	GR	20	1966	3	DS	D	300	66	4	2933	I	100	2933	3960												
401	GR	20	1966	2	DS	D	110	66	4	1076	N															
402	GR	29	1966	2	DS	D	264	110	1	1076	I	100	1076	1452												
403	GR	25	2000 11A-4		RS	Q	2200	3330			P									4	3	5	4	4	Y	
404	GR	24	2000 11A-6	1	DS	D	460	290	4	19763	P	100	19763	26680		A	P	S	N							
405	GR	13	2000 11A-6		RS	Q	3080	2630			I									4	3	3	3	4	Y	
406	GR	13	2000 11A-8		RS	Q	1540	1080			I									2	3	3	3	4	N	
407	GR	13	2000 11A-8		RS	Q	2290	1420			I									1	3	3	3	4	N	
408	GS	5	2000 12A-2		RS	P	2640	2970			I									4	3	3	3	4	Y	
409	GS	31	2000 12A-4		RS	P	680	360			P									3	3	3	3	4	N	
410	GS	5	2000 12A-4		RS	Q	4610	1080			I									3	3	3	4	4	Y	
411	GS	5	2000 12A-4		RS	Q	2640	900			I									3	3	3	3	4	Y	
412	GR	12	2000 11A-8		RS	Q	1700	1300			I									3	2	3	3	4	N	
413	GS	31	2000 12A-4		RS	Q	4400	2600			I									4	4	3	3	4	N	
414	GS	29	2000 13A-7		RS	D	600	600			P									2	2	1	2	2	N	
415	GS	33	2000 14A-4		EF	Q	3400	2600			P									2	4	4	4	4	N	
416	GB	18	2000 12A-9		RS	D	370	280			P									1	2	1	1	4	N	
417	GR	4	2000 12A-4		RS	Q	1870	1390			I									3	3	3	3	4	N	
422	GB	16	2000 14A-10		RS	Q	3960	1390			I									3	3	3	3	4	N	
423	GB	10	2000 15B-4		EF	Q	4500	1100			P									3	3	3	4	4	Y	
424	GB	14	2000 16B-2		RS	Q	3740	5040			P									3	3	3	3	4	Y	
426	GS	31	2000 12A-4		RS	P	2000	3000			I									4	3	4	3	4	N	
427	GS	36	2000 12A-4		RS	P	1800	3500			I									4	3	4	3	4	N	
428	GR	20	2000 12A-6		RS	Q	6500	4000			P									4	3	4	4	4	Y	
429	GB	10	2000 14A-10		EF	Q	3000	3000			P									4	3	4	4	2	Y	
430	GR	23	2000 10A-5		RS	P	2200	3500			P									2	3	3	3	4	Y	
431	GR	25	2000 11A-4		RS	P	1300	1000			P									4	4	4	3	4	N	
432	GS	25	2003	3	DS	D	200	120	8	7111	P	100	7111	9600	75	A	C	S	R							Y



Garcia River 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 Garcia River watershed. The mass wasting features were developed from an interpretation of aerial photographs from the 1950's-2000 with field observations taken in 1998 and 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 mapped landslides are categorized in a database in the mass wasting report for the Garcia WAU (Section A).

Deep-Seated Landslides

Shallow-Seated Landslides

- < 500 cubic yards
- 500 - 5000 cubic yards
- > 5000 cubic yards

MRC Ownership

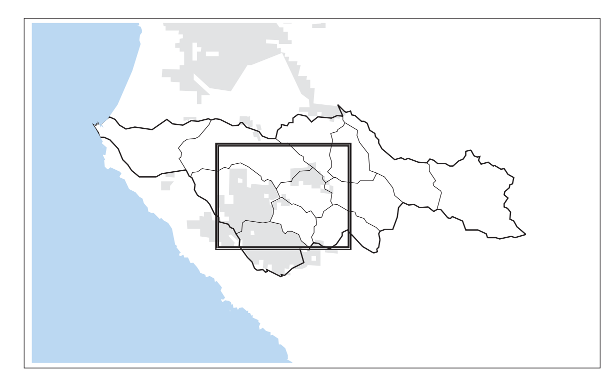
Planning Watershed Boundary

Garcia River Watershed Boundary

Flow Class

- Class I
- Class II
- Class III

Sheet 1



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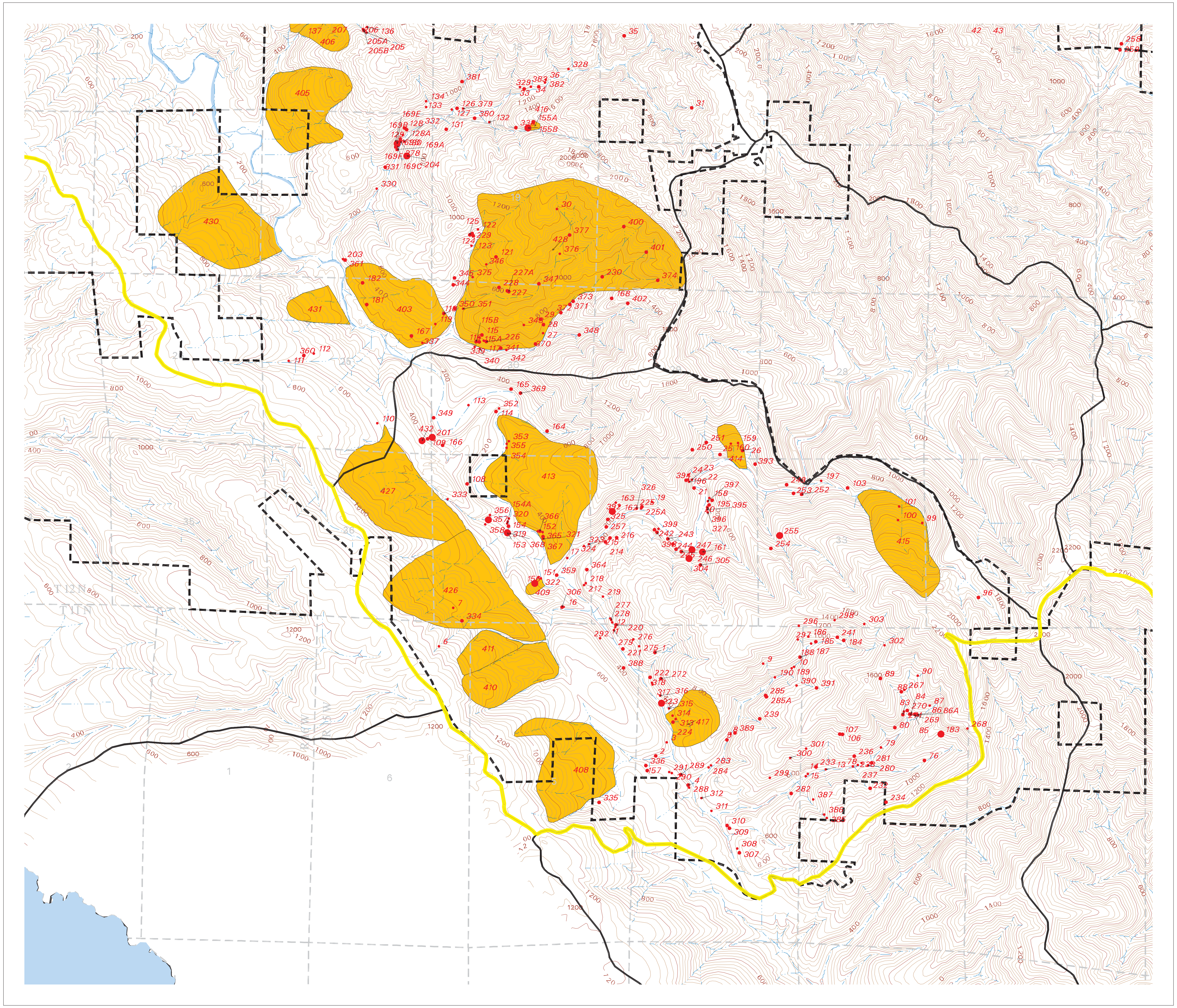
September 2003



Garcia River Watershed Analysis Unit

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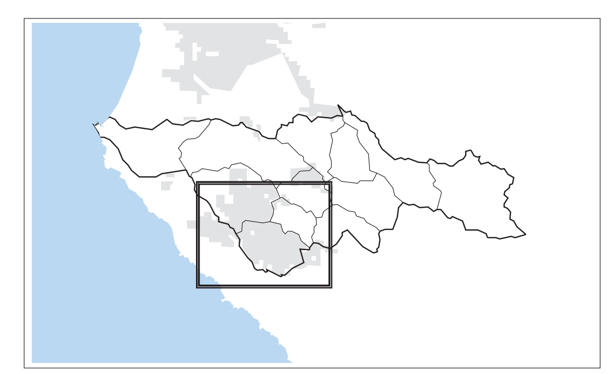
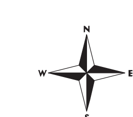
MRC Ownership
Planning Watershed Boundary
Garcia River Watershed Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 2





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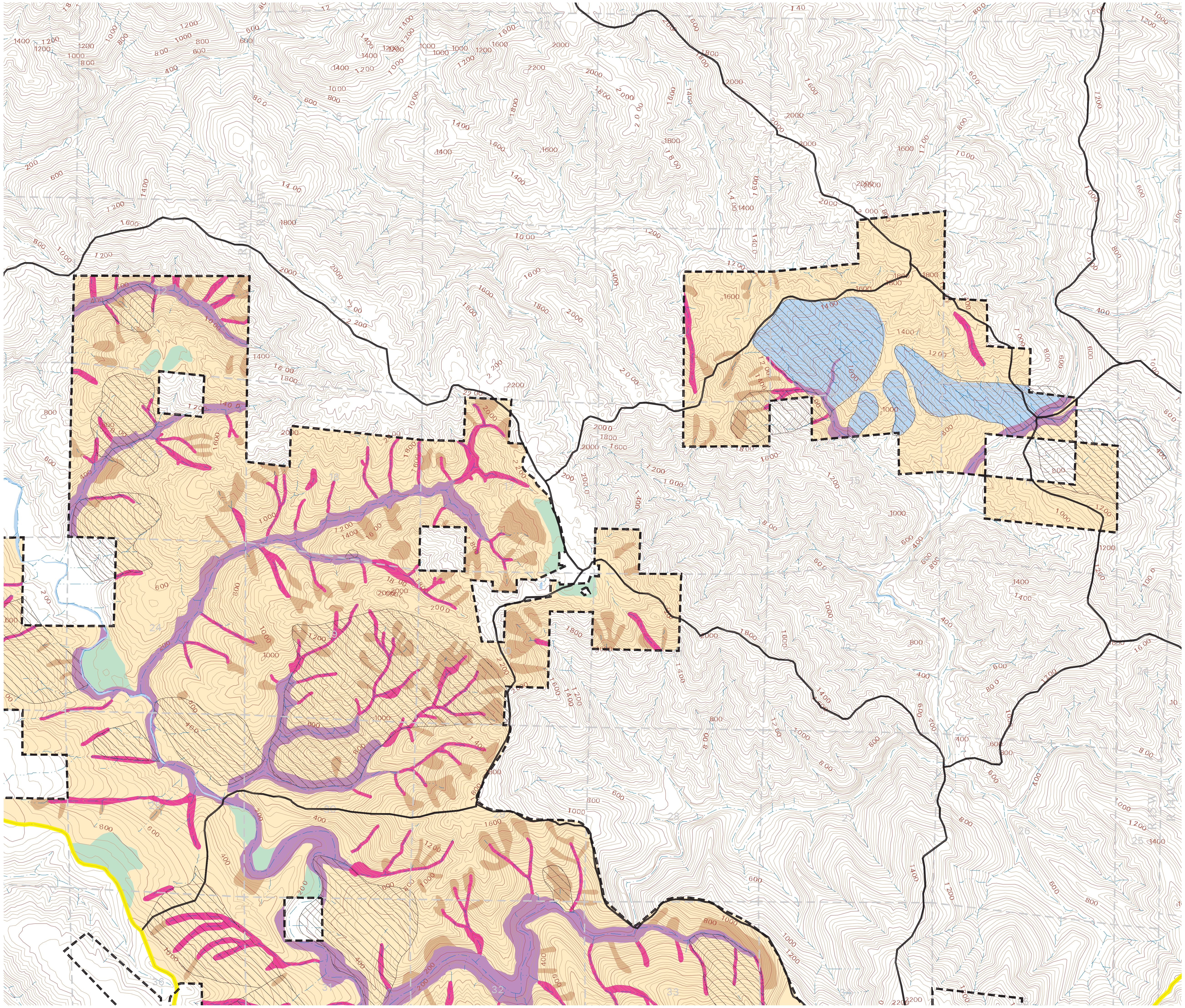


Garcia River Watershed Analysis Unit

Map A-2 Mass Wasting Map Units

This map presents an interpretation of the mass wasting map units (MWMUs) delineated for the Garcia WAU. The MWMUs characterize the landscape by similar geomorphic attributes, shallow-seated landslide potential, and sediment delivery potential. The MWMU designations for the Garcia 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 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 Garcia WAU is certainly more complex than generalized MWMUs delineated for this evaluation. The MWMUs are only meant to be a starting point for gauging the need for site-specific field assessments. Field observations will over-ride unit boundaries of this map.

Unit 1: Steep slopes or inner gorge along low gradient watercourses

Unit 2: Steep slopes or inner gorge adjacent to select intermittent or ephemeral streams

Unit 3: Steep, dissected topography

Unit 4: Non-dissected topography

Unit 5: Low relief topography

Unit 6: Identified earthflow complexes

Deep Seated Landslides

MRC Ownership

Planning Watershed Boundary

Garcia River Watershed Boundary

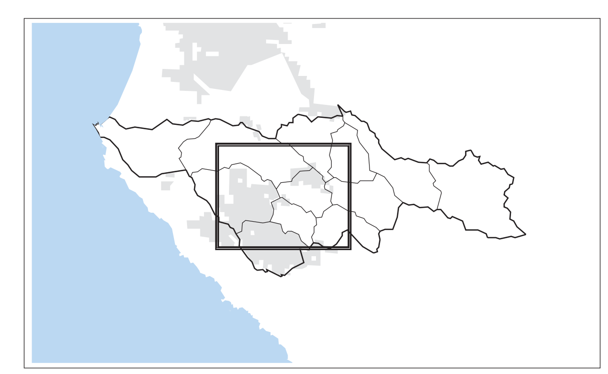
Flow Class

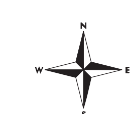
Class I

Class II

Class III

Sheet 1





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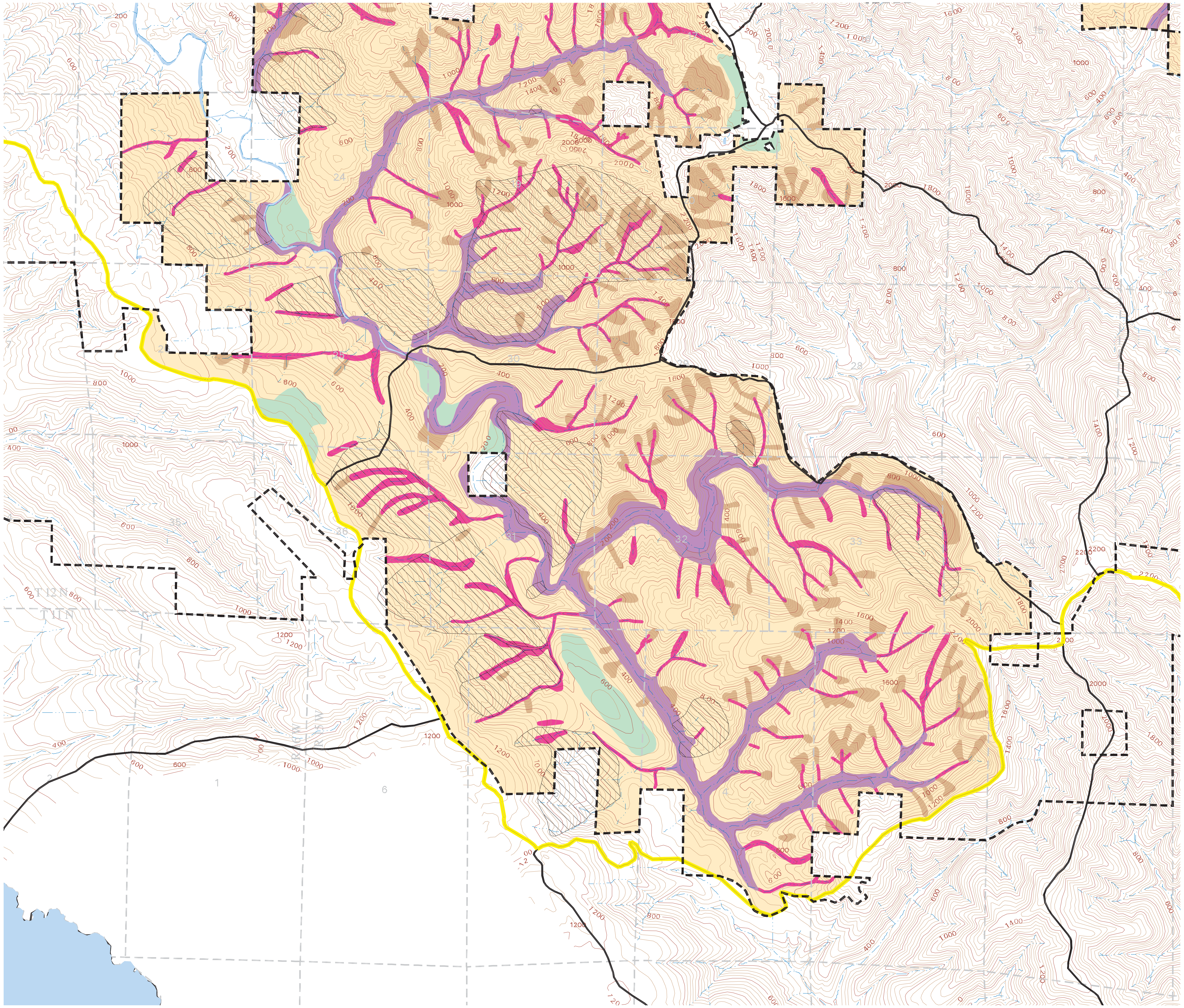

Garcia River Watershed Analysis Unit

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- Unit 2: Steep slopes or inner gorge adjacent to select intermittent or ephemeral streams
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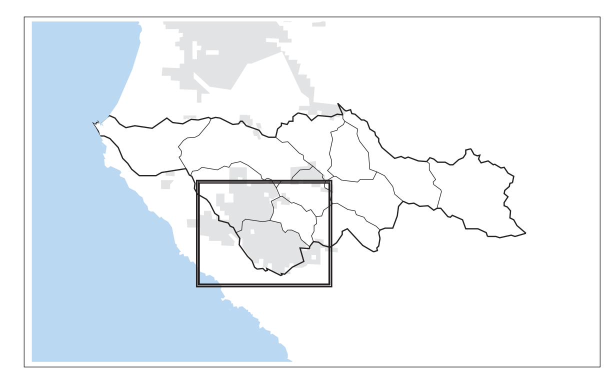
- Deep Seated Landslides
- MRC Ownership
- Planning Watershed Boundary
- Garcia River Watershed Boundary

Flow Class

- Class I
- Class II
- Class III

Sheet 2



0 1/2 1 Mile

September 2003