Upper Trinity River Sediment Source Analysis

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ABSTRACT

This analysis qualifies and quantifies the types of sediment sources and amount of sediment delivery and yield. Subwatersheds within the Upper Trinity River are ranked according to their probability of sediment delivery. The analysis uses empirical data and predictive models to help account for short and long-term sediment delivery from natural and management related landslide, surface, and fluvial erosion. The Upper Trinity River watershed bounds the analysis area, drains about 690 mi^2, and is characterized as a very steep drainage with a contorted drainage pattern. Sediment source analysis results indicate that relative to landslide sediment delivery, surface erosion represents a small percentage of the long-term sediment yield. The surface erosion sediment yield rates are above background, however. Most of the sediment transported and stored within the stream network is from background or naturally active landslides (62 percent). GMA sediment source inventory results indicate that landslides associated with road construction and use activities represent about 26 percent of the total sediment delivery, and features associated with timber harvest activities represent about 12 percent. The landslide sediment delivery risk analysis results indicate that 54 percent of the subwatersheds are 25 percent over background. The surface and fluvial erosion risk analysis results indicate that 38 percent of the subwatersheds are 25 percent over background. Model results also indicate that sediment sources on private lands account for a large portion of the total management related sediment delivery. The two different models used for this analysis produced very similar results and agree within 20 percent. Monitoring, designed to measure the background sediment yield from three relatively unmanaged subwatersheds, provided a measure to verify model results. Suspended sediment transport monitoring data indicate that sediment source model results are reasonable given the large analysis area, model limitations, and known data gaps.

1.0 INTRODUCTION

The purpose of this report is to document the data, results, and findings of the Upper Trinity River (UT) Planning Watershed sediment source analysis. As part of the development of the Upper Trinity River Watershed Analysis and Action Plan which is being funded by the State Water Resources Control Board, a sediment source analysis is being conducted by Graham Matthews & Associates (GMA) for the watershed above Trinity Lake dam.

The sediment source analysis is designed to qualify and quantify the relative sediment contribution from different erosion sources, identify which of the UT subwatersheds produce excess sediment, and provide land managers a tool to develop strategies to prevent and reduce management related chronic and acute erosion. The sediment source analysis includes an inventory of natural and management related erosion sources and measures which sources produce the most sediment.

The inventoried and modeled erosion sources can be divided into two categories termed acute and chronic. Landslides tend to deliver sediment infrequently or acutely, during short and intense events or spurts, as the slide originally happens, or years later as the slide moves again. Landslides can be triggered naturally or by land use activities depending on factors like climate, soils, bedrock geology, and slope steepness. On the other hand, chronic erosion occurs frequently and typically delivers fine sediment during rainfall-runoff events.

This analysis used two different sediment source analysis models and compared the results to measured sediment yield. The first method used sediment budget techniques (Reid and Dunne, 1996) to inventory and measure sediment sources and erosion rates. The inventory, land form, and land use data were used to calculate sediment delivery and yield for a 20 year time period. The second method used a sediment delivery risk model to predict the probability of sediment delivery from inventoried erosion sources. Available data was input into the model and the likelihood of sediment delivery was estimated for the Q_2 and Q_{25} flood events. The results were compared to load allocations specified in the Trinity River TMDL (EPA, 2001).

2.0 METHODS

The following section summarizes the sediment source analysis methods, data, and information. This sediment source analysis follows hydrologic and geologic analysis methods outlined in McCammon et. al. (1998) and CDC (2001), and sediment budget methods described by Reid and Dunne (1996), Washington Department of Natural Resources, (1995), and USDA Forest Service (2004) to identify the major controllable sediment discharge sources in the Upper Trinity River (UT) planning watershed. GIS is used to process the data layers, and Excel is used to calculate the amount and probability of sediment delivery. The models estimate the background and management related sediment delivery from landslide, surface, and fluvial erosion processes.

This sediment source analysis attempts to account for the short and long-term sediment input to the stream network average and episodic rainfall-runoff and snowmelt driven flood events. A design flood analysis is used to estimate the probability of sediment delivery. Frequent flooding (i.e., Q_2) is used to quantify chronic fine sediment delivery that tends to occur on an annual basis and increases the suspended sediment load. For example, road surface erosion during rainstorms is a common source of chronic sediment. Infrequent flooding (i.e., Q_{25}) is used to quantify acute sediment delivery. Large flood events tend to trigger land form scale erosion and sediment delivery to the drainage network and increase the fine and coarse sediment load. During large floods, the sediment transport capacity of the stream network is commonly exceeded and the downstream transport distance of coarse sediment is limited. Stream networks within the Upper Trinity River project area naturally aggrades and degrades through time in response the frequency and magnitude of infrequent flood events. This risk analysis compares the background and existing sediment delivery rates for the design flood events.

2.1 Hydrology

Existing precipitation, streamflow, and sediment transport data were summarized for the project area and used to characterize the ranges of air temperature, precipitation, and streamflow magnitude, timing, duration, and frequency. Data from the US Geological Survey (USGS), USDA Forest Service (FS), Bureau of Reclamation (BOR), and California Department of Water Resources (CDWR) were gathered and summarized for this analysis. The Log Pearson Type III and graphical flood frequency analysis methods were used to estimate the flood magnitude for the two and one hundred year recurrence intervals.

2.2 Drainage Basin Characteristics

2.2.1 Watershed Stratification

The 26 subwatersheds delineated as part of the GMA (2001) sediment source analysis are used for this analysis (Table 2.2.1 and Plate 1). There are large (>16 mi^2) and small (<16 mi^2) subwatersheds. Land form and land use data are summarized for each of the subwatersheds.

Table 2.2.1. List of Upper Trinity subwatersheds and corresponding drainage areas, does not include Trinity Lake area.

Watershed	Drainage Area (acres)	Drainage Area (mi2)
Bear Creek	2880	4.5
Buckeye Creek	3286	5.1
Cedar Creek	4485	7.0
Coffee Creek	74477	116.4
Eagle Creek	9658	15.1
East Fork Stuart Fork	14485	22.6
East Fork Trinity River	59367	92.8
East Side Trinity Lake	41496	64.8
Graves Creek	3399	5.3
Hatchet Creek	1220	1.9
Minnehaha Creek	2406	3.8
Mule Creek	4024	6.3
Ramshorn Creek	8202	12.8
Ripple Creek	1583	2.5
Scorpion Creek	4363	6.8
Snowslide Gulch Area	7722	12.1
Squirrel Gulch Area	9699	15.2
Stoney Creek	3479	5.4
Stuart Arm Area	22080	34.5
Stuart Fork	40016	62.5
Sunflower Creek	1654	2.6
Swift Creek	35853	56.0
Tangle Blue Creek	13848	21.6
Upper Trinity Mainstem Area	6319	9.9
Upper Trinity River	40343	63.0
West Side Trinity Lake	10792	16.9
Grand Total	427135	667.4

2.2.2 Watershed Morphometry

The shape, texture, drainage pattern, and drainage efficiency of the subwatersheds are used to qualify and quantify the frequency and magnitude of upland sediment flux and instream sediment transport and storage. Watershed features are measured from topographic maps, aerial photos, and 10-meter Digital Elevation Models (DEMs) are used to quantify drainage area, maximum and minimum elevation, basin length, stream network length and channel type. For example, Plate 2 shows the slope steepness distribution for the UT as predicted from the DEM.

The sediment delivery factor is used to estimate sediment yield from each subwatershed. This factor quantifies a watershed's physical attributes as an index of sediment transport, storage, and delivery potential. Use of this factor assumes that sediment transport and yield are a function of stream power (Geier and Loggy, 1995). For a given watershed, the sediment yield factor (Ps) (also called sediment delivery factor) is the product of slope steepness, basin length, drainage density, and flood prone discharge (Fitzgerald et al., 2000).

2.2.3 Watershed Geology and Geomorphology
The bedrock geology and geomorphology within the UT subwatersheds are used to characterize and quantify landslide, surface, and fluvial erosion processes. The lumped bedrock geology documented in GMA (2001) was used for this analysis. The USDA Forest Service (2005) geomorphology layer that covers the UT watershed was included in the landslide modeling phase of this analysis.

2.3 GMA Measured Sediment Transport and Yield

2.3.1 Measured Streamflow and Sediment Transport from GMA Monitoring
GMA has operated two continuous and 29 intermittent streamflow and sediment monitoring sites within the UT (Table 2.3.1). The continuous streamflow monitoring sites are on the East Fork Trinity River at Trinity County Road 106, and Coffee Creek at Highway 3. Suspended sediment and turbidity samples have been taken intermittently at the continuous streamflow sites from 2000 to 2006. The intermittent sites are near the outlet of several of the subwatersheds stratified as part of the sediment source analysis (Table 2.3.1 and Table 2.2.1). Suspended sediment and turbidity samples have been taken intermittently at these sites for two water years (2000 and 2005).

All of the sites are maintained and operated according to GMA streamflow and sediment sampling standard operating procedures. Streamflow and sediment data by site are presented in Appendix 2.

2.3.2 Measured Total Sediment Yield from Delta Surveys
One of the more reliable estimates of long-term watershed sediment yields could come from tributary deltas where they are deposited into either natural lakes or man-made reservoirs.

When lake levels were low in WY2000 and 2001, GMA (2001) completed detailed field surveys of the delta deposit of Stuart Fork, a mostly undisturbed tributary flowing primarily out of the Trinity Alps Wilderness. GMA compared their surveys to a 1957 5-foot contour map prepared by the U.S. Bureau of Reclamation prior to the construction of Trinity Dam and developed estimates of long-term sediment yield based on these data.

For this project, we decided to update the 2001 survey of the Stuart Fork delta to current conditions, as well as survey two other nearby watersheds with differing land use histories and watershed areas (Mule Creek and East Fork Stuart Fork).

The process of delta volume accumulation computation involves field topographic and bathymetric surveys, preparation of digital terrain models for both sets of survey data, and then computing the net change between the two surfaces.

2.3.2.1 Field Surveys

Field surveys used the following horizontal coordinates NAD83, California Coordinate System 83, Zone 1 (CCS83, Z1), while the vertical datum is NAVD 1988.

Detailed topographic maps of the various delta study sites were developed. Either a Topcon APL-1A Robotic Total Station with a Husky MP2500 Data Collector or Trimble 4700/4800 survey grade RTK GPS equipment was used for the conventional topographic surveying.

In the field, points were surveyed in a rough grid fashion with an average approximate point density 20 ft apart, although actual point locations are chosen by topographic breaks rather than a set distance apart. The more topographically complex a section of ground or stream channel, the more points were required to accurately document topography. In many areas, the topography was quite complex due to depositional features (Figure 2.3.1).

Figure 2.3.1. Example of delta sediment deposit surveyed to estimate the background sediment delivery rate.

2.3.2.2 Bathymetric Surveys

Bathymetric survey data were collected using a boat-based bathymetric mapping system which combines a survey-grade echo sounder (RESON Nav110) with a survey-grade RTK GPS (Trimble 4700/4800). Where depths were too shallow or adequate satellite coverage not available, conventional GPS or total station surveys were used to collect bathymetric survey data. The boat based surveys were completed using a grid system within the lake, whereby transects are surveyed 20'– 30' apart with approximate spacing between points of 2' – 5'.

2.3.2.3 Data Management, Post-processing, and Editing

Bathymetric data are collected on an onboard laptop computer running Navisoft Survey software. Raw files are converted to points with x, y, and z coordinates and depth within the Navisoft software and then copied to Microsoft Excel for editing. Points are numbered and sorted using several routines to weed out spurious points, resulting from the effects of turbulence, turbidity, aquatic vegetation, poor GPS resolution, etc. All boat-based bathymetric data are combined with "ground-based" survey points (total station or wading GPS) in AutoCAD Software (Land Development Desktop 2004), where final editing is accomplished by building DTM's , creating contours, and inspecting for horizontal and vertical errors.

2.4 Landslide Source Analysis

2.4.1 GMA Landslide Inventory

2.4.1.1 Data Sources

The landslide source analysis combines data from CDWR (1980), GMA (2001), and McBain and Trush (2005). The first phase identified and inventoried landslides discernable on aerial photographs. The second phase consisted of field-verifying about 12 percent of the mapped landslides to validate the aerial photograph interpretation, estimate landslide thickness, and map small landslides not recognizable on the photos. All of the GIS and Excel files are stored electronically in the project file and are available on CD.

2.4.1.2 Landslide Inventory Methods

The GMA landslide inventory was performed in two phases. The inventory was completed using office and field methods, and it focused on mapping natural and management related active landslides.

The first phase of the landslide inventory was office based and obtained existing data and landslide maps. The most complete map was published in CDWR (1980) that represents the 1978 aerial photos. This map was digitized by GMA and was updated using stereographic pairs of black and white and color aerial photos. The most recent aerial photos were taken in 2003 and are at a scale of about 1:18,000 (1 inch equals 1,500 feet).

The aerial photo landslide inventory documented the location, type, geometry, and time period of landslides in the watershed. This information was used to estimate sediment input to streams and assess relationships between land use and landslide activity. For the UT, CDWR (1980) mapped the entire Planning Watershed, GMA (2001) mapped 147 mi^2 of the Planning Watershed, and McBain and Trush (2005) mapped the remaining area. The latter two inventories were combined for this analysis.

A mirror stereoscope was used to identify landslides on the aerial photos, and landslide location was found on the corresponding USGS 7.5-minute topographic map (i.e., 1:24,000, or 1 inch equals 2,000 ft). For a given landslide, the dimensions were measured (i.e., length and width) scaled from the photo scale to 1:24,000. The landslide outline was then hand-drawn on an acetate sheet overlaid on the topographic map. After being mapped on the acetate overlay, the landslide was measured a second time to check the scaling. The landslide was then numbered and classified based on attributes visible on the photo. The overlays were then digitized into the GIS.

For each landslide identified on the aerial photos, the following information was recorded in the landslide database:

- Landslide number.
- Year of the aerial photo on which the landslide first appears.
- Number and flight line of the aerial photo on which the landslide first occurs.

- Landslide classification (described below).
- Certainty of identification: d = definite, p = probable, q = questionable.
- Activity level using the following categories: active, inactive, or relict
- Landslide width and length
- Sediment delivery to streams (described below)
- Landslide triggering mechanism (described below)

The second phase of the landslide inventory was field based and inventoried a representative sample of the aerial photo mapped landslides. Data were collected on landslide dimensions and the percentage of sediment entering streams. This fieldwork included documentation, measurement, and description of the smaller landslides that cannot be identified with certainty on aerial photos. The results were used to help verify aerial photo measurements and interpretations, and to document the size of landslides that can reasonably be identified on aerial photos. The field sampling also mapped smaller landslides that will not be identified on the aerial photos. Typically, only landslides with areas of 3,000 to 5,000 square feet can be reliably and consistently identified on 1:10,000 to 1:24,000 scale aerial photos in most terrains. The actual size of landslides that can reliably be identified varies with the scale and quality (black and white or color, age and resolution) of the aerial photos.

About 12 percent of the landslides mapped from aerial photos were field verified. The sample size was primarily a function of access (i.e. permission, distance from road access, etc. The landslide characteristics mapped during the field inventory include the following:

- Landslide area, volume, and surface erosion estimates as appropriate.
- Land use associated with landslide activity (e.g. forest harvesting, road fills and cuts).
- Triggering mechanisms that contributed to the initiation or reactivation of landslides (e.g. overloading, saturation from redirected surface water, root strength deterioration).
- Delivery of landslide sediment to streams.

Data and techniques suitable for field analysis and measurements of landslides followed those outlined in Turner and Schuster (1996).

2.4.1.3 Landslide Classification

The landslide classification system used for this analysis follows Crudden and Varnes (1996), which use material type, movement type, and activity level to classify the landslide type. The material types include rock, debris, and earth, and movement types include fall, flow, landslide, spread, and topple. Activity level is not critical here because all of the landslides included in the inventory are assumed to be active. A simplified landslide classification system was used because most of the inventory was completed using aerial photos and certain details of landslide features could not be measured (Turner and McGuffey, 1996)

The GMA (2001) and McBain and Trush (2005) landslide inventories used different classification systems, so this analysis merged the two and uses a modified version of Crudden and Varnes (1996) and CDC (1999) (Table 2.4.1). The landslide material types were lumped into bedrock, debris, or earth. McBain and Trush (2005) did not include the earth material type, but GMA (2001) did include the earth material type. Rock is classified as bedrock or very large blocks of material. Debris is classified as coarse soil with 50 percent greater than 4 mm. Earth is classified as fine soil with 50 percent less than 4mm.

Landslide movement types interpreted from the aerial photos include falls, slides, and flows. Slides and flows are differentiated based on the water content and rate of movement. Slides tend to have a lower water content and move slower than flows. Flows tend to move as a liquid. Depending on soil type, slope, and water content the movement type of a given landslide can change downslope and features were classified accordingly. Falls and topples are similar movement mechanisms and could not be distinguished on the aerial photos, and only fall was used for this analysis. No spreads were interpreted in the mapping area. In addition, movement types were combined where a landslide appeared to exhibit a transition from one movement type to another. For example, a Rock Fall that transitions to a Rock Slide was recorded as Rock Fall + Slide (McBain and Trush, 2005). Translational and rotational failures were lumped into the slide and flow movement types.

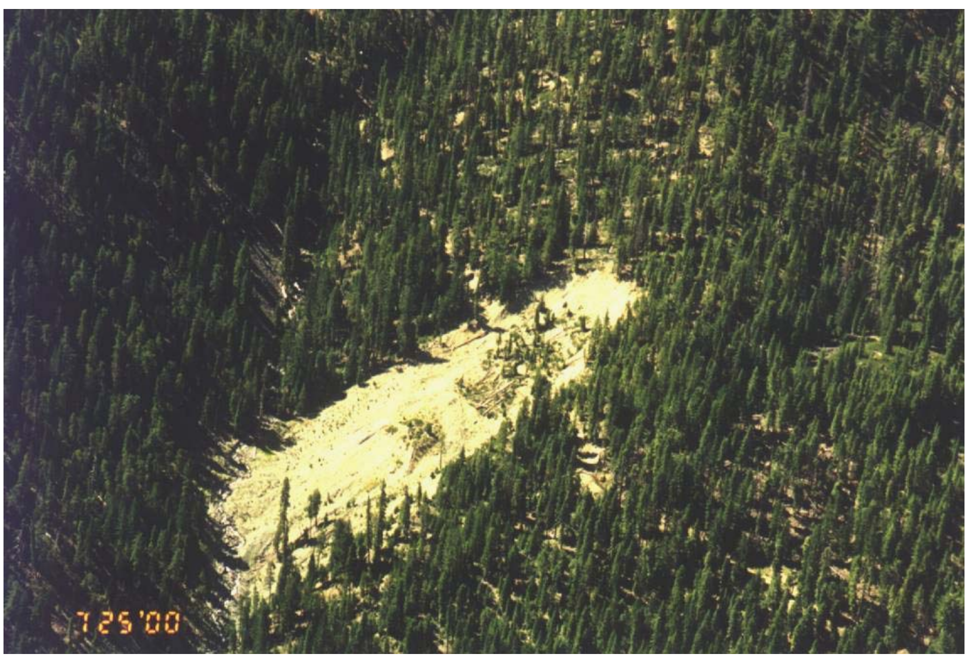

Figure 2.4.1. Example of debris slide with high sediment delivery.

Table 2.4.1. Landslide types used for the two different UT landslide inventories.

GMA (2001)	Description	Revised Code for landslide type	McBain & Trush (2005)	Description	Revised Code for landslide type
C	Inner gorge debris landslide	IG	DFL	Debris flow	DF
D	Debris torrent	DSF	DSL	Debris landslide	DS
E	Earthflow	RFL	DSL + FL	Debris landslide and flow	DSF
G	Gully	DFS	RFA	Rock fall	RF
S	Debris landslide	DS	RFA + SL	Rock fall and landslide	RFS
			RSL	Rock landslide	RS

The following describes the different types of landslides included in the database:

- Debris Flow (DF): made up of coarse material, moves as a flow, has a rapid rate of movement, and tend to bulk or grow downslope.
- Gully (DFS): made up of coarse material, moves as both a flow and a landslide, has a rapid rate of movement, and tend to bulk or grow downslope.
- Debris Landslide (DS): made up of coarse material, moves as a landslide, has a slow to rapid rate of movement, and are confined vertically and laterally by stable material.
- Debris Torrent (DSF): made up of coarse material, moves as both a landslide and a flow, has a rapid rate of movement, and tend to bulk or grow downslope.
- Inner Gorge Debris Landslide (IG): made up of coarse material, moves as a landslide along the upper and lower channel bank, has a rapid rate of movement, and is confined by the valley walls.
- Earthflow (RFL): made up of earth (i.e., fine) material, moves as a flow, and has a slow rate of movement.
- Rock Fall (RF): made up of bedrock material and moves as a fall.
- Rock Fall and Landslide (RFS): made up of bedrock material and moves as a flow and landslide.
- Rock Landslide (RS): made up of bedrock material and moves as a landslide.

2.4.1.4 Landslide Volume and Mass

The displaced landslide volume and mass are the product of landslide area (A) and average depth (D). The landslide area is estimated using the mapped landslide polygon connecting the head, margins, and toe of each feature. The landslide area is for a horizontal plain and does not account for the landslide travel angle (Cruden and Varnes, 1996). As a result, the actual landslide area is underestimated for steep slopes much like the actual watershed drainage area. Each type of landslide is assigned an average depth. Field verification data show that landslide depth has a wide range for the same material and movement type (CDC, 1999, GMA, 2001, and McBain and Trush, 2005). This analysis assumes a constant average depth for each landslide type (Table 2.4.2). Like the landslide area, the actual depth is not accurately represented. For rock falls and slides, this analysis assumes that 50 percent of the feature area moves downslope.

Table 2.4.2. Estimated average landslide depth by type.

Landslide Type	Description	Depth (feet)	Notes
DF	Debris flow	9.0	
DFS	Gully	3.0	
DS	Debris slide	7.5	
DSF	Debris torrent	8.5	same as debris landslide and flow
IG	Inner gorge debris landslide	7.5	
RF	Rock fall	0.5	assumes 50% of feature area fails
RFL	Earthflow	12.0	
RFS	Rock fall and landslide	0.5	assumes 50% of feature area fails
RS	Rock landslide	0.5	assumes 50% of feature area fails

2.4.1.5 Landslide Delivery

The volume and weight of sediment delivery to the stream network is estimated for each landslide type. The sediment delivery was classified differently for GMA (2001) and McBain and Trush (2005) (Table 2.4.3). The sediment delivery coefficients were combined for this analysis. Each feature is classified according to its delivery potential. Sediment delivery was mapped where there was an obvious connection with the stream network.

If a landslide appeared to deliver sediment to the stream network, the percentage of sediment delivered was estimated as one of five volume classifications (Table 2.4.3). Figure 2.4.1 is an example of a debris slide with a sediment delivery coefficient of 0.75. All inner gorge debris slides are assumed to deliver 98 percent of the original landslide volume, and earthflows with connection to the stream network are assumed to deliver five percent of the displaced volume. Landslides with no sediment delivery potential were removed from the landslide analysis. Table 2.4.4 lists the average sediment delivery coefficient by landslide type.

Table 2.4.3. Average landslide sediment delivery by type for previous inventories.

Sediment Delivery Code (GMA, 2001)	Sediment Delivery Coeff (GMA, 2001)	Sediment Delivery Code (McBain & Trush, 2005)	Sediment Delivery Coeff (McBain & Trush, 2005)
1	0.02	-	-
2	0.25	0-33%	0.17
3	0.5	34-66%	0.5
4	0.75	67-100%	0.85
5	0.85	-	-

Table 2.4.4. Average landslide sediment delivery by type for this analysis.

Landslide Type	Description	Average Sediment Delivery Coeff (%)
DF	Debris flow	73
DFS	Gully	60
DS	Debris slide	75
DSF	Debris torrent	82
IG	Inner gorge debris landslide	98
RF	Rock fall	49
RFS	Earthflow	5
RS	Rock fall and landslide	40
RFL	Rock landslide	25

2.4.1.6 Landslide Triggering Mechanism

The landslide triggering mechanism is defined by the process(s) that initiated landslide activity, natural or management related. Some of the natural triggering mechanisms include reduced soil strength due to slope saturation, removal of lateral support by stream downcutting, and reduced root strength after severe wildland fire. Some of the management related triggering mechanisms include removal of lateral support above road cuts, increased weight from road fills, reduced soil strength due to slope saturation from road drainage or timber harvest, and reduced root strength after timber harvest (CDC, 1999). The debris slide shown in Figure 2.4.1 is an example of where a road contributed to landslide activity. In this example, the likely triggering mechanisms are removal of lateral support and increased water flow along the soil/rock interface.

Table 2.4.5. Land use codes used in landslide inventory.

Old Land Use Code	New Land Use Code	Description
B	N	Brush non-management
C	T	timber harvest clear-cut
F	N	Forest
Nat	N	Natural
P	T	timber harvest partial cut
RC	R	Road cut
RF	R	Road fill
Roa	R	Road
Tim	T	timber harvest

For this analysis, the mechanism that triggered a give landslide is classified into three categories: natural; road related; and timber harvest related. GMA (2001) and McBain and Trush (2005) classified the associated land use for each landslide. This analysis cross-walked the land use codes and verified the associated land uses for several features (Table 2.4.5). Ground disturbance associated with forest roads and timber harvest activities appears to be a major landslide triggering mechanism, however, other non-forest land uses like grading associated with urban development do contribute to slope instability.

2.4.1.7 Landslide Inventory Data Analysis Assumptions
The landslide inventory analysis only included landslides that were definitely or probably present as interpreted from aerial photos. Questionable landslides were not analyzed unless they were field verified and shown to be present and active. In addition, the analysis did not include landslides that do not deliver sediment to the stream network. The remaining landslide dataset was sorted by subwatershed, landslide type, year active, ownership, bedrock geology, and slope position.

Summary tables for the UT and subwatersheds were prepared for use in interpreting the data and performing volume calculations. The volume of delivering landslides in each subwatershed was computed based on delivery percentage multiplied by landslide area and landslide thickness. Temporally, the landslides are assumed to deliver the evacuated volume over a twenty year period from 1983 to 2003. Landslide volumes were converted from cubic yards to tons based on soil bulk density data (i.e., 1.3 tons/yd^3). This allows comparison of sediment inputs to sediment transport values, which are usually computed in term of weight rather than volume.

For the CDWR (1980) landslide map, none of the landslide data listed above existed for these slides. GMA (2001) made the following assumptions:

- All slides were assumed to have a "definite or probable" certainty, thus none were discarded from further consideration.
- Slides were only sub-divided by debris landslide and debris torrent categories, as defined by CDWR.
- Used the average landslide thicknesses from GMA field inventory combined with the GIS area to estimate landslide volume.
- Assumed that the average delivery rates for the two types from field data were applicable to all of the CDWR slides.
- Intersected road and harvest coverages applicable to the 1979 time period to determine a land use category for each landslide. Slides that were located in harvest units were assumed to be harvest-related, while those within a 100-foot buffer of the roads layer were assumed to be road-related. All other slides were assumed to be non-management related.

2.4.2 GEO13 Landslide Risk Model

2.4.2.1 Data Sources
This analysis uses existing landslide data and information from CDWR (1980), GMA (2001), Trinity County Resource Conservation District (RCD), and USDA Forest Service. Landslide, bedrock, soil, and land use data were compiled by GMA and RCD and updated using aerial photo interpretation and field inventories. All of the GIS and Excel files are stored electronically in the project file and are available on CD.

The private and public timber harvest data are stored in a GIS layer called Disturbed. The Disturbed layer is a compilation of private Timber Harvest Plans (THPs), the Forest

Service timber harvest database, and aerial photo mapping. The roads layer includes private and public roads and is maintained by the RCD.

The base landslide layer was developed by the USDA Forest Service (2005). This layer was verified and updated using data and information from CDWR (1980), GMA (2001), , and McBain and Trush, Inc. (2005). The landslide data are compiled in a GIS layer called Geomorphology or GEO13. This layer is stratified by slope position, slope steepness, background/management landslide failure rates, upland delivery potential, and land use information. Active and dormant landslides have been mapped on the public and private portions of the Upper Trinity River project area and digitized in GIS. Before this analysis, the GEO13 original layer had 1,892 acres of active landslides. McBain and Trush (2005) mapped 7,332 acres of active landslides which were integrated with the GEO13 layer.

2.4.2.2 Landslide Model

The risk of landslide sediment delivery is quantified using the amount of material delivered to the stream network per Q_{25} flood event for background and existing watershed condition. The level of risk is used to characterize acute sediment delivery during infrequent flood events. Occurring infrequently (four percent chance per year), the Q_{25} flood event is used as the design flood event because floods of equal or greater magnitude typically trigger upland and inner gorge mass movement and cause watershed scale disturbance. The model framework and assumptions are based on the USDA Forest Service (2004) GEO13 landslide modeling process.

2.4.2.3 Model Assumptions

The following is a list of the assumptions made as part of the landslide modeling process.

- A large portion of the material delivered to the stream network during infrequent floods is stored for decades to centuries directly downstream from the point of delivery.
- Landslides that occur in high order channels in the lower portion of the stream network deliver more sediment per unit area. As the drainage area increases the downstream transport potential increases.
- Background landslide sediment delivery rates are based on undisturbed conditions, and active landslides associated with land use are not included.
- Active landslides that intersect timber harvest units are management related.
- Roads that cross landslides increase the rate of movement and sediment delivery.
- Upland sediment delivery potential is a function of slope steepness, slope position, and proximity to the stream network.
- The volume (yds^3) of sediment delivered is converted to weight (tons) using the bulk density of partially saturated loose earth (i.e., 1.3 tons/yds^3)

2.4.2.4 Background Landslide Failure Rates

The background landslide failure and sediment delivery rates are estimated using available data summarized in GMA (2001), Elder and Reichert (2005), USDA Forest Service (2005), and Raines (1998). The active landslides were classified using the scheme described above in Section 2.4.1.3, and the dormant and relict landslides were classified using USDA Forest Service (2001). There are 13 types of slides used in the model that represent active, semi-active, and dormant landslides. For background conditions, active landslides and inner gorge slides produce the majority of the material relative to surface and fluvial erosion (Table 2.4.6).

Table 2.4.6. GEO13 landslide type categories and background erosion rates.

Landslide Type	Description	Background (yds^3/Q_{25}/acre)
0	unknown	0.25
1	Active landslides	25.92
2	Toe zones dormant slides	1.89
3	Dormant landslides	1.89
4	Granitic bedrock, steep slopes (>65%)	1.00
5	Granitic bedrock, low to moderate slopes (<65%)	0.53
6	Non-granitic bedrock, steep slopes (>65%)	1.23
7	Cenozoic volcanic bedrock, moderate slopes (15%-45%)	0.05
8	Non-granitic bedrock, low to moderate slopes (<65%)	0.25
9	Inner gorge developed in unconsoildated deposits	19.94
10	Inner gorge developed in granitic bedrock	6.36
11	Other inner gorge	5.14
12	Debris basins	1.06
13	Unconsolidated deposits (e.g., Qg, Qt, Qal, Q)	2.17
99	Waterbodies; lakes & polygon streams	0.00

2.4.2.5 Disturbance Landslide Failure Rates and Recovery

Sediment delivery from management caused landslides is estimated by intersecting the Geomorphology, Disturbed, and Roads layers and calculating the percent over background. Where landslides and disturbances overlap, the sediment delivery is calculated and summed for a given subwatershed.

Sediment delivery from timber harvest caused landslides is the product of the disturbed area and the disturbance coefficient (Table 2.4.7). The high or moderate disturbance level is classified using the type of timber harvest. For timber harvest, the silvicultural prescription and yarding method determine the disturbance level. Clear-cut and heavy thinning using mechanical or cable yarding methods are classified as high disturbance. Moderate to light thinning using mechanical or cable yarding methods is classified as moderate disturbance. Landslides triggered by timber harvest tend to recover slowly and are difficult to feasibly stabilize. This analysis factors the age of harvest and the amount of linear recovery by decade. All timber harvest related landslides are assumed to be fully recovered in 40 years.

The road-landslide sediment delivery is the product of the road prism area and the disturbance coefficient (Table 2.4.7). The road prism area includes the cut slope, fill slope, and driving surface. Road width was estimated for each category of surface type. Native surface roads were given a 35 foot width, rocked roads a 45 foot width, paved roads a 55 foot width, and highways a 100 foot width. Landslides triggered by roads tend to recover slowly and often continue to produce sediment unless stabilization measures are implemented. This analysis uses the existing land form condition to estimate road-landslide related sediment delivery and does not factor the age of a given road into the calculations.

Table 2.4.7. GEO13 landslide type categories and disturbance erosion rates.

Landslide Type	Description	Road Disturbance Coeff	High Disturbance Coeff	Moderate Disturbance Coeff
0	unknown	18.3	2.1	1.2
1	Active landslides	753.1	94.6	60.3
2	Toe zones dormant slides	154.5	5.9	3.9
3	Dormant landslides	154.5	5.9	3.9
4	Granitic bedrock, steep slopes (>65%)	585.4	10.4	5.7
5	Granitic bedrock, low to moderate slopes (<65%)	35.1	5.5	3.0
6	Non-granitic bedrock, steep slopes (>65%)	81.8	2.5	1.9
7	Cenozoic volcanic bedrock, moderate slopes (15%-45%)	0.5	0.3	0.2
8	Non-granitic bedrock, low to moderate slopes (<65%)	18.3	2.1	1.2
9	Inner gorge developed in unconsoildated deposits	308.5	42.5	31.2
10	Inner gorge developed in granitic bedrock	699.5	110.0	58.2
11	Other inner gorge	168.6	8.8	7.0
12	Debris basins	25.0	17.0	9.0
13	Unconsolidated deposits (e.g., Qg, Qt, Qal, Q)	6.4	5.5	3.8
99	Waterbodies; lakes & polygon streams	0.0	0.0	0.0
* rates are in yds3/Q25/acre				

2.4.2.6 Landslide Sediment Delivery Potential

Each landslide, background or management related, is assigned a sediment delivery potential coefficient that is based on the slope position, slope steepness, and proximity of the landslide to the stream network. Inner gorge failures, by definition, have the highest sediment delivery potential, whereas slides near the ridge have the lowest. DEMs and the mapped stream network are used to spatially orient each landslide within the project area and assign a sediment delivery coefficient.

2.5 Surface and Fluvial Erosion Source Analysis

2.5.1 GMA Surface Erosion Inventory

2.5.1.1 Data Sources

The landslide source analysis combines data from CDWR (1980), GMA (2001), and McBain and Trush (2005). The first phase identified and inventoried landslides discernable on aerial photographs. The second phase consisted of field-verifying about 12 percent of the mapped landslides to validate the aerial photograph interpretation, estimate landslide thickness, and map small landslides not recognizable on the photos. All of the GIS and Excel files are stored electronically in the project file and are available on CD.

2.5.1.2 Road Surface Erosion

The purpose of this part of the sediment source analysis is to identify portions of the road network that deliver fine sediment to streams. This analysis developed an understanding of the overall effects of the road system on sediment yield by roughly quantifying the amount of sediment delivered to streams from roads in a subwatershed. The road surface erosion estimates are compared to the estimated sediment delivery rates for natural and other erosion sources associated with land management activities.

Unlike surface erosion from exposed hillslopes where revegetation usually occurs within a few years, road surfaces can continue to erode as long as the road is used. If the surface and subsurface are stable, the road cut-slopes and fill-slopes tend to stabilize with time, reducing erosion. Road surfaces continue to produce fine-grained sediments over the life of the road as a function of surface type and level of traffic. A native surface road with high use during wet and dry periods will produce the most road erosion.

The approach used to estimate surface erosion rate for a give type of road, was to examine road segments for characteristics of the road prism, drainage system, and traffic as they influence the delivery of sediment to the stream system, and calculate road sediment yield based on them. Factors were applied for differing conditions of the road tread, cut-slopes and fill-slopes, and traffic use that increase or decrease the estimated sediment yield of that segment. The result is an estimate of sediment yield for each road segment. The sediment yield estimate was further modified according to the estimated sediment delivery to the stream network along that segment.

Data were collected for the following factors and road attributes that influence the amount of sediment delivered to streams from roads:

- The erodibility of the soil/geology the road is built upon
- Precipitation amount, frequency, and intensity
- The age of the road
- Road drainage pattern (insloped/outsloped/crowned)
- Probability that sediment from road reaches stream (depends on distance and slope between road drain and stream, amount of obstructions to trap sediment, and road area that collects water and sediment)
- Length of road that delivers to stream
- Width, surface type and durability, traffic use, and slope of road tread
- Cut-slope cover and height
- Fill-slope cover and height
- Ditch width, slope, and armoring

2.5.1.3 Procedure

Road segment groups were analyzed to produce estimates of the sediment delivery rate for each road segment type. That rate was applied to all of the segments of that road type in each subwatersheds, resulting in an estimate of sediment delivery from roads for each subwatershed. The amount of sediment delivered to the stream from each road segment type was estimated by apportioning the inherent erosion rate among the road prism components. Each component rate was modified by factors based on road prism characteristics and the percentage of the road delivering sediment into the steam system. The final product is the rate of sediment delivered to streams from road segment types.

The rate multiplied by the length of each segment type in each subwatershed provides the total sediment from roads for each sub-basin.

Since it was not realistic to visit every road segment in every watershed, the road system was stratified to enable representative portions of the roads to be sampled. Each road "type" was characterized, and sediment yields determined and extrapolated to other roads of the same type. Road types consist of segments of similar hillslope location (riparian, mid-slope, and ridge), surfacing (paved, rocked, native), and geologic terrane.

Field Inventory was used to verify traffic and surface information, to verify segment types and grouping, to check average road attributes (tread, ditch, cut slope, fill slope) and prism dimensions, to collect information on cover percentage on cut- and fill-slopes, to review localized problem areas, and to determine potential delivery to streams. Prior to field inventory, GMA performed GIS analyses to identify those portions of the road network within the standard 200-foot buffer from a Class I, II, or III watercourse (i.e. riparian roads). Because of the much greater delivery from riparian roads, these areas were prioritized. During field surveys, information on road sediment delivery was also collected for each segment. At each drainage site, the potential for sediment delivery to the stream was determined.

GMA (2001) inventoried 101.8 miles of roads in the Trinity River. Very few surveys occurred in the UT portion of the watershed. Road erosion rates for bedrock geology types within the UT were used to extrapolate road erosion rates.

2.5.1.4 Development of the Road Model

A formula was developed in order to estimate total sediment delivered for the entire UT. The formula used was similar to the formula used in SEDMODL, which was used in the Sediment Source Analysis for the South Fork Trinity River (Raines, 1998). The formula developed does not, however, account for road use factors, precipitation factors, or road slope factors.

Tread erosion was based on both measured attributes and erosion factors found in the Washington Department of Natural Resources Standard Methodology for Conducting Watershed Analysis, Surface Erosion Module (Washington Forest Practices Board, 1995), with modifications based on additional empirical road erosion research conducted in the Pacific Northwest (Raines, 1998). Field measured attributes for tread drainage included; segment length, road width, ditch width, and delivery percentage. Geological erosion rates based on geology were obtained from both the default geology coverage's supplied with SEDMODL (Bond and Wood 1978, Huntting et al. 1961, Walker and MacLoed 1991) and the modified geologic erosion rates used in the South Fork Trinity River Sediment Source Analysis (Raines, 1998). The maximum geologic erosion rates were used because the values seemed most applicable. Tread surfacing factors were based on the factors used by Raines in the South Fork Trinity River Sediment Source Analysis. Tread erosion was then calculated as the product of the above-mentioned attributes.

Tread Erosion = Geologic Erosion Rate x Tread Surfacing Factor x Segment Length x Road Width x Delivery Factor

Cut-bank and fill-slope erosion was calculated based primarily on physically observed attributes. Cut-bank erosion attributes included; cut-bank height, an armoring factor (based on exposed bedrock and vegetation), the average depth of eroded material (based on exposed root and rock as well as rills and gullies), the length of cut-bank, and a delivery percentage. Total cut-bank erosion for each segment was calculated as the product of these attributes.

Cut-bank Erosion = Cut-bank Erosion (depth) x Cut-slope Cover Factor x Segment Length x Cut-slope Height x Delivery Factor

Other sources of erosion such as fill failures, cut-bank failures, crossing failures, and gullies were recorded for each drainage segment. Volumes of sediment eroded were recorded as well as an estimate of the time period (by decade) of the erosion. Decade of erosion was based on indicators such as vegetation coverage and tree age. Delivery was based on field investigations of each erosional feature. Total erosion from other sources was calculated as the product of volume and delivery.

The total amount of erosion from each drainage segment is calculated as the sum of tread erosion, cut-bank erosion, and other sources of erosion. Total erosion is then divided by the length of the segment and by the age of the road. The ratio of segment length to total length surveyed was then used to derive an adjusted total erosion amount recorded in tons per mile per year. Total erosion from each site was then summed for each of the geologic types and then sorted by both surface type and hillslope location. These values were then used to develop surface erosion rates (tons/mi/year) which could then be applied to data extracted from the project GIS.

2.5.1.5 Road Surface Erosion Calculations

Surface erosion from roads within each subwatershed was computed for existing conditions by stratifying by geology, stratifying by location (riparian, mid-slope, and ridge categories), and stratifying by road surface (paved, rocked, and native categories) and then applying the appropriate rate developed from the field inventories. Surface erosion from roads was estimated for a 20 year period.

Slope positions were assigned using the following methodology. To determine the location of Riparian roads, all Class I and Class II streams were buffered by 200 feet on either side. All roads segments within this buffer were considered Riparian. To determine the location of Ridge roads, ridgelines were identified by creating watershed boundaries from the 10-meter DEM with a minimum area of approximately 75 acres. Next all Class I streams were buffered by 500 feet to clip the watershed boundaries away from the riparian zone. The resulting ridgeline coverage was then buffered by 100 feet on either side. All road segments within this buffer were considered Ridge roads. All the roads segments that did not fall into the 200 foot riparian buffer or the 100 foot ridge buffer were considered to be Mid-Slope.

2.5.1.6 Timber Harvest Surface Erosion

Surface erosion from areas disturbed by timber harvest activities is most often related to various surface disturbance activities, primarily skid trails and increased rainfall-runoff. Without access to verify rates for harvested areas (almost all recently harvested land in the watershed is privately owned), we were limited to application of a single sediment delivery rate that was obtained from the literature. The rate of four tons/ac/year was selected from a review of the literature and values used in the South Fork Trinity River Sediment Source Analysis (Raines 1998) for the post-1974 period reflecting development of Forest Practice Rules regulating harvesting methods. For pre-1974 harvesting, the rate was assumed to be 12 tons/ac/year or three times as great prior to regulation. These values were applied to all harvested areas, regardless of sivilculture method, by the appropriate period. Surface erosion from harvest areas was estimated for a 20 year period.

The timber harvest history was compiled using the following data and information: maps of timber harvesting prepared by CDWR (CDWR 1980) were digitized and input into the project GIS thus providing information from 1940 to 1978, maps contained in CDF THP's for the period 1979-2003 were digitized and combined with USFS compartment data to arrive at harvest acreages by subwatershed for the current period.

2.5.2 Surface and Fluvial Erosion Risk Model

2.5.2.1 Data Sources

Surface and fluvial erosion sediment delivery rates are estimated using the STATSGO 4th order soils coverage, the NOAA 2 year, 6 hour rainfall intensity, 10-meter Digital Elevation Model (DEM) derived slope position, slope steepness, and the mapped stream network. These layers are intersected into a layer called KCRLS. Land use data are intersected with the KCRLS layer.

2.5.2.2 Model Assumptions

The risk of surface and fluvial erosion sediment delivery is quantified using the amount of material delivered to the stream network per Q_2 flood event for background and existing conditions. The level of risk is used to characterize chronic sediment delivery during frequent flood events. Occurring once every one to two years, the Q_2 flood event is used as the design flood event because it typically causes surface, rill, and gully erosion. The model framework and assumptions are based on the USDA Forest Service (2004) surface erosion modeling process. A modified version of the Universal Soil Loss Equation (USLE) is used to estimate background and management related surface and fluvial erosion.

The following is a list of the assumptions made as part of the surface and fluvial erosion modeling process.

- A large portion of the material delivered to the stream network during frequent floods is transported downstream rapidly.

- Background surface and fluvial erosion sediment delivery rates are based on undisturbed conditions where very little erosion occurs.
- The 2 year, 6 hour rainfall event causes surface runoff and a Q_2 flood event.
- Roads and timber harvest increase the frequency and magnitude of rainfall-runoff and erosion
- Native surface road erosion rates are calculated using the bare soil K factor. For rocked and paved roads, an erosion rate of 0.01 $yds^3/acre/Q_2$ is used.
- The amount of road traffic influences road surface erosion rates. Main roads are assumed to have a year round traffic, and small native surface roads are assumed to not have traffic during the winter due to snow.
- Surface and fluvial erosion caused by timber harvest disturbances recover with time using the following equation:

$$C = 0.244\ X^{-1.54}$$

X = years
C = ground cover recovery factor

- Upland sediment delivery potential is a function of slope steepness, slope position, and proximity to the stream network.
- The volume (yds^3) of sediment delivered is converted to weight (tons) using the bulk density of fully saturated loose fine sediment (i.e., 0.7 $tons/yds^3$).

2.5.2.3 Background Surface and Fluvial Erosion Rates

The background surface and fluvial erosion rates are estimated using available data summarized in Elder and Reichert (2005), GMA (2001), and Raines (1998). The unit erosion rate is estimated using a modified form of the Universal Soil Loss Equation (USLE) as follows:

$$A = KCRLSD*0.7$$

A = unit erosion rate (yds3/acre/Q_2)
K = soil erodibility factor for bare soil
C = ground cover factor
R = rainfall-runoff factor
LS = upland length and slope
D = delivery factor

Each soil type is assigned a bare soil erodibility factor (K). A ground cover factor (C) is used to modify K for a given soil type. For undisturbed conditions, the models assumes that 99 percent of the ground is covered and that very little natural surface and fluvial erosion occurs (i.e., C = 0.01). R is calculated from the 2 year, 6 hour rainfall event using the following equation:

$$R = 10.2*p^{2.17}$$

p = 2 year, 6 hour rainfall event

The slope factor (LS) and delivery factor (D) are delineated using the slope position and steepness from DEMs. The slope factor is estimated by subdividing upland areas into polygons greater and less than 35 percent slope. The delivery factor was developed using the DEM derived slope position, slope steepness, and proximity to the stream network.

2.5.2.4 Disturbance Surface and Fluvial Erosion Rates

The disturbance surface and fluvial erosion rates are estimated using the modified USLE equation described above. The KCRLS layer is intersected with the Disturbed layer and the output is used to calculate erosion by subwatershed (Table 2.5.1).

Surface and fluvial erosion from timber harvest is the product of the disturbed area and the unit erosion rate (A). The high or moderate disturbance level is classified using the type of timber harvest, and the disturbance level is determined by the type of silvicultural prescription and yarding method. Clear-cut and heavy thinning using mechanical or cable yarding methods are classified as high disturbance. Moderate thinning using mechanical or cable yarding methods is classified as moderate disturbance. Light thinning using mechanical or cable yarding methods is classified as light disturbance.

Table 2.5.1. List of disturbance coefficients for different timber harvest treatment types.

Treatment Type	Disturbance Coefficient	Treatment and Method
L/HE	0.05	light thin helicopter
M/HE	0.08	moderate thin helicopter
L/CA	0.1	light thin cable
L/TR	0.18	light thin tractor
M/CA	0.2	moderate thin cable
H/HE	0.25	clear-cut or heavy thin helicopter
H/CA	0.5	clear-cut or heavy thin cable
M/TR	0.5	moderate thin tractor
H/TR	0.8	clear-cut or heavy thin tractor

Surface and fluvial erosion caused by timber harvest activities tends to recover rapidly. This analysis factors the age of harvest and the amount of non-linear recovery by year using the equation listed in the model assumptions section above.

The road caused surface and fluvial erosion is the product of the road prism area and unit erosion rate. The bare soil K factor is used unless the road surface is rocked or paved. For rocked and paved roads, an erosion rate of 0.01 $yds^3/acre/Q_2$ is used. The road prism area includes the cut slope, fill slope, and road surface. Like the landslide model, road width was estimated for each category of surface type. Native surface roads were given a 35 foot width, rocked roads a 45 foot width, paved roads a 55 foot width, and highways a 100 foot width. Surface and fluvial erosion on roads remains constant unless erosion control measures are implemented, and long-term surface and fluvial erosion from the road surface is a function of traffic levels.

2.5.2.5 Surface and Fluvial Erosion Sediment Delivery Potential

This model assumes that a large portion of the material delivered to the stream network during frequent flooding is transported as wash and suspended load and is rapidly delivered to the larger stream network. Representing chronic sediment delivery, soils with a high percentage of fines less than 3.25 mm are assumed to produce and deliver the majority of the suspended sediment load.

Each surface and fluvial erosion source, background or management related, is assigned a sediment delivery coefficient that is based on the slope position, slope steepness, and proximity to the stream network. Erodible soils on steep slopes have the highest delivery potential, whereas soils near the ridge have the lowest. DEMs and the mapped stream network are used to spatially orient each soil group within the project area.

3.0 RESULTS AND DISCUSSION

3.1 Hydrology

Surface waters sourced from the UT Planning Watershed are temporarily stored behind Trinity and Lewiston Dams. Since 1963, outflow has been regulated to maximize power generation and flow diversion, and the precipitation and streamflow of this area are measured continuously as part of ongoing reservoir management. Recent efforts to restore the fisheries below the dams have focused on the water and sediment budget and describe the UT hydrology in great detail (e.g., USFWS and Hoopa Valley Tribe, 1999). This section summarizes the relevant existing data and reports to characterize the precipitation, streamflow, and sediment transport of the UT.

3.1.1 Precipitation

The precipitation magnitude, frequency, duration, intensity, and timing as part of the sediment source analysis models to qualify and quantify the erosion and sediment delivery potential. For the UT, the average annual precipitation is about 50 inches at 4,000 feet with 90 percent falling between October and April (Plate 3). Long duration snow and rain storms are common. Short duration thunderstorms occur infrequently during the summer and fall. Because the elevation of the UT ranges from about 2,400 feet (i.e., about 35 inches) at Lewiston Dam to about 9,000 feet (i.e., over 75 inches) near the headwaters in the Trinity Alps Wilderness there is a wide range of average annual precipitation. Most of the precipitation above 6,000 feet is in the form of snowfall and below is a mix of snow and rain. The frequency and intensity of the 100 year, 24 hour storm event is between 7 and 10 inches of precipitation, and the 2 year, 6 hour is between 1.6 and 2.2 inches.

3.1.2 Streamflow

The streamflow magnitude, frequency, duration, intensity, and timing are used to help qualify and quantify the sediment transport and storage potential of the UT. Since the 1800s a variety of streamflow records have been kept in the UT. Presently, there are two continuous US Geological Survey streamflow gages above and below Trinity Lake (Trinity River near Lewiston and Trinity River above Coffee Creek). GMA presently operates two continuous streamflow gages on Coffee Creek at Highway 3 and East Fork Trinity River at Trinity County Road 106. GMA also operates 29 other intermittent streamflow sites on various tributaries to the UT. These sites are described in greater detail below.

Long-term streamflow records show that for subwatersheds with an average elevation lower than 4,000 feet floods tend to result from rainfall-runoff and base flows are a function of groundwater discharge. For subwatersheds with headwater an average elevation higher than 4,000 feet, floods tend to result from rain on snow events and base flows are a function of drainage area (USGS, 1967). In addition, higher elevation watersheds have a snowmelt peak that typically occurs in the spring.

Flood frequency analysis is a method used to predict the magnitude of a flood that would be expected to occur, on average, in a given number of years (recurrence interval) or to have a specific probability of occurrence in any one year (e.g., one percent chance event). Typically, the observed annual maximum peak discharges are fitted to the distribution using a generalized or station skew coefficient, although numerous other distributions may also be used. When long records are available, the station skew is generally used exclusively. The Trinity River Flow Evaluation Report, hereafter TRFE (USFWS and Hoopa Valley Tribe, 1999), included flood frequency of the Lewiston gage records using the Log-Pearson Type III distribution for both pre- and post-dam flow regimes. The $Q_{1.5}$ event (flood event that would occur on average once every 1.5 years) was reduced by the dam from 10,700 to 1,070 cfs, while the Q_{10} was reduced from 36,700 to 7,500 cfs.

A flood frequency analysis was completed for the historic and present gage sites in the UT watershed to help predict subwatershed sediment yield potential. These gages include Trinity River near Lewiston, Trinity River above Coffee Creek near Trinity Center, Coffee Creek near Trinity Center, and Slate Creek near Trinity Alps. Figure 3.1.1 illustrates the graphical flood frequency plots. The largest floods recorded at the gages occurred in 1974 and 1964. Flood frequency was calculated using the Log Pearson Type III method (Table 3.1.1), and the USGS Regional Equations (Table 3.2.1).

Table 3.1.1. Results of Log Pearson Type III flood frequency calculations.

Percent Chance	Recurrence Interval	Trinity RV nr Lewiston (cfs)^	Trinity RV abv Coffee (cfs)	Coffee CK nr Trinity Ctr (cfs)*	Slate CK nr Trinity Alps (cfs)*
1	100	69,938	25,660	28,000	1,197
2	50	59,146	21,860	26,354	814
4	25	48,881	18,167	15,032	547
10	10	36,084	13,484	7,185	315
20	5	26,906	10,053	4,131	201
50	2	14,950	5,509	2,014	102
99	1.0101	2,466	789	1,228	40

^ = Trinity River near Lewiston if for pre-dam flood events.
* = Coffee Creek and Slate Creek peak Q estimates based on limited data.

The long period of streamflow records for the Trinity River provides considerable insight into the geomorphic significance of the various storm events, particularly when combined with other regional and historic data. Known large flood events in the region, many of which would also have occurred in the watershed, have occurred in Water Years 1862, 1890, 1956, 1965, 1974, 1986, and 1997. The largest of these were likely to have been the 1862 and 1965 events, followed by the 1974, 1997, 1956 and 1890 events (not necessarily in that order by magnitude). The relative significance of these individual flood events would have varied throughout the watershed, even without construction of the dam.

The TRFE report included a flow duration analysis on mean daily discharges for both the pre- and post-dam flow regimes. Pre-dam a discharge of 1,000 cfs was exceeded almost 42 percent of the time, while post-dam this occurs only about 5.7 percent of the time. At low flows, the current minimum flows of 300 cfs are well in excess of the historic pre-dam flows, when 300 cfs was exceeded only about 65 percent of the time, and 5 percent of the time flows got lower than 100 cfs.

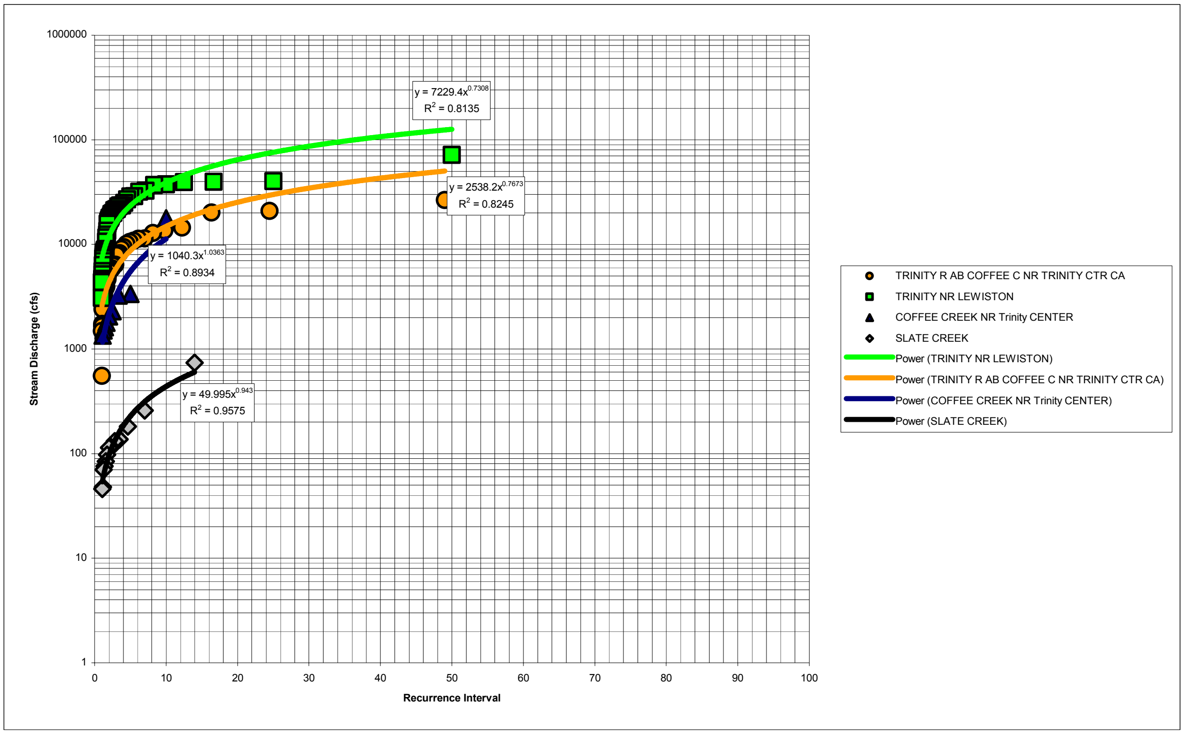

Figure 3.1.1. Graphical flood frequency for Upper Trinity continuous streamflow gages.

Annual runoff data has been compiled in the Trinity River watershed at the various USGS, CDWR, and HVT streamflow gages for variable periods of record. Unimpaired mean annual runoff for the Trinity watershed at Lewiston, for the 1912-2000 period is 1,246,000 acre-feet. The annual unimpaired runoff data are plotted in Figure 10. Interestingly, only one of the four largest volumes of runoff (WY1941, 1958, 1974, and 1983) is associated with a large flood year. The other years had very high annual precipitation, but it was spread out enough that no unusually large flows were generated. The extended dry period from 1917-1937 really stands out in the cumulative departure analysis, showing that over the 20-year period, cumulatively runoff fell below the mean by over 6,000,000 acre-feet, or almost 5 years worth of average flows.

3.2 Drainage Basin Characteristics

3.2.1 Watershed Morphometry

The slope elements, shape, texture, and drainage pattern of the stratified subwatersheds are used to characterize and quantify sediment yield potential. The UT drains 691 mi^2 of planar land area and flows from north to south with an elevation range of 6,233 feet (i.e., 2,625 to 8,858). The reservoir occupies about 24 mi^2 of the UT drainage area making the effective drainage 667 mi^2. The average subwatershed slope or relief ratio is 16 percent and ranges from five to 49 percent (Table 3.2.1 and Plate 1). The drainages are steep and concave with minor benches created by faults and geologic formation contacts (Figure 3.2.1).

According to the USGS 7.5 minute quadrangle blue line stream layer, there are 714 miles of perennial streams, and over 1,400 miles of intermittent and ephemeral channels. There are several cirque lakes near the headwaters and springs are common at all elevations.

The UT watershed has a contorted drainage pattern that trends along more resistant rock types and fault zones. The steep and dense drainage network results from heavy precipitation, shallow erosion resistant bedrock, and tectonic uplift (Plate 2). DEM analysis of the stream network indicates that during fully saturated conditions, the total stream network length may be about 4,000 miles with 86 percent of the channels steeper than 10 percent slope and one percent less than 1.5 percent slope. The average drainage density from the DEM stream network is 6.5 miles per square mile (Table 3.2.1), whereas the average density from the USGS blue line streams is 3.3 miles per square mile. The DEM network represents the active drainage network during large flood events and is used as a measure of drainage efficiency. These data show that the UT has high drainage efficiency with the majority of the stream network producing and transporting sediment and a small percentage storing massive quantities of delivered sediment.

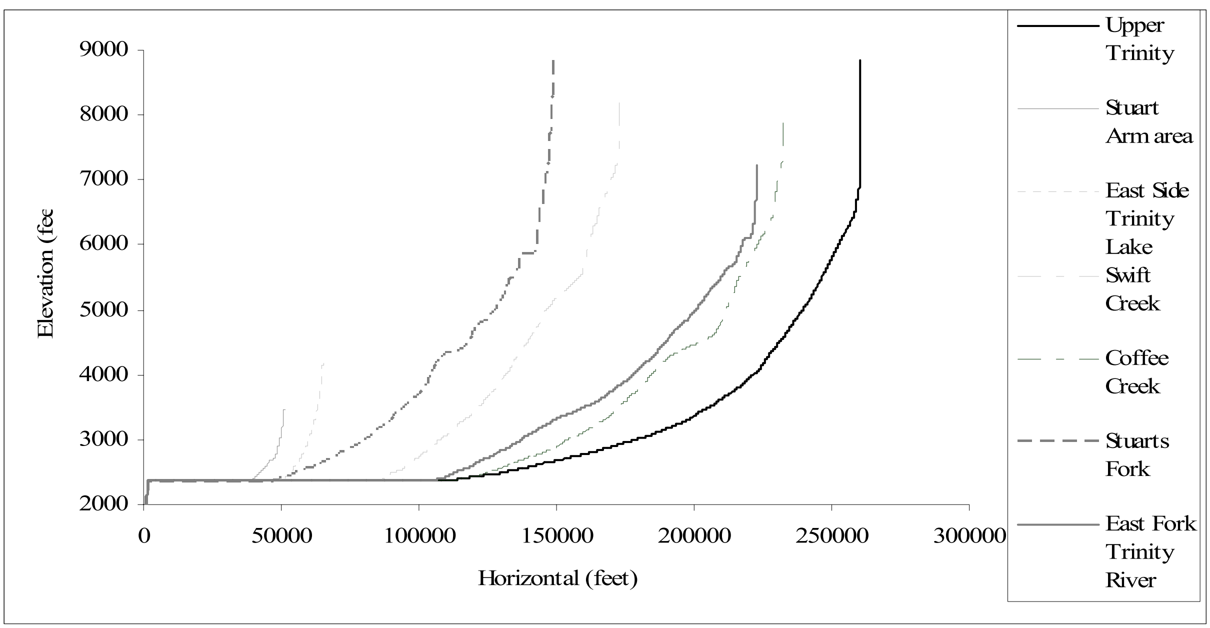

Figure 3.2.1. Graph showing selected subwatershed longitudinal profiles, all horizontal distances start from the Trinity Lake dam. Vertical exaggeration is about 2:1.

The headwater drainage network is made up of steep source type channels (i.e., slope > 10 percent) with narrow valleys where the potential stream energy exceeds upland debris flux. As a result, most of the sediment delivered to the network is rapidly transported downstream. Upper and lower bank erosion and failure are common. About 13 percent of the network is made up of transport channels (i.e., slope between 1.5 and 10 percent).

These channels tend to store and transport punctuated coarse sediment inputs as a function of large woody debris dams and bedrock constrictions. During flooding, the potential stream power of source and transport channels is high moving six foot boulders as bedload (USGS, 1967). The response channels, with wide valleys, make up a small percentage of the drainage network but store a large portion of total sediment input. Because the amount of sediment input exceeds the transport capacity, the response channels tend to be wide and braided with natural levees and meanders.

These observations are critical to understanding the sediment delivery, transport, and yield dynamics of the UT and show that natural and management related upland sediment sources have a high probability of being delivered to the low gradient channels and Trinity Lake. There are very few sediment storage areas between the headwaters and the head of the reservoir (Figure 3.2.1). Past flood studies for the upper Trinity River and Coffee Creek support this conclusion (USGS, 1967).

Table 3.2.1. Watershed morphometry variables listed by Upper Trinity subwatersheds.

Watershed	Drainage Area (mi^2)	Average Elevation (feet)	Relief Ratio	Q_2 USGS (cfs)	Q_{100} USGS (cfs)	Q_{100} unit (cfs)	Stream Density (mi/mi^2)	P_s
Bear Creek	4.5	5716	0.15	167	1282	690	6.1	0.031
Buckeye Creek	5.1	4559	0.15	283	2000	988	7.4	0.043
Cedar Creek	7.0	4528	0.13	382	2665	1348	6.6	0.019
Coffee Creek	116.4	6513	0.06	3963	30110	17857	6.7	0.164
Eagle Creek	15.1	6051	0.09	525	4014	2316	7.0	0.048
East Fork Stuart Fork	22.6	5048	0.15	1073	7629	3473	6.4	0.034
East Fork Trinity River	92.8	5749	0.05	3575	25891	14234	6.2	0.112
East Side Trinity Lake	64.8	4009	0.13	3107	19220	12471	5.2	0.264
Graves Creek	5.3	5048	0.17	210	1516	815	6.3	0.045
Hatchet Creek	1.9	3430	0.14	119	747	367	7.3	0.008
Minnehaha Creek	3.8	5443	0.25	161	1223	577	7.0	0.092
Mule Creek	6.3	5158	0.22	321	2385	965	6.7	0.018
Ramshorn Creek	12.8	5078	0.14	520	3702	1966	6.7	0.065
Ripple Creek	2.5	4965	0.21	115	850	476	6.6	0.069
Scorpion Creek	6.8	4659	0.17	335	2349	1311	6.7	0.058
Snowslide Gulch Area	12.1	4545	0.49	531	3600	2321	7.8	0.085
Squirrel Gulch Area	15.2	3554	0.17	815	4941	2915	6.4	0.036
Stoney Creek	5.4	5301	0.18	282	2136	834	6.5	0.034
Stuart Arm Area	34.5	3945	0.17	1508	9301	6636	5.2	0.083
Stuart Fork	62.5	7011	0.07	2349	18941	9594	6.5	0.145
Sunflower Creek	2.6	4812	0.19	110	792	497	6.8	0.029
Swift Creek	56.0	6275	0.07	2290	17620	8596	7.1	0.059
Tangle Blue Creek	21.6	6049	0.09	626	4679	3320	6.5	0.047
Upper Trinity Mainstem Area	9.9	4812	0.39	376	2599	1899	6.9	0.076
Upper Trinity River	63.0	6664	0.08	1674	12747	9673	6.0	0.089
West Side Trinity Lake	16.9	3395	0.11	793	4629	3243	5.5	0.024
Grand Total	667.4	5611	0.03	19693	131920	102411	6.3	0.337

3.2.2 Geology and Geomorphology

The majority of the UT dissects the Klamath Mountains Geomorphic Province (Plate 4), which has primarily resulted from stream erosion of an elevated plateau resulting in a basin dissected by drainage channels. Soils in the basin are generally thin and well-drained, on steep to moderate slopes over sedimentary, intrusive, and metamorphic rocks. This province is divided into the Eastern Klamath and Central Metamorphic with small areas occupied by the Weaverville Formation and Quaternary glacial and fluvial deposits (Irwin, 1960). There are several intrusive bodies of rock mainly in the western and northern portions of the UT watershed. Outcrop mapping shows that the bedrock generally dips to the east, with the older eastern unit overlying the younger western unit. Plutonic rocks intruded the metamorphic rocks throughout the watershed.

The Eastern Klamath Sub-province occupies the eastern one-third of the watershed and includes the Trinity ultramafic sheet, Copley greenstone, and Bragdon Formation (Plate 4). These units are generally considered to be stable and erosion-resistant, with the exception of serpentinites contained in the ultramafic rocks that are characterized as readily susceptible to mass movement. West of the Eastern Klamath sub-province is the Central Metamorphic sub-province. Two medium-grade to high-grade metamorphic rock units comprise this group: the Salmon Hornblende Schist and Abrams Mica Schist. Both of these units are considered moderately erodible.

North and southeast of Weaverville are light-colored, coarse-grained diorites of the Shasta Bally Batholith and associated Weaver Bally Batholith (Plate 4). Hillslopes formed by these granitic rocks are deeply weathered. Slopes are erodible and have a high rate of sediment delivery when protective vegetation is removed. The Canyon Creek pluton in the north central part and Ironside Mountain Batholith in the western half of the watershed are light-to medium-colored hornblende quartz diorites. They form steep slopes and are not considered serious erosion problems.

The Weaverville Formation consists of weakly consolidated mudstone, sandstone, and conglomerate with an impervious dark green clay matrix, and sparse interbeds of light-colored tuffs (Irwin, 1974). The Weaverville Formation tends to be unstable, particularly along road cuts and streambanks where slopes are oversteepened.

Glacial deposits are found in the northern part of the watershed including Stuarts Fork, Swift Creek, and Coffee Creek valleys. Alpine glaciation shaped the headwaters of the UT and benches visible in Figure 3.2.1. In the lower portion of these subwatersheds, terraces composed of sand and gravel from glacial erosion flank much of the response channel types.

3.2.3 Land Use History

The history of the Trinity River and its watershed is dominated by resource development, whether by mining, timber harvest, or water resources storage and diversion. Given the generally steep, mountainous terrain, relatively little flat land exists, and thus agriculture has played only a minor role in the economic development of the watershed. Logging, mining, fisheries, and recreation are the predominant uses.

Gold mining began in 1848 with the discovery of gold at Reading Bar near Douglas City. The gold rush brought a large influx of miners and settlers to the area. Relatively small mining operations gave way to huge hydraulic operations moving millions of cubic yards of hillslope and floodplain materials. The hydraulic mining era continued until the 1930s, much later than in most of California. Today, mining is mostly limited to small suction dredging operations which are predominately recreational, though there are over 7,000 mining claims across Trinity County.

Timber harvest began in the mid 1850's in response to the large population increase during the mining era and in conjunction with mining activities. Only the largest and most accessible trees were harvested in this time period. Following World War II, with much higher demands, significant volumes of timber were harvested and the number of mills increased sharply. Production averaged over 200 million board feet between 1950 and 1990. Industry changes and natural resource concerns have led to a significant reduction in harvest volumes (primarily on federal lands) in recent years, and Trinity County presently has one mill compared to 28 in 1961.

After 1940, tractor yarding and the construction of roads, skid trails and landings were the primary types of logging practices. Until the Forest Practices Act was passed in 1973, logging practices were unregulated. This Act required road construction and timber harvesting practices intended to protect aquatic habitat and watershed resources. During the past twenty years the use of cable yarding on steeper slopes has increased substantially. Plate 5 shows the UT timber harvest history by decade. Plate 6 shows the present road network.

3.2.4 Land Ownership

Detailed ownership maps for the watershed were obtained from a variety of sources including Trinity County and the USFS in a GIS-based format (Plate 7). The majority of the basin is under some form of public ownership, including the Trinity Alps Wilderness area, Shasta-Trinity National Forest, Bureau of Land Management, Bureau of Reclamation, and various state and county entities. Ownership patterns in the basin, particularly upstream of Coffee Creek, are often a checkerboard pattern of public and private lands as a result of railroad grants, mining laws, and homestead laws.

3.3 GMA Measured Sediment Transport and Yield

3.3.1 Measured Streamflow and Sediment Transport

Streamflow and sediment transport data are used to help verify and understand sediment source analysis results. There is a significant relationship between suspended sediment concentration and turbidity and the East Fork Trinity River at Trinity County Road 106 (EFTR) and Coffee Creek at Highway 3 (CCH3) (Figure 3.3.1). This relationship shows that most of the elevated turbidity results from suspended sediment transported as wash load. The EFTR regression equation was used to predict the suspended sediment concentration for sampling events that only measured turbidity.

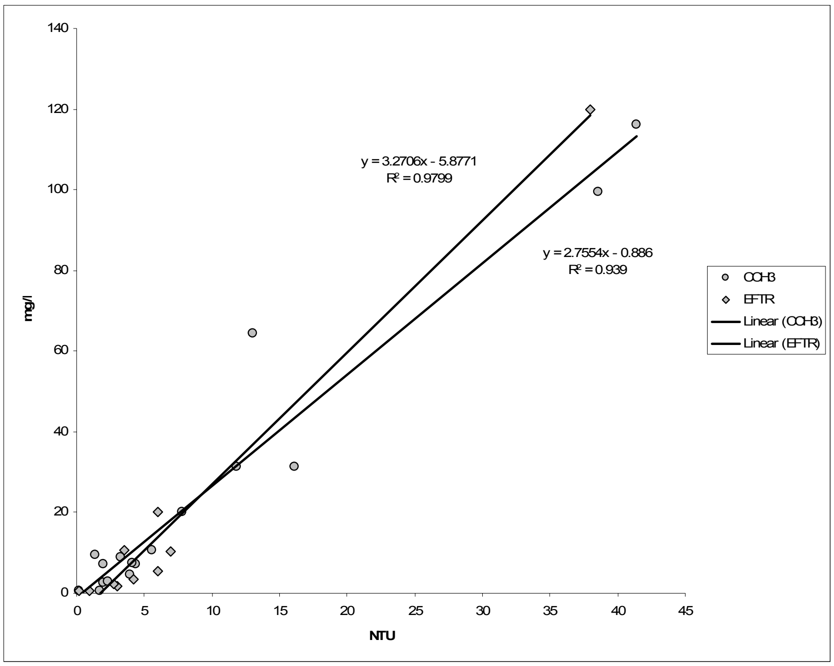

Figure 3.3.1. Suspended sediment versus turbidity rating curve for the East Fork Trinity River and Coffee Creek.

The streamflow records were used to help verify the flood frequency analysis results for Coffee Creek, the estimated Q_2 and Q_{100} flood for each subwatershed, and confirm the characterization of rainfall runoff relationships. A comparison of the different flood frequency methods used shows that the USGS regional regression equation overestimates the Q_2 and Q_{100} flood event and indicates that for Coffee Creek at Highway 3 the 1964 flood was slightly less than a Q_{100} flood event. The continuous streamflow records show that the Upper Trinity flood hydrograph is driven by rainfall-runoff during the winter and by snowmelt during the spring (Figure 3.2.2).

Suspended sediment and turbidity samples were taken during water years 2000 and 2005. This analysis focuses on water year 2005 data because the peak streamflow resulted from a rain-on-snow event and represents present land form conditions (Figure 3.3.3).

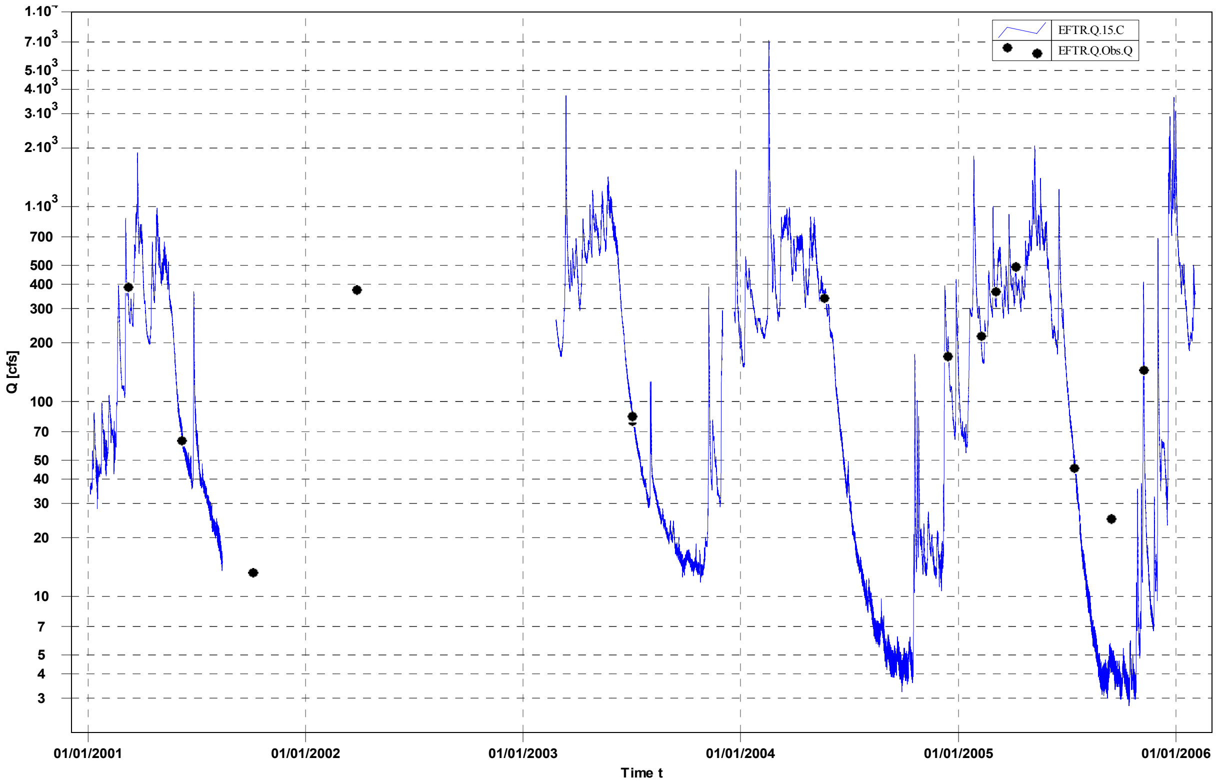

Figure 3.3.2. East Fork Trinity River hydrograph for water years 2000-2005.

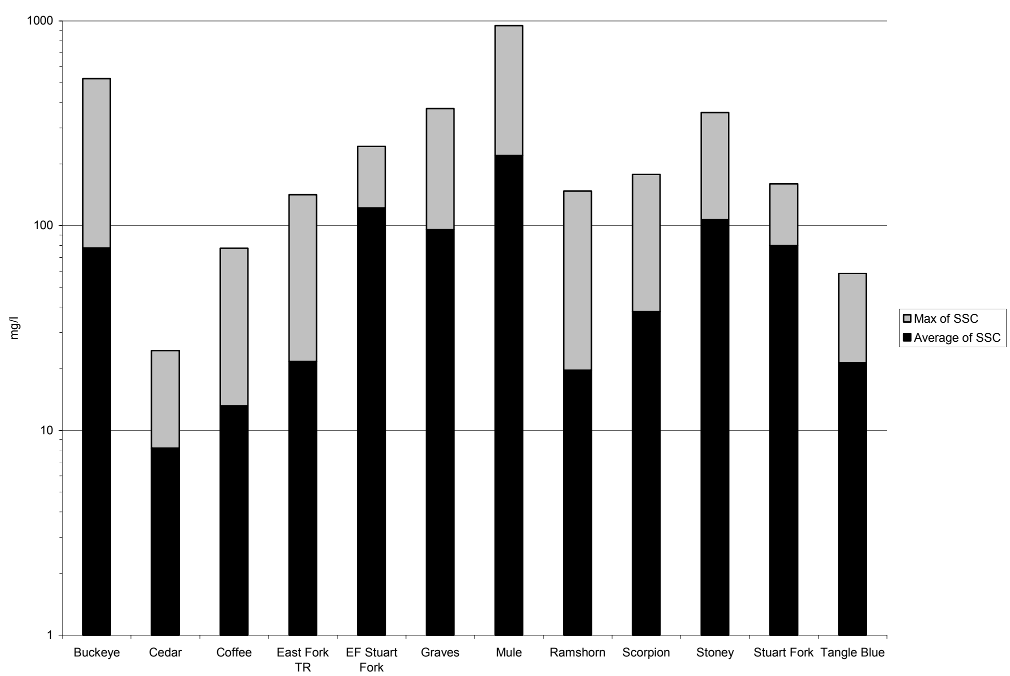

Figure 3.3.3. Water year 2005 average and maximum suspended sediment concentration by site.

According to the continuous streamflow records, for water years 2000 and 2005 the annual peak streamflows were about a Q_2 flood event. For water year 2000 the peak occurred in the spring as a result of snowmelt, whereas, for water year 2005 the peak occurred during the winter as a result of a rain-on-snow event (Figure 3.3.2).

From October 2005 to January 2006, a total of 63 sediment samples were taken and most sites were sampled eight times. Figure 3.3.3 shows the average and maximum suspended sediment concentration for each site sampled. Mule had the highest maximum and average suspended sediment concentration in water year 2005. Buckeye, Graves, Stoney, and East Fork Stuarts Fork had the next highest maximum suspended sediment concentration, whereas East Fork Stuart, Stoney, and Graves had the next highest average concentration.

3.3.2 Measured Total Sediment Yield From Delta Surveys

3.3.2.1 Delta Survey Results

Appendix 3 shows the results of the surveys and sediment weight calculations between datasets. Two plots are shown for each delta, one containing a plan view of the pre-dam topography, the 2001 or 2005 surveys, and an isopach map or contour map of volume change with the green contour lines showing fill, while red lines represent cut.

Table 3.3.1 shows the results of the volume calculations for each site. For each site, the net fill in cubic yards is converted to tons using a multiplier of 1.5 (assuming a bulk density of 111 pounds/cubic foot), then adjusted for the amount of fines not trapped in the delta area, then divided by the drainage area, and finally divided by either 40 or 44 years, the time since closure of Trinity Dam. The purpose of the fines adjustment is to take into account the likely amount of finer grained material such as clays and silts that would have been carried further out into the reservoir and not deposited in the main feature. Based on size analysis data presented in Knott (1974) for suspended sediment samples for the Trinity River at Lewiston (pre-dam), Weaver Creek, and the North Fork Trinity River, clay particles make up about 10% (North Fork Trinity) to 30% (Weaver Creek) of the load. Silts make up 37-43% of the total. Much of the silt is deposited in the delta, while most of the clay in suspension probably travels further out into the lake. We estimate that 20% of the load is not accounted for in the delta surveys, and the above results are adjusted by 1.2.

Computations suggest a sediment yield of 184 tons/mi^2/year for Stuart Fork, a yield of 697 tons/mi^2/year for East Fork Stuart Fork, and a yield of 1094 tons/mi^2/year for Mule Creek.

Table 3.3.1. Calculations involved in determining sediment yields based on tributary delta surveys.

TRIBUTARY DELTA	Survey Results (CY) Cut	Survey Results (CY) Fill	Survey Results (CY) Net	Multiplier CY to tons	Delta Deposit (tons)	Estimated Loss of fines beyond surveys	Fines Loss factor	Est. Total Sed Production (tons)	Watershed Area (mi^2)	Years since Dam Closure	Avg Annual Sed Yield (tons/mi^2/yr)
Stuart Fork	212700	468600	255900	1.5	383850	20%	1.2	460620	62.5	40	184
East Fork Stuart Fork	24300	409400	385100	1.5	577650	20%	1.2	693180	22.6	44	697
Mule Creek		168500	168500	1.5	252750	20%	1.2	303300	6.3	44	1094

3.3.2.2 Background Rates of Sediment Yield

Estimation of background rates of sediment yield is an important, but particularly challenging, component of a sediment source analysis. Few data exist regarding such rates, and no generally accepted method is available to compute or estimate such values. Two methods for assessing background rates are described here:

1. Using values from the voluminous literature of the mainstem Trinity River watershed and adjoining areas (i.e. Knott 1974, BLM 1995, and Raines 1998).
2. Directly measuring the accumulated delta for Stuart Fork, a relatively undisturbed watershed, now flowing into Trinity Lake.

The following summarizes the background rates of sediment yield from the literature for watershed outside the UT. Knott (1974) computed suspended sediment yields based on field measurements of sediment transport in the 1950s and 1960s at the Trinity River at Lewiston, Weaver Creek, North Fork Trinity River, South Fork Trinity, and Trinity River near Hoopa. He then adjusted these short-term values to long-term rates for the 1912-1970 base period. Average annual sediment transport rates are shown below:

AVERAGE ANNUAL ADJUSTED LONG-TERM RATES FROM KNOTT (1974)

Station	Suspended Sediment Discharge		Bedload Discharge		Total Load Discharge	
	(tons)	(tons/mi²)	(tons)	(tons/mi²)	(tons)	(tons/mi²)
Trinity River at Lewiston	120,000	165				
Weaver Creek nr. Douglas City	34,600	715	4,000	80	38,600	798
North Fork Trinity River at Helena	54,700	362	17,000	110	71,700	475
South Fork Trinity River near Salyer	860,000	958	320,000	360	1,180,000	1,314
Trinity River near Hoopa	2,520,000	1,170	600,000	280	3,120,000	1,454

If bedload is estimated for the Trinity River at Lewiston as 15% of suspended load, then a long-term rate for the upper watershed would be about 190 tons/mi^2/year. This value is very similar to the computed rate based on the Stuart Fork Delta surveys just described (184 tons/mi^2/year).

3.4 Landslide Source Analysis

3.4.1 GMA Landslide Inventory

3.4.1.1 Landslide Inventory Field Verification

GMA (2001) digitized 280 active landslides shown on the CDWR (1980) landslide map and mapped and digitized a total of 659 active landslides within the entire UT. Landslides mapped from aerial photos were given a certainty of recognition rating with 44 percent definite, 40 percent probable, and 16 percent questionable. Results from field verification show that most of the "questionable" features were not slides and several new features were mapped during verification.

Landslide field-verification surveys were performed to assess whether the features observed were actually slides, state of activity, establish thickness by landslide type, which is needed to perform volume calculations, validate the size of landslides mapped from aerial photography, and validate the land use category assigned to each landslide.

Of the 659 mapped active landslides, 77 landslides or 12 percent were field verified. All of the "definite" and "probable" features we examined in the field were indeed slides. The distribution of verified slides by Planning Watersheds and subwatersheds is shown below. Each field verified landslide was mapped and dimensions (width, length, and thickness) measured. With the exception of debris torrents, the observed thicknesses fall within the ranges of other recent sediment source analyses on the north coast, whereas McBain and Trush (2005) found a wide range of landslide thickness that did not correlate with type.

The Mendocino Redwood Company (MRC) (1999) found, based on extensive field inventories, that road-related slides in the Albion River watershed in Mendocino County had a mean thickness of 5.5 feet, while non-road related slides had an average thickness of only 4.0 feet. The landslide depths measured as part of this analysis are deeper than those measured by MRC in the Noyo (MRC, 1999). Stillwater Sciences (1999) used 1.3 m (4 feet) for shallow landslides in the South Fork Eel Basin, based on average thicknesses from Kelsey et al. (1995) in the Redwood Creek Basin, and Kelsey (1977) from the Van Duzen basin. Exactly the reverse of the Albion landslide depths was found in the Garcia River watershed, where data from surveys conducted by Louisiana-Pacific showed that landslides averaged a depth of 5.5 feet while road fill failures averaged 4.0 feet in depth.

GMA (2001) compared field measured landslide area, computed from average width multiplied by average length, with the GIS area for the feature. The actual area of 88 landslides was measured in the field. The categories are ranges defined as a plus or minus percentage around a perfect match. For example, GMA found 23 slides that the ratio of the areas was within 10 percent of a perfect match. 40 slides, or almost 50 percent of the slides field-verified, were within a range of +/- 20 percent, and 78 percent of the slides were within a range of +/- 40 percent. Of the 88 landslides field verified, 51 had a ratio of less than one (i.e., the GIS area was smaller than the field verified area) while 37 were greater than one. The average ratio for all 88 slides was 1.04, which indicates that the aerial photo mapping is fairly accurately, and thus the values calculated areas should be reasonable given that only 12 percent of the slides were field verified.

3.4.1.2 Landslide Inventory Results

The landslide database was sorted by certainty and all of the questionable slides that were not field verified were eliminated from the analysis. The database was filtered again based on the analysis of sediment delivery, and features mapped as non-delivering were eliminated. Determination of sediment delivery status is based on the judgment of the geologist performing the mapping and takes into account landslide position relative to the adjacent watercourse, slope at terminus of landslide or run-out area, and slope elements. The total number of landslides included in the database went from 659 to 347 features (Table 3.4.1).

Table 3.4.1. List of UT subwatersheds with total number of landslides and percent of total. Subwatersheds with large portion of total shown in bold.

Subwatershed Name	Drainage Area (mi2)	Number of Landslides	Number per Unit Area	% of Total
Bear Creek	4	5	1.1	1.4
Buckeye Creek	5	1	0.3	0.4
Cedar Creek	7	1	0.1	0.2
Coffee Creek	116	53	0.5	15.3
Eagle Creek	15	31	2.1	9.0
East Fork Stuart Fork	23	4	0.2	1.2
East Fork Trinity River	93	23	0.2	6.6
East Side Trinity Lake	65	16	0.2	4.6
Graves Creek	5	2	0.4	0.6
Hatchet Creek	2	-	0.0	0.0
Minnehaha Creek	4	8	2.2	2.4
Mule Creek	6	1	0.1	0.2
Ramshorn Creek	13	17	1.3	4.8
Ripple Creek	2	2	0.8	0.6
Scorpion Creek	7	2	0.3	0.6
Snowslide Gulch Area	12	39	3.2	11.2
Squirrel Gulch Area	15	2	0.1	0.6
Stoney Creek	5	3	0.5	0.8
Stuart Arm Area	35	14	0.4	4.0
Stuart Fork	63	28	0.5	8.2
Sunflower Creek	3	-	0.0	0.0
Swift Creek	56	29	0.5	8.4
Tangle Blue Creek	22	24	1.1	7.0
Trinity Lake	24	4	0.2	1.2
Upper Trinity Mainstem Area	10	14	1.4	4.0
Upper Trinity River	63	21	0.3	6.2
West Side Trinity Lake	17	3	0.2	0.8
Grand Total		347		

The filtered landslide inventory layer was intersected in GIS with the subwatershed, bedrock geology, land ownership, road, and timber harvest layers. Summary tables for the subwatersheds were prepared to help interpret the data and perform sediment volume and weight calculations (Table 3.4.2, Table 3.4.3, Table 3.4.4, and Table 3.4.5).

Table 3.4.2. UT landslide types showing percent of total.

Landslide Code	Landslide Type	Number
DF	Debris flow	9
DFS	Debris flow and landslide	3
DS	Debris landslide	77
DSF	Debris landslide and flow	129
IG	Inner gorge debris landslide	35
RF	Rock fall	10
RFS	Rock fall and landslide	15
RS	Rock landslide	26
RFL	Earthflow	42
	Total	347

Landslides are distributed fairly evenly over the UT watershed. The Bear Creek, Eagle Creek, Minnehaha Creek, Ramshorn Creek, Snowslide Gulch Area, Tangle Blue Creek, and Upper Trinity Mainstem Area subwatersheds have the most slides per unit drainage area with at least one landslide per square mile (Table 3.4.1). Note that Eagle Creek has nine landslide per mi^2 of watershed drainage area.

Table 3.4.3. Bedrock geology sorted by landslide type.

	Debris Flow	Debris Flow and Landslide	Debris Landslide	Debris Landslide and Flow	Inner Gorge	Earth flow	Rock Fall	Rock Fall and Landslide	Rock Lands lide	Grand Total
Lumped Geology	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Bragdon Formation	8	0	23	0	6	0	0	0	0	6
Central Metamorphic	0	0	9	5	6	0	0	0	19	6
Copley Greenstone	8	0	3	0	10	0	7	5	0	2
Eastern Klamath	8	0	8	1	12	11	7	18	16	7
Granitic	0	0	8	28	14	20	43	27	5	19
Ultramafic Rocks	77	100	49	65	53	69	43	50	59	60

The majority of the mapped landslides were debris slides and flows followed by earthflows (Table 3.4.2). Most of the landslides occurred in ultramafic bedrock regardless of type (Table 3.4.3), however, the fact that most of the UT is mapped as ultramafic accounts for this trend. About 19 percent of the total landslides occurred in granitics which is as much as the Bragdon Formation, Copley Greenstone, and Eastern Klamath sub-province combined. This finding is consistent with the relatively stable bedrock types listed in CDWR (1980).

The landslide data were also sorted by triggering mechanism and related land use. Table 3.4.4 shows that about 68 percent of the total number of mapped active landslides were triggered by natural processes. These data were sorted further by land ownership (Table 3.4.5). Roads have produced about 26 percent of the delivered sediment from slope failure, and timber harvest activities about 12 percent. The percentage attributable to timber harvest is within the range reported in other sediment source inventories (e.g., Raines, 1998).

Results indicate that Eagle Creek, Snow Slide Gulch Area, East Side Trinity Lake, and Coffee Creek subwatersheds have produced about 57 percent of the total inventoried landslide sediment delivery (Table 3.4.5). Within Eagle Creek, 83 percent of the sediment delivery resulted from naturally triggered landslides and 17 percent from road related failures and the background unit sediment delivery rate is 10,032 tons/mi^2/year (Table 3.4.6 and Plate 8). For the Snow Slide Gulch Area, 52 percent of the delivery resulted from natural failures, nine percent from road failures, and 39 percent from timber harvest triggered landslides. Both of these subwatersheds have several large deep seated rotational earthflows that became active following road construction and timber harvest.

Table 3.4.4. Landslide type sorted by triggering mechanism as related to land use.

Landslide Type	Natural %	Road %	Timber %	Grand Total %
Debris flow	2	6	0	3
Debris flow and landslide	0	1	7	1
Debris landslide	21	26	20	22
Debris landslide and flow	43	25	24	37
Inner gorge debris landslide	6	21	11	10
Rock fall	4	1	0	3
Rock fall and landslide	6	0	0	4
Rock landslide	10	4	0	7
Earthflow	7	16	39	12
% of Total	68	23	9	100

The East Side Trinity Lake Area subwatershed has several road related landslide (67 percent of total), and only five percent of the total sediment delivery is from natural failures. The majority of the landslides within the Coffee Creek subwatershed (68 percent of total) are classified as natural, and road and timber harvest are related to 13 and 19 percent, respectively. Within the Stoney Creek subwatershed, 100 percent of the landslide sediment delivery is from one road related failure. There are no mapped naturally active landslides, and this one landslide has produced 2.1 percent of the total sediment delivery to the UT (Table 3.4.5). The unit landslide sediment delivery rate for this subwatershed is 173 tons/mi^2/year (Table 3.4.6 and Plate 8).

Plate 9 shows the percent over background for mapped active landslide sediment delivery. The lower subwatersheds adjacent and above the reservoir include Stuart Arm Area, Mule Creek, Scorpion Creek, and East Side Trinity Lake are 300 percent over background.

Landslide sediment delivery was summarized by land owner as well as subwatershed. Inventory results show that 27 percent of the active landslides occur on private land and 73 percent on Public land. About 19 percent of the landslides occur on private industrial timber lands. For landslide sediment delivery from industrial timber lands, 20 percent is background, 59 percent is related to road failures, and 20 percent is related to timber harvest activities (Table 3.4.7). The percentage attributable to background or natural landslides is substantially less on private lands.

Table 3.4.5. List of subwatersheds, land use, and estimated volume of sediment delivered from landslides.

Subwatershed Name	Natural		Road		Timber		Grand Total	
	Weight*	%	Weight*	%	Weight*	%	Weight*	%
Bear Creek	210,784	100	0	0	0	0	210,784	1
Buckeye Creek	0	0	40,914	100	0	0	40,914	0
Cedar Creek	409	100	0	0	0	0	409	0
Coffee Creek	1,624,900	68	316,121	13	456,894	19	2,397,914	12
Eagle Creek	2,972,778	83	609,985	17	0	0	3,582,763	18
East Fork Stuart Fork	12,276	100	0	0	0	0	12,276	0
East Fork Trinity River	109,639	27	295,112	72	4,719	1	409,469	2
East Side Trinity Lake	127,555	5	1,764,270	67	751,291	28	2,643,116	13
Graves Creek	7,889	22	27,276	78	0	0	35,165	0
Hatchet Creek	0	0	0	0	0	0	0	0
Minnehaha Creek	358,142	100	0	0	0	0	358,142	2
Mule Creek	562	100	0	0	0	0	562	0
Ramshorn Creek	325,026	69	65,896	14	77,683	17	468,605	2
Ripple Creek	121,062	100	0	0	0	0	121,062	1
Scorpion Creek	0	0	145,597	100	0	0	145,597	1
Snowslide Gulch Area	1,450,034	52	259,360	9	1,099,210	39	2,808,605	14
Squirrel Gulch Area	0	0	56,653	100	0	0	56,653	0
Stoney Creek	0	0	418,992	100	0	0	418,992	2
Stuart Arm Area	106,225	11	853,046	89	0	0	959,271	5
Stuart Fork	1,185,350	100	0	0	0	0	1,185,350	6
Sunflower Creek	0	0	0	0	0	0	0	0
Swift Creek	703,477	100	0	0	0	0	703,477	3
Tangle Blue Creek	1,010,315	70	346,716	24	81,828	6	1,438,859	7
Upper Trinity Mainstem Area	976,933	68	454,381	32	0	0	1,431,313	7
Upper Trinity River	508,570	70	137,410	19	81,151	11	727,132	4
West Side Trinity Lake	15,510	40	23,472	60	0	0	38,982	0
Grand Total	11,827,434	62	5,815,202	26	2,552,777	12	20,195,413	100

* = weight in tons for a 20 year period

About 73 percent of the active landslides occur on Public lands. For landslide sediment delivery, about 73 percent of the total weight is attributable to natural landslides, 18 percent is related to road failure, and nine percent is related to timber harvest activities (Table 3.4.7). The difference between the percent background on Public and industrial timber lands likely results from the lack of public timber harvest and road building in the last 20 years. The rate of harvest is much greater on private lands, and the harvested areas tend to be in the lower portions of the watershed especially on the west side of Trinity Lake (Plate 5). The activation of landslides on industrial timber lands appears to be a function of the rate of harvest as shown in Table 3.4.7.

Table 3.4.6. Unit sediment delivery rates for background and disturbance related landslides by subwatershed.

Subwatershed Name	Watershed Code	Drainage Area (mi^2)	Background Sediment Delivery Rate (tons/mi2/yr)'	Management Related Sediment Delivery Rate (tons/mi2/yr)'
Bear Creek	13	4.5	2,504	0
Buckeye Creek	5	5.1	168	398
Cedar Creek	6	7.0	178	0
Coffee Creek	15	116.4	893	332
Eagle Creek	1	15.1	10,032	2021
East Fork Stuart Fork	17	22.6	195	0
East Fork Trinity River	16	92.8	244	162
East Side Trinity Lake	24	64.8	259	1940
Graves Creek	11	5.3	232	257
Hatchet Creek	4	1.9	161	0
Minnehaha Creek	8	3.8	4,932	0
Mule Creek	2	6.3	188	0
Ramshorn Creek	10	12.8	1,447	560
Ripple Creek	9	2.5	2,597	0
Scorpion Creek	7	6.8	171	1068
Snowslide Gulch Area	22	12.1	6,346	5630
Squirrel Gulch Area	25	15.2	168	187
Stoney Creek	3	5.4	173	3854
Stuart Arm Area	27	34.5	302	1236
Stuart Fork	14	62.5	1,130	0
Sunflower Creek	12	2.6	160	0
Swift Creek	18	56.0	837	0
Tangle Blue Creek	19	21.6	2,523	990
Upper Trinity Mainstem Area	20	9.9	5,237	2301
Upper Trinity River	21	63.0	591	173
West Side Trinity Lake	26	16.9	409	70

' = average for 20 year period

Table 3.4.7. Landslide sediment delivery for background, roads, and timber harvest by land ownership.

Owner	Natural Weight*	%	Road Weight*	%	Timber Weight*	%	Grand Total Weight*
Industrial timber	1019547	20%	2961866	59%	1009011	20%	4990423
Private	297203	37%	231576	29%	280566	35%	809345
Public	10515231	73%	2623528	18%	1265174	9%	14403933
Grand Total	11831980	59%	5816970	29%	2554751	13%	20203701

* = weight in tons over 20 years

3.4.1.3 Confidence in Analysis

The confidence in this analysis is medium to high. There are several sources of uncertainty in the landslide inventory. The active landslides were mapped from aerial photos at different scales. Landslide inventory field verification improved the reliability of the landslide data as described above.

Although few datasets are available to compare the difference between field-based and aerial photo-based landslide analyses, a study by the Oregon Department of Forestry (ODF) (1999) following the 1996 storms provides additional confirmation of the challenges facing aerial photo-based landslide interpretations. ODF points out that active landslides are often not visible on aerial photos due to forest cover. Certainly, forest canopy may make detection of landslides more difficult, and it seems reasonable to suspect that a higher percentage of landslides in a recently harvested area may be visible compared to that visible in a mature forest. This may not be as much as of an issue for this analysis where large areas of the UT are covered in naturally thin timber, brush, and rock. Field verification within mature timber stands needs to be completed to better quantify natural landslide frequency.

In heavily forested subwatersheds (e.g., East Side Trinity Lake) the inherent bias towards detecting more landslides within younger forest stands using aerial photos may significantly affect the ratio of landslide densities for recently clear cut stands compared to mature stands. ODF (1999) found that if one were comparing landslide density using 1:6,000 aerial photo analysis, the ratio of landslides in the clear cut stands versus those in mature forest stands is about 21:1, while for ground-based measurements that ratio is about 2:1. For 1:24,000 scale aerial photo analysis, the clear cut to mature forests ratio of landslide density is 17:1. This ratio is likely less for the UT since the landslides were mapped at 1:18,000 scale and only large obvious features were included in the analysis. For example, about half of the landsides identified from aerial photos were not included in this analysis.

Comparison to mass wasting rates developed in other north coast California watersheds with similar geology suggests that the results of this analysis are reasonable. Recent work within the adjacent South Fork Trinity River, the Van Duzen River, and Redwood Creek watersheds provides the best basis for comparison. Raines (1998) estimated rates of mass wasting for the South Fork Trinity River watershed at between 21 and 1,985 tons/mi^2/year for four planning watersheds for a 47-year period between 1944 and 1990. In Grouse Creek, Raines and Kelsey (1991) estimated rates at 4,330 tons/mi^2/year for budget period of 1960-1989. PWA (1999) estimated average sediment rates from all sources of 2,690 tons/mi^2/year for the Van Duzen River. CRWQCB estimated mass wasting in Redwood Creek at 2,050 tons/mi^2/year for the period 1954-1997. The average rate for this analysis is 2,433 tons/mi^2/year with a maximum of 12,054 tons/mi^2/year.

3.4.2 GEO13 Landslide Risk Model

3.4.2.1 Landslide Risk Model Results

Using the GEO13 model, the risk of background and management related landslide sediment delivery was estimated for each subwatershed within the UT (Table 3.4.8). The different watershed scales give a range of probable sediment delivery for similar land forms and land use disturbances. The background sediment delivery per square mile of drainage area is fairly uniform over the project area (Plate 10). The Eagle, Minnehaha, and Snowslide Gulch Area subwatersheds have landslide unit sediment delivery rates greater than 2,200 tons/ mi^2/Q_{25} which is similar to rates presented above. The high sediment delivery rate per unit drainage area results from the density of naturally active landslides (Plate 10).

For smaller subwatersheds, less than 16 mi^2, the landslide model results indicate that Buckeye, Sunflower, Cedar, Hatchet, and Graves subwatersheds have the highest probability of delivering substantial amounts of sediment to the stream network at 200 percent over background (Table 3.4.8 and Plate 11). The high percent over background is partially a result of the watershed scale where land use impacts are concentrated. Several other smaller subwatersheds are delivering sediment at greater than 25 percent over background (Table 3.4.8 and Plate 11). Subwatesheds with low disturbance levels, as far as landslide sediment delivery, appear to be Minnehaha and Upper Trinity Mainstem Area at less than zero percent over background. The least disturbed small subwatersheds are Eagle and Bear at less than -55 percent over background (Table 3.4.8 and Plate 11).

For the larger subwatersheds, greater than 16 mi^2, the results indicate that Stuart Arm Area and West Side Trinity Lake have the highest probability of delivering sediment at greater than 100 percent over background (Table 3.4.8 and Plate 11). The broad watershed scale partially accounts for the lower percent over background because disturbance related sediment delivery is diluted as watershed size and in-channel sediment storage increase. Subwatesheds with low disturbance levels appear to be Swift Creek, Upper Trinity River, and Tangle Blue Creek at less than zero percent over background. The least disturbed large subwatersheds are Coffee and Stuarts Fork at less than -50 percent over background (Table 3.4.8 and Plate 11).

For all of the subwatersheds, roads have the highest probability of causing excess landslide sediment delivery and are likely to produce about 36 percent of the total. It appears that timber harvest activities are likely to produce about 12 percent of the landslide sediment delivery. For landslides associated with timber harvest activities, it appears that 86 percent of the potential sediment delivery is from industrial timber lands, and 14 percent from public lands. This trend likely results from the rate of timber harvest where the public land rate is much lower. For landside sediment delivery from road failure, public roads have the highest sediment delivery risk (53 percent) followed by industrial timber land roads (38 percent). For this statistic, public includes state and federal roads. The remaining nine percent is attributed to private and county roads.

Table 3.4.8. SDRA landslide model results for background and disturbed conditions showing total and unit load by subwatershed.

NAME	Drainage Area (mi2)	Landslide Background (tons/Q25)	Disturbed Landslides (tons/Q25)	Road Landslides (tons/Q25)	Percent over Background	Landslide Background (tons/Q25/mi2)	Disturbed Landslides (tons/Q25/mi2)	Road Landslides (tons/Q25/mi2)
Bear Creek	4.5	3046	0	12	-100	677	0	3
Buckeye Creek	5.1	3210	3968	10707	357	625	773	2085
Cedar Creek	7.0	4148	5363	8966	245	592	765	1279
Coffee Creek	116.4	102119	13197	34123	-54	878	113	293
Eagle Creek	15.1	33247	1318	13132	-57	2203	87	870
East Fork Stuart Fork	22.6	15828	7837	8115	1	699	346	359
East Fork Trinity River	92.8	53748	28654	77141	97	579	309	832
East Side Trinity Lake	64.8	34373	13438	46219	74	530	207	713
Graves Creek	5.3	3463	3518	7360	214	652	662	1386
Hatchet Creek	1.9	519	495	1138	214	272	259	597
Minnehaha Creek	3.8	9614	4	8647	-10	2558	1	2300
Mule Creek	6.3	6967	5003	6374	63	1108	796	1014
Ramshorn Creek	12.8	9080	2078	8979	22	709	162	701
Ripple Creek	2.5	2126	926	1314	5	859	374	531
Scorpion Creek	6.8	4572	1215	6374	66	671	178	935
Snowslide Gulch Area	12.1	32251	15757	43657	84	2673	1306	3618
Squirrel Gulch Area	15.2	6980	3706	12571	133	461	245	830
Stoney Creek	5.4	5602	6239	4850	98	1031	1148	892
Stuart Arm Area	34.5	15792	10119	31176	162	458	293	904
Stuart Fork	62.5	77823	5633	1786	-90	1245	90	29
Sunflower Creek	2.6	1550	2057	3403	252	600	796	1316
Swift Creek	56.0	64814	21193	27193	-25	1157	378	485
Tangle Blue Creek	21.6	15132	333	10207	-30	699	15	472
Upper Trinity Mainstem Area	9.9	8698	519	7315	-10	881	53	741
Upper Trinity River	63.0	47142	8355	26693	-26	748	133	423
West Side Trinity Lake	16.9	5663	2771	9993	125	336	164	593

3.4.2.2 Confidence in Analysis

The confidence in this analysis is medium. There are several sources of uncertainty in the input data to the landslide model. The reliability of the model results is a function of the accuracy of input data (i.e., Geomorphology and Disturbed layers) and assumptions. This portion of the analysis generally agrees with the GMA landslide inventory results presented above. The two methods are compared in greater detail below.

The Geomorphology layer was mainly mapped from aerial photos, and the quality of the layer varies geographically over the project area. For example, most of the landslides within the Trinity Alps are not field verified due to access. About 20 percent of the mapped landslides have been field verified by GMA (2001), the Forest Service, and McBain and Trush (2005). The lack of access to private lands also limited field verification.

The disturbance layers, to include timber harvest and roads, were mapped from various sources. The private land use history is the least accurate and was mapped from the filed THPs, time-series aerial photos, with very little field verification. For example, a large portion of the timber harvest area in the Upper Trinity and East Fork Trinity River is not represented on the harvest history layer. The private road network was mapped by the RCD and Elder and Reichert (2005) from the 1998 and 2003 aerial photos with limited field verification (Plate 6). The public land use history includes information available from the Forest Service and has fairly extensive field verification completed by the Forest Service, RCD, and GMA.

3.5 Surface and Fluvial Erosion Source Analysis

3.5.1 GMA Surface Erosion Inventory

3.5.1.1 Surface Erosion Inventory Results

Surface erosion modeling from inventory data (GMA, 2001) shows that the average sediment delivery rate is about 56 tons/mi^2/year. For a 20 year period of erosion, road surface erosion represents 56 percent of the total, and timber harvest surface erosion represents 44 percent of the total (Table 3.5.1). Surface erosion sediment delivery is about two percent of the total sediment delivery weight that includes background and management related landslide and surface erosion.

For the smaller subwatersheds, less than 16 mi^2, the surface erosion inventory results indicate that the Squirrel Gulch Area, Snowslide Gulch Area, Cedar Creek, Stoney Creek, and Buckeye Creek subwatersheds have produced the most management related surface erosion (Table 3.5.1). The Stoney Creek subwatershed has the highest sediment delivery rate at 100 tons/mi^2/year, with 65 percent attributed to timber harvest surface erosion, and 35 percent to road erosion. The lowest sediment delivery rates for the smaller subwatersheds appear to be in the Minnehaha Creek, Eagle Creek, and Bear Creek subwatersheds (Table 3.5.1).

For the larger subwatersheds, greater than 16 mi^2, the results indicate that the East Fork Trinity River, East Side Trinity Lake, Stuart Arm Area, and Swift Creek subwatersheds have produced the most management related surface erosion (Table 3.5.1). The East Fork Trinity River subwatershed has produced 21 percent of the total surface erosion sediment delivery, with 51 percent attributed to timber harvest surface erosion, and 49 percent road surface erosion. The Stuart Arm Area subwatershed has the highest sediment delivery rate at 99 tons/mi^2/year. The lowest sediment delivery rates for the larger subwatersheds appear to be in the Coffee and Stuart Fork subwatersheds (Table 3.5.1).

Surface erosion from roads and timber harvest activities was also summarized by land ownership. Surface erosion inventory model results indicate that about 50 percent of the disturbance related sediment delivery is from industrial timber lands, 41 percent from public (includes state and federal), and nine percent from county and domestic private (Table 3.5.2). For timber harvest surface erosion, the relative contribution varies by decade (Table 3.5.3), where as the rate of public timber harvest decreases with time, so does the surface erosion from public lands. Since 1970, 50 percent of the surface erosion was delivered between 1990 and 2000 with 81 percent from industrial timber lands (Table 3.5.3). Over the last decade, 19 percent of the sediment delivery has occurred with 97 percent from industrial timber lands.

Table 3.5.1. Surface erosion rates from road and timber harvest activities by subwatershed.

Subwatershed Name#	Drainage Area (mi^2)	Road Surface Erosion Weight*	Percent Total	Timber Surface Erosion Weight*	Percent Total	Management Total Weight*	Management Sediment Delivery Rate (tons/mi2/year)'	Management Sediment Yield (tons/year)'	Management Sediment Yield Rate (tons/mi2/year)'
Bear Creek	4.5	21	100%	0	0%	21	0	0	0
Buckeye Creek	5.1	5,532	57%	4173	43%	9,705	95	21	4
Cedar Creek	7.0	6,951	53%	6059	47%	13,011	93	12	2
Coffee Creek	116.4	20,701	65%	11167	35%	31,869	14	261	2
Eagle Creek	15.1	3,300	95%	182	5%	3,482	12	8	1
East Fork Stuart Fork	22.6	16,596	42%	22800	58%	39,396	87	66	3
East Fork Trinity River	92.8	63,485	49%	66323	51%	129,808	70	724	8
East Side Trinity Lake	64.8	46,662	63%	27713	37%	74,375	57	983	15
Graves Creek	5.3	4,332	57%	3231	43%	7,562	71	17	3
Hatchet Creek	1.9	2,684	72%	1065	28%	3,749	98	2	1
Minnehaha Creek	3.8	1,028	97%	27	3%	1,055	14	5	1
Mule Creek	6.3	4,138	51%	4050	49%	8,188	65	7	1
Ramshorn Creek	12.8	6,505	68%	3019	32%	9,524	37	31	2
Ripple Creek	2.5	1,707	56%	1344	44%	3,052	62	11	4
Scorpion Creek	6.8	4,274	76%	1320	24%	5,595	41	16	2
Snowslide Gulch Area	12.1	10,017	74%	3592	26%	13,609	56	58	5
Squirrel Gulch Area	15.2	11,689	50%	11770	50%	23,459	77	42	3
Stoney Creek	5.4	3,831	35%	7030	65%	10,862	100	18	3
Stuart Arm Area	34.5	38,841	57%	29304	43%	68,146	99	284	8
Stuart Fork	62.5	4,825	33%	9944	67%	14,769	12	107	2
Sunflower Creek	2.6	2,034	48%	2248	52%	4,282	83	6	2
Swift Creek	56.0	23,735	41%	34373	59%	58,108	52	172	3
Tangle Blue Creek	21.6	8,106	91%	765	9%	8,871	20	21	1
Upper Trinity Mainstem Area	9.9	6,629	80%	1639	20%	8,268	42	32	3
Upper Trinity River	63.0	34,434	70%	14855	30%	49,289	39	220	3
West Side Trinity Lake	16.9	15,406	64%	8521	36%	23,926	71	28	2
Total and Percent of Total	667	347,464	56%	276514	44%	623,978	47	3,154	5

* = weight in tons for a 20 year period (1980 to 2000)

Table 3.5.2. Road surface erosion sediment delivery by land ownership.

Land Owner	Weight*	%
Industrial Timber	173653	50.0
Private/County	30832	8.9
Public	143052	41.2
Grand Total	347537	100.0

Table 3.5.3. Timber harvest surface erosion sediment delivery by decade and land ownership.

Land Owner	Decade 1970 Weight*	%	1980 Weight*	%	1990 Weight*	%	2000 Weight*	%	Grand Total Weight*
IND	55	0.0	52530	24.0	115557	52.8	50868	23.2	219009
PRV		0.0	8394	56.2	5771	38.6	770	5.2	14935
PUB	8227	16.2	19449	38.2	22125	43.5	1051	2.1	50851
Grand Total	8281	2.9	80372	28.2	143453	50.4	52689	18.5	284796

3.5.1.2 Confidence in Analysis

The confidence in this analysis is medium. There are several sources of uncertainty in the input data to the surface erosion model. The reliability of the model results is a function of the accuracy of input data and assumptions. The method of characterizing sediment delivery from roads used in this sediment source analysis has a number of limitations. The results are considered approximate based on the presently available information. Detailed road inventories need to be completed in the UT to prioritize road treatment needs on public and private lands.

Some roads considered native in this report may in fact be rocked or have rocked sections. There are no estimates for sediment yields caused by culvert failure and washout, although in some watershed analyses or road analysis these have been considered significant volume sources. Road surface slope is not specifically taken into account, although typically more drainage features exist for steeper roads and these would have been evaluated in the field inventories. Traffic or use patterns and rates are particularly difficult to accurately predict.

We assumed that any road included in the GIS probably still delivered some sediment, particularly because these older roads were built to far different standards than roads constructed in the last 10 to 25 years. That older roads often still produce considerable sediment is borne out by findings in the various studies (Toth, 1991, Mills, 1991, and ODF, 1999). Toth reported the results of a road damage inventory conducted in Washington that found that roads constructed in the last 15 years survived a landslide-inducing storm with minimal damage, while roads constructed earlier had very high damage rates. Road monitoring in Oregon has documented similar findings (Mills, 1991). The recent ODF (1999) study found that although landslides associated with old roads were typically smaller than the landslides associated with actively used roads, they were still several times larger on average than landslides not associated with roads. Of the 506 slides mapped by ODF, 20 were associated with old roads and 37 were associated with active roads, while the erosion volume from old roads was 54,700 yd^3 vs. 65,000 yd^3

for the active roads. Overall, 19 percent of the sediment volume delivered to stream channels came from landslides associated with old roads. Based on this information, exclusion of old or even abandoned roads from the analysis should not occur without extensive field verification.

The computed values for the UT watershed are similar, but slightly smaller than road erosion rates reported for the South Fork Trinity watershed (Raines 1998), which were developed using a more sophisticated GIS based road model, SEDMOD.

3.5.2 Surface and Fluvial Erosion Risk Model

3.5.2.1 Surface and Fluvial Erosion Risk Model Results

The surface and fluvial erosion model results show that the average Q_2 flood event sediment delivery rate for the UT is about 510 tons/mi^2/Q_2. For the Q_2 flood event sediment delivery, 51 percent is from background surface and fluvial erosion, 36 percent is from road erosion, and 12 percent is from timber harvest activity erosion.

For the smaller subwatersheds, less than 16 mi^2, the surface and fluvial erosion model results indicate that Buckeye, Hatchet, West Side Trinity Lake, and Cedar subwatersheds have a high probability of delivering substantial amounts of chronic sediment to the stream network at 100 percent over background (Table 3.5.4 and Plate 12). Like the landslide model results, the high percent over background is partially a result of the watershed scale where land use impacts are concentrated. The remaining smaller subwatersheds are delivering less than 35 percent over background (Table 3.5.4 and Plate 12). The least disturbed, as far as surface and fluvial erosion, smaller subwatersheds appear to be Mule, Graves, Snowslide Gulch Area, Ripple, Sunflower, Upper Trinity Mainstem Area, Ramshorn, and Scorpion at less than 15 percent over background. The Minnehaha, Eagle, and Bear subwatersheds are at less than -50 percent over background (Table 3.5.4 and Plate 12).

For the larger subwatersheds, greater than 16 mi^2, the results indicate that East Fork Stuart Fork and Stuart Arm Area have a high probability of delivering substantial amounts of surface and fluvial sediment at greater than 70 percent over background (Table 3.5.4 and Plate 12). The least disturbed larger subwatersheds appear to be Upper Trinity River and Tangle Blue at less than 10 percent over background. The Stuarts Fork and Coffee subwatersheds are at less than -70 percent over background (Table 3.5.4 and Plate 12).

For all of the subwatersheds, roads are producing about 75 percent of the disturbance related surface and fluvial erosion sediment delivery and timber harvest activities 25 percent. The model results indicate that 53 percent of the road erosion is from industrial timber lands, and 45 percent from public lands. For timber harvest surface and fluvial erosion, the model indicates that 97 percent of the erosion is from industrial timber lands (Table 3.5.5). As discussed above, this high percentage is likely a result of the rate of timber harvest on private lands.

Table 3.5.4. Surface and fluvial erosion risk from road and timber harvest activities by subwatershed.

NAME	Drainage Area (mi2)	Surface/Fluvial Erosion Background (tons/Q2)	Disturbed Surface/ Fluvial Erosion (tons/Q2)	Road Surface/ Fluvial Erosion (tons/Q2)	Percent over Background	Surface/Fluvial Erosion Background (tons/Q2/mi2)	Disturbed Surface/ Fluvial Erosion (tons/Q2/mi2)	Road Surface/ Fluvial Erosion (tons/Q2/mi2)
Bear Creek	4.5	764	0	15	-98	170	0	3
Buckeye Creek	5.1	1256	2075	1720	202	245	404	335
Cedar Creek	7.0	1886	1512	2517	114	269	216	359
Coffee Creek	116.4	28362	2908	3511	-77	244	25	30
Eagle Creek	15.1	3564	1	701	-80	236	0	46
East Fork Stuart Fork	22.6	5489	4598	4906	73	243	203	217
East Fork Trinity River	92.8	21461	1171	23812	16	231	13	257
East Side Trinity Lake	64.8	22990	3015	29305	41	355	46	452
Graves Creek	5.3	1356	39	1472	11	255	7	277
Hatchet Creek	1.9	447	645	547	166	235	338	287
Minnehaha Creek	3.8	729	0	250	-66	194	0	67
Mule Creek	6.3	1857	29	995	-45	295	5	158
Ramshorn Creek	12.8	3189	19	2168	-31	249	1	169
Ripple Creek	2.5	502	2	555	11	203	1	224
Scorpion Creek	6.8	1988	30	1201	-38	292	4	176
Snowslide Gulch Area	12.1	2553	978	1787	8	212	81	148
Squirrel Gulch Area	15.2	3200	527	3641	30	211	35	240
Stoney Creek	5.4	1566	721	1324	31	288	133	244
Stuart Arm Area	34.5	6788	5214	6357	70	197	151	184
Stuart Fork	62.5	13237	1312	1326	-80	212	21	21
Sunflower Creek	2.6	756	41	681	-4	292	16	263
Swift Creek	56.0	10704	8967	6297	43	191	160	112
Tangle Blue Creek	21.6	4418	4	2167	-51	204	0	100
Upper Trinity Mainstem Area	9.9	2367	15	1962	-16	240	1	199
Upper Trinity River	63.0	14360	133	8864	-37	228	2	141
West Side Trinity Lake	16.9	4106	3118	5073	100	243	185	301

3.5.2.2 Confidence in Analysis

The confidence in this analysis is medium. There are several sources of uncertainty in the input data to the surface and fluvial erosion model. The reliability of the model results is a function of the accuracy of input data (i.e., KCRLS and Disturbed layers) and assumptions. In addition, the equation used to calculate the unit erosion rate (A) is not verified for steep watersheds. Model precision is high, however, and all calculations are repeatable.

The KCRLS layer was developed from the existing data and information listed above. The quality of the layer is limited by scale where most of the variables were mapped regionally. Field verification of this layer is very limited. Sediment source inventories conducted in the Stuart Arm Area and East Fork Trinity River by the RCD were used to help very road condition and erosion rates. The same disturbance layers were used for the landslide and surface/fluvial erosion models. As described above, the private land use history is the least accurate, and the public land use history has the most field verification.

Table 3.5.5. Surface and fluvial erosion risk from road and timber harvest activities by land ownership.

Ownership	Road Sediment Delivery (tons/Q_2)	%	Timber Harvest Sediment Delivery (tons/Q_2)	%	Grand Total (tons/Q_2)
Industrial Timber	59490	53	35982	97	95471
Private/County	3035	3	0	0	3035
Public	50629	45	1093	3	51722
Grand Total	113154	75	37075	25	150229

3.6 Sediment Source Analysis Discussion

3.6.1 Subwatersheds Ranked by Sediment Delivery Risk

The sediment source analysis results were used to identify which subwatersheds within the UT have and are likely to continue to produce excess sediment. Results indicate that for landslide sediment delivery, 54 percent of the UT planning subwatersheds exceed the 25 percent over background target (Plates 9, 11, and 12). For surface and fluvial erosion sediment delivery, 38 percent of the subwatersheds exceed the target.

For subwatersheds less than 16 mi^2, the combined risk of landslide, surface, and fluvial sediment delivery is highest for the following subwatersheds at greater than 50 percent over background:

- Buckeye Creek
- Sunflower Creek
- Cedar Creek
- Hatchet Creek
- Graves Creek
- Squirrel Gulch Area
- Stoney Creek
- Scorpion Creek

For subwatersheds greater than 16 mi^2, the risk of sediment delivery is highest for the following:

- Stuart Arm Area
- Snowslide Gulch Area
- East Fork Trinity River
- East Side Trinity
- West Side Trinity

For all of the subwatersheds, roads are increasing the probability of sediment delivery during frequent and infrequent flooding. The risk of acute and chronic sediment delivery is not evenly distributed among the subwatersheds. Several of the subwatersheds have a high probability of landslide sediment delivery, but a low to medium probability of surface and fluvial erosion sediment delivery. For example, the East Fork Trinity River, a relatively managed subwatershed, is 97 percent over background for landslide sediment delivery, whereas it is 16 percent over background for surface and fluvial sediment delivery.

Results indicate that sediment delivery from landslide failure represents a large portion of the short and long-term sediment yield to Trinity Lake. The excess sediment delivery likely result from road related landslides and the analysis shows that most of the erosion is occurring within active landslides (Type 1), dormant landslides (Type 3), and non-granitic bedrock areas (Type 8) from native surface roads. For Type 1 landslides, 72 percent of the features were a combination of debris slides and flows (Table 3.6.1). After background, roads failures were commonly related to active debris slides and flows.

Geomorphic Types 3 and 8 sediment delivery rates are high because most of the roads are located on these land forms.

Table 3.6.1. Sediment delivery for background and disturbed conditions by landslide type.

Landslide Type	Natural % Weight*	Road % Weight*	Timber % Weight*	Grand Total % Weight*
Debris flow	57	43	0	2
Debris flow and slide	31	11	59	0
Debris slide	40	44	16	25
Debris slide and flow	80	15	6	45
Inner gorge debris slide	37	61	2	12
Rock fall	100	0	0	0
Rock fall and slide	100	0	0	1
Rock slide	93	7	0	0
Earthflow	40	23	38	15
Grand Total	59	29	13	100

* = weight in tons for 20 year period

3.6.2 Model Comparison

The GMA sediment source inventory and sediment delivery risk analysis models were compared to better understand and qualify the reliability of the results. The models used the same land form and land use data as input, but handled the mechanisms and period of sediment delivery and yield differently. Results for the GMA sediment source inventory are for a specified time period (i.e., 20 years), whereas the sediment delivery risk analysis results are for a given flood frequency or probability of occurrence. Model results are compared for the sediment budget time period of 20 years. This comparison assumes that over the last 20 years, one Q_{25} year, or greater, flood occurred and several Q_2 floods occurred. The flood of 1997 is within the last 20 years and is representative of a Q_{25} flood event, and several Q_2 flood events have occurred as shown by the continuous streamflow records as described above.

The predicted amount of landslide and surface erosion were summed for the GMA sediment source inventory and compared to the results of the landslide and surface and fluvial erosion sediment delivery risk models. Table 3.6.2 shows that the different models generally agree within 20 percent. Given the different sources of uncertainty within each model, this percent difference is considered acceptable and qualitatively supports sediment source analysis results.

Table 3.6.2. Percent of total sediment delivery for the two different sediment source analysis models.

	GMA Landslide Inventory*	SDRA Landslide Model	SDRA Surface/Fluvial Erosion Model
Background	62.0	49.0	52.0
Harvest	12.0	14.3	12.0
Road	26.0	36.3	36.0
Total Management	38.0	50.6	48.0

* = includes landslide and surface erosion

3.6.3 Measured versus Modeled Sediment Rate Results Comparison

This analysis has the benefit of measured sediment yield and transport rates. The delta survey and sediment transport monitoring results described above were compared to the GMA sediment source inventory and sediment delivery risk analysis results.

The delta survey data described above in Section 3.3.2.1 provide a reasonable estimate of the actual average annual sediment yield to Trinity Lake since the time the dam was built (i.e., about 44 years). The measured average annual sediment yield rate was compared to the predicted average annual rate from the GMA inventory sediment sources analysis. Delta surveys were completed for the Stuart Fork, East Fork Stuart Fork, and Mule Creek subwatersheds.

The sediment delivery rates predicted using the models agree within 100 percent for the East Fork Stuart Fork and Mule Creek subwatersheds (Table 3.6.3). The predicted average annual sediment delivery rate is much lower than the measured. This result suggests that the GMA sediment source inventory is underestimating actual sediment delivery and yield.

The percent difference is high for the predicted and measured sediment delivery rate for the Stuarts Fork subwatershed (Table 3.6.3). The predicted and measured sediment yield rate, however, agree within seven percent. The difference between the sediment delivery rates is likely caused by the large drainage area of the Stuarts Fork subwatershed and the large volume of sediment storage within the drainage network. The East Fork Stuarts Fork and Mule Creek do not have as much storage potential (Figure 3.2.1 and Table 3.2.1), and most of the sediment delivered to the stream network over the last 44 years has been transported to Trinity Lake. Whereas, for the Stuarts Fork subwatershed, it is likely that most of the sediment delivered to the stream network over the last 44 years is stored within the drainage.

Table 3.6.3. Comparison of measured and modeled sediment delivery and yield rates.

	Subwatershed Name		
	Stuart Fork	East Fork Stuart Fork	Mule Creek
Drainage Area (mi^2)	62.5	22.6	6.3
Sediment Yield Potential (Ps)	0.15	0.03	0.02
Measured Sediment Yield Rate (tons/year/mi2)'	184	697	1094
GMA Inventory SSA Sediment Delivery Rate (tons/mi2/year)'	1142	282	253
GMA Inventory SSA Sediment Yield Rate (tons/mi2/year)'	171	8	5
GMA Inventory SSA Sediment Delivery Rate (% diff)	521%	-60%	-77%
GMA Inventory SSA Sediment Yield Rate (% diff)	-7%	-99%	-100%

The measured streamflow and sediment transport data collected on Coffee Creek and the East Fork Trinity River (Appendix 2) were compared to the modeled surface and fluvial erosion sediment yield rates. Assuming 15 percent of the sediment load is suspended, the results show that there is a significant difference between the measured and predicted suspended sediment discharge for a Q_2 flood event (Table 3.6.4). This difference likely results from the fact that the sediment delivery risk model roughly accounts for actual sediment yield as stated above.

If the difference between the measured results for Coffee Creek and East Fork Trinity are compared, the predicted results appear reasonable. The watersheds are about the same size, yet there is a 96 percent difference in their measured suspended sediment discharge. The measured difference agrees with the predicted difference where Coffee Creek has less management related sediment delivery (Table 3.5.4).

Table 3.6.4. Comparison of measured and modeled suspended sediment discharge for the Q_2 flood event.

Site	Drainage Area (mi^2)	Measured SSD ($tons/Q_2/mi^2$)*	Modeled SSD ($tons/Q_2/mi^2$)*
Coffee Creek at Highway 3	116.4	1	45
East Fork Trinity River at Trinity County Road 106	92.8	26	75
	Percent Difference	-96	-40

*for a rainfall runoff driven Q_2 flood event lasting two days

5.0 REPORT LIMITATIONS

This sediment source analysis relies heavily on existing data and information. The constraints under which this work was completed have been well described. Graham Matthews & Associates provide their findings, conclusions, and recommendations after preparing such information in a manner consistent with that level of care and skill ordinarily exercised by members of the profession practicing under similar conditions in the fields of hydrology, fluvial geomorphology, and geology. Several data gaps have been identified to include: accurate timber harvest history, road condition surveys, natural landslide rates in mature forests, and long-term sediment transport measurements.

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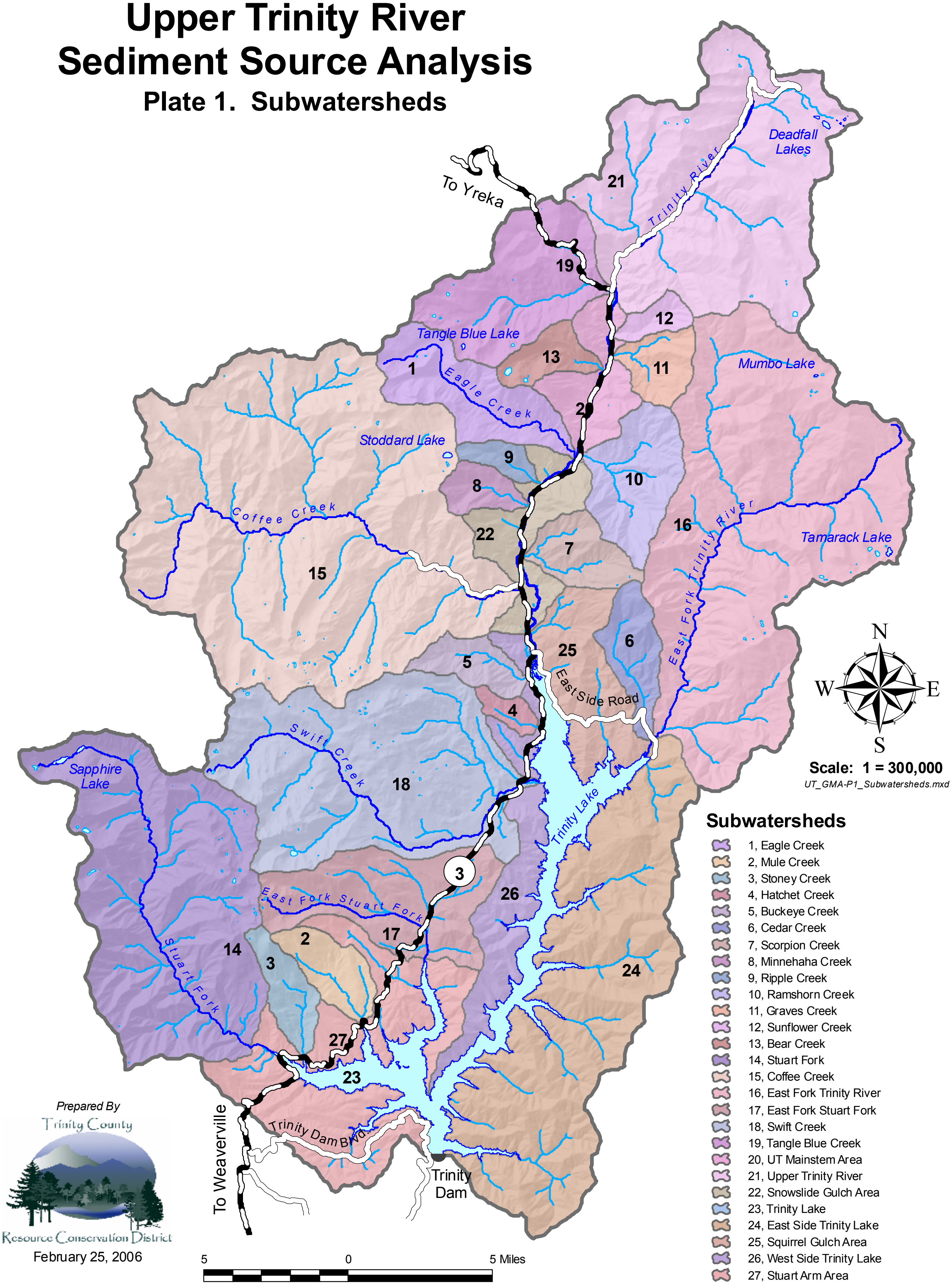
APPENDIX 1

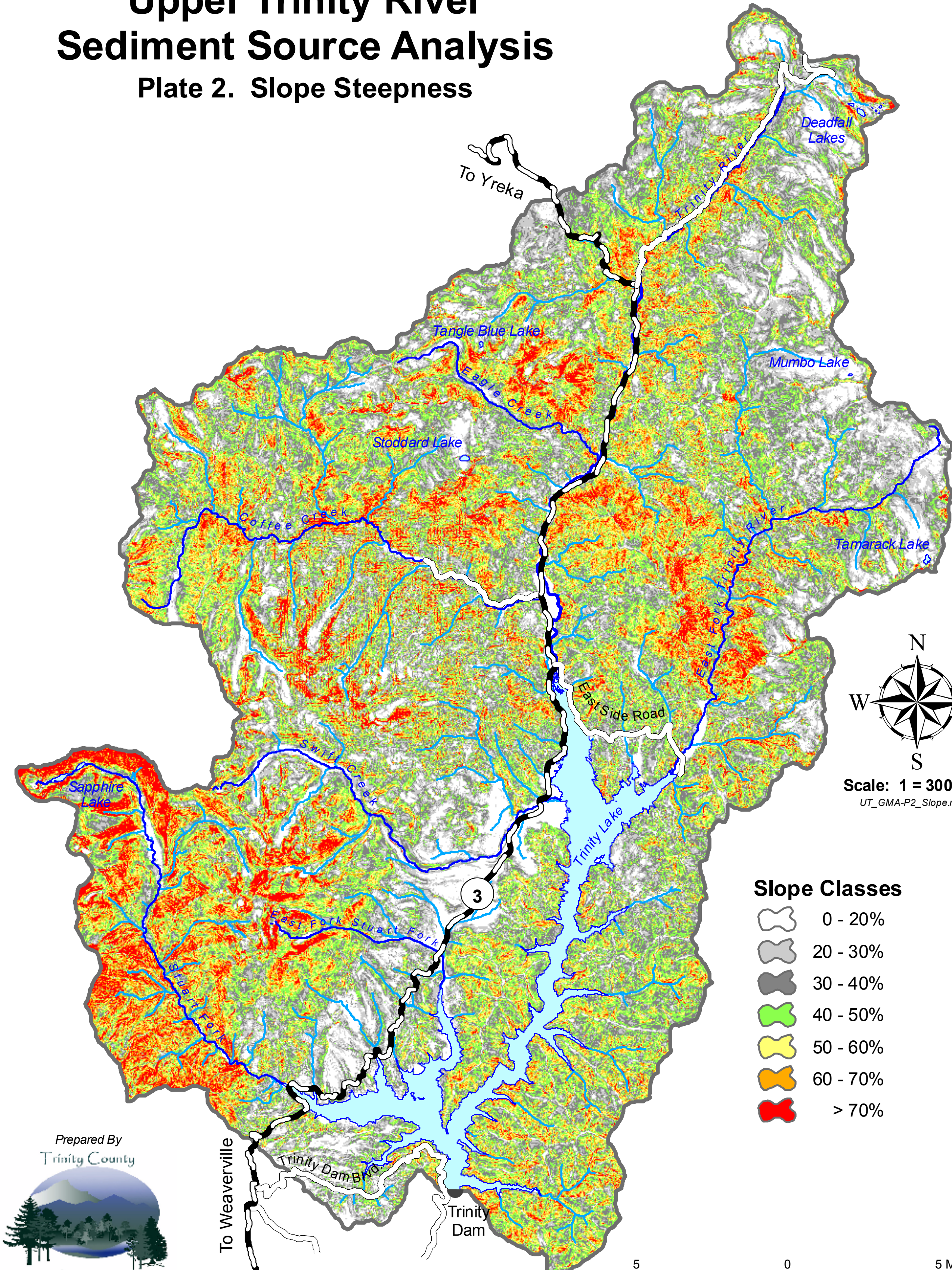
Upper Trinity River Watershed GIS Plates

PLATE 1: Sub-watersheds
PLATE 2: Slope
PLATE 3: Precipitation
PLATE 4: Geology
PLATE 5: Harvests
PLATE 6: Roads
PLATE 7: Ownership
PLATE 8: Landslides
PLATE 9: Landslide Percent
PLATE 10: Geo 13 Model Results Sediment Delivery Risk
PLATE 11: Geo 13 Model Results Percent above Background Results
PLATE 12: SDRA Surface and Fluvial Erosion Percent over Background Results

Upper Trinity River
Sediment Source Analysis
Plate 1. Subwatersheds



Upper Trinity River
Sediment Source Analysis
Plate 2. Slope Steepness



Scale: 1 = 300,000

UT_GMA-P2_Slope.mxd

Prepared By

Trinity County Resource Conservation District

February 25, 2006

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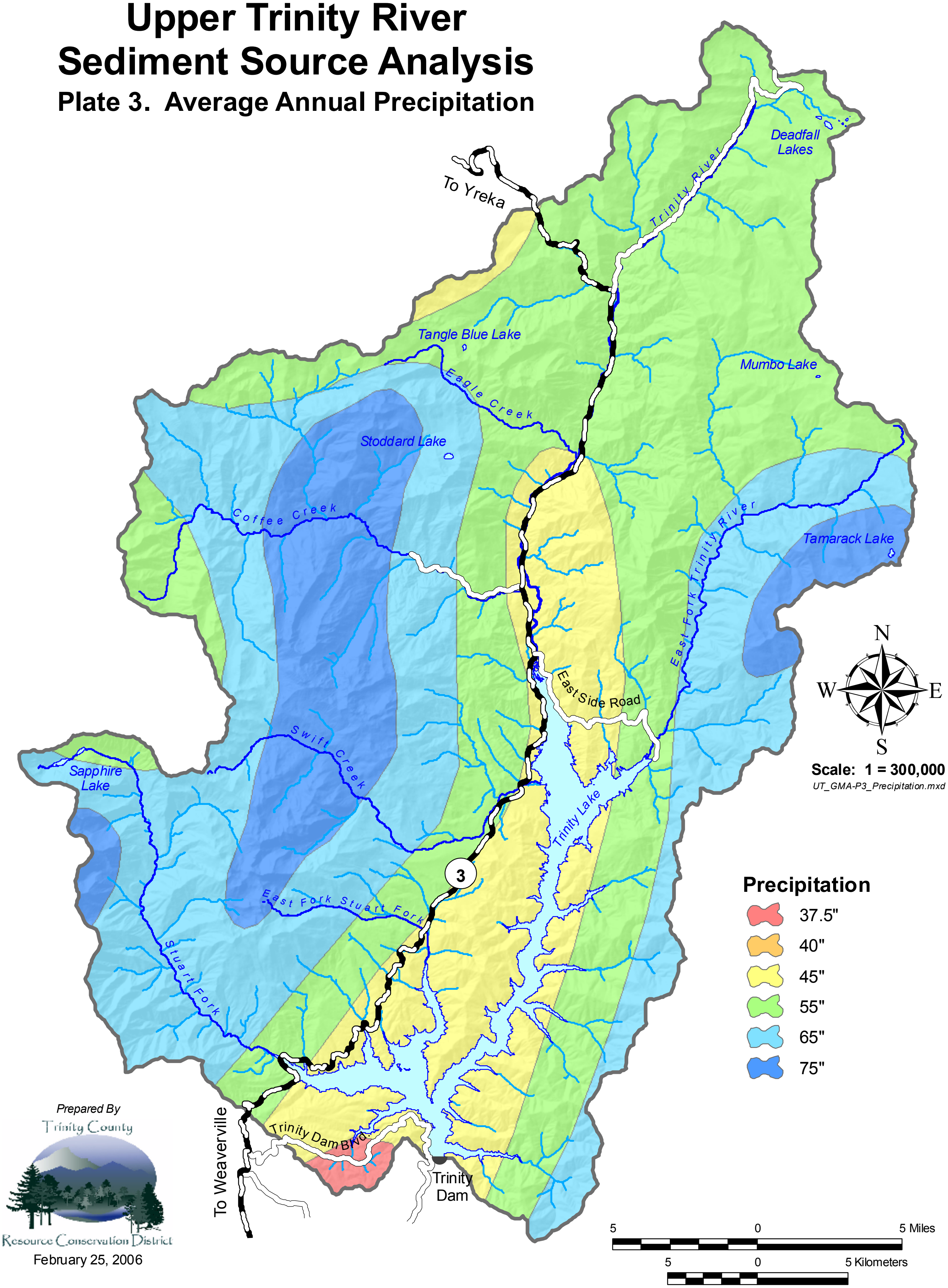
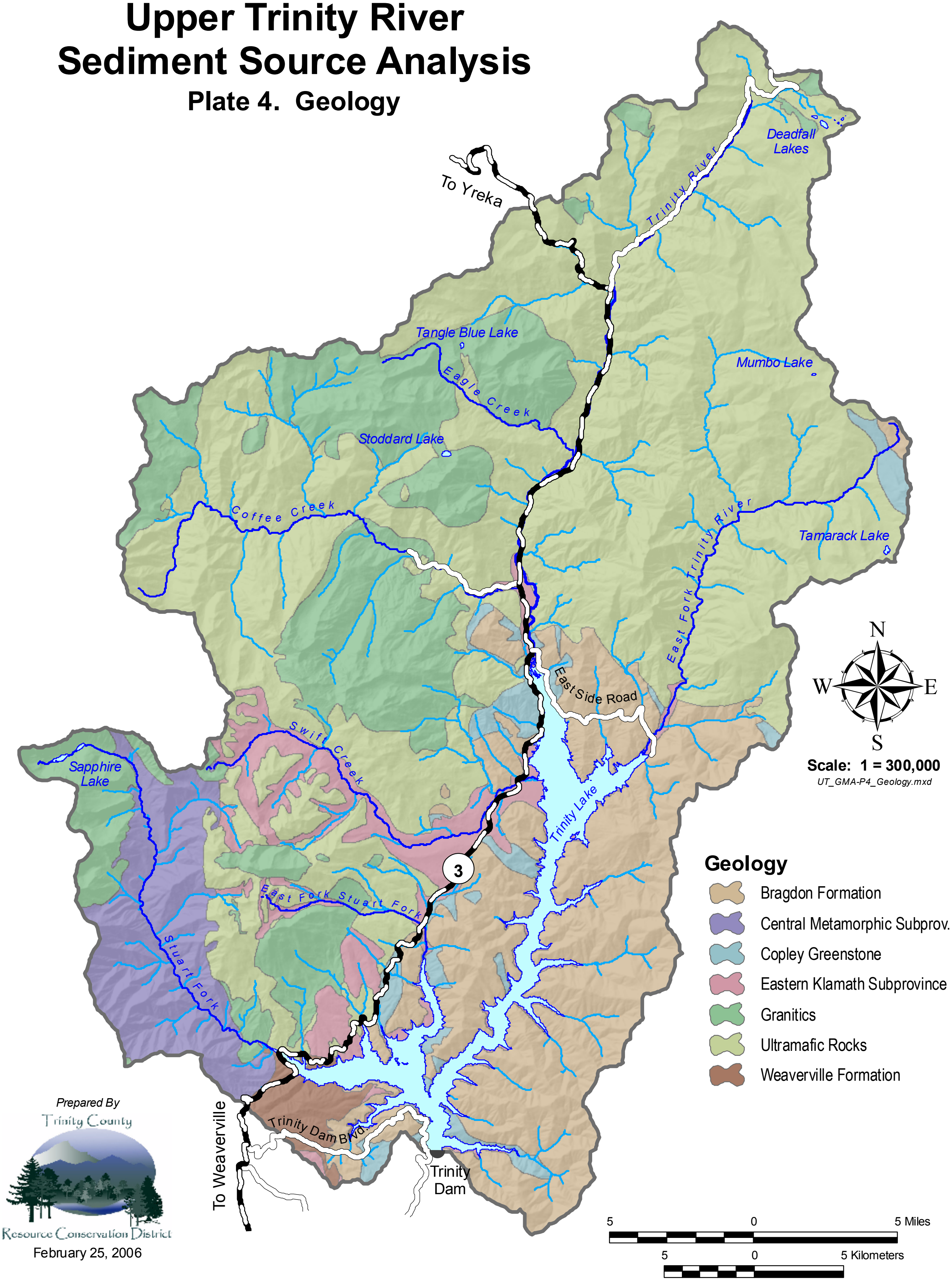
Upper Trinity River
Sediment Source Analysis
Plate 3. Average Annual Precipitation



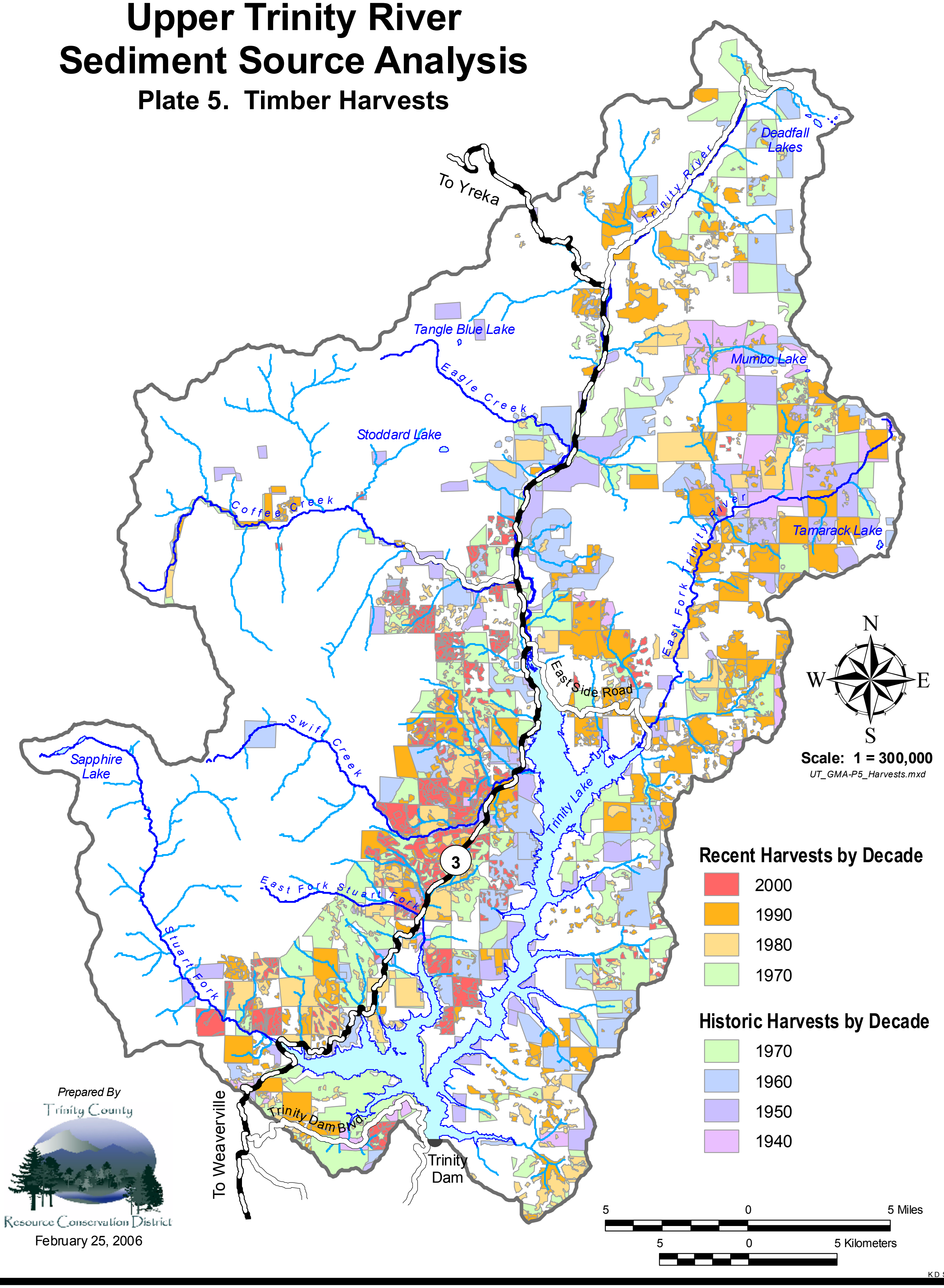
Upper Trinity River Sediment Source Analysis

Plate 4. Geology



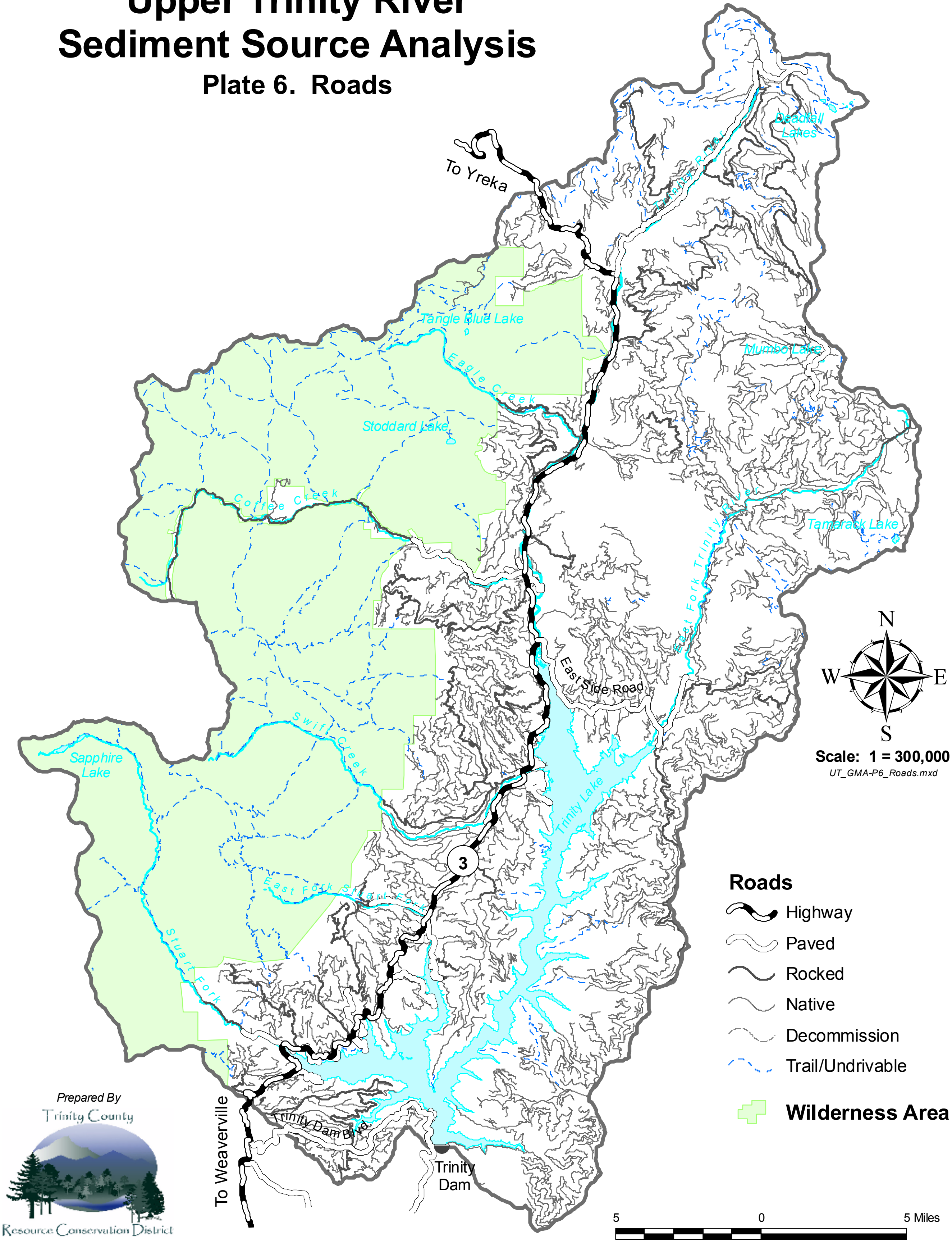
Upper Trinity River Sediment Source Analysis

Plate 5. Timber Harvests



Upper Trinity River Sediment Source Analysis

Plate 6. Roads



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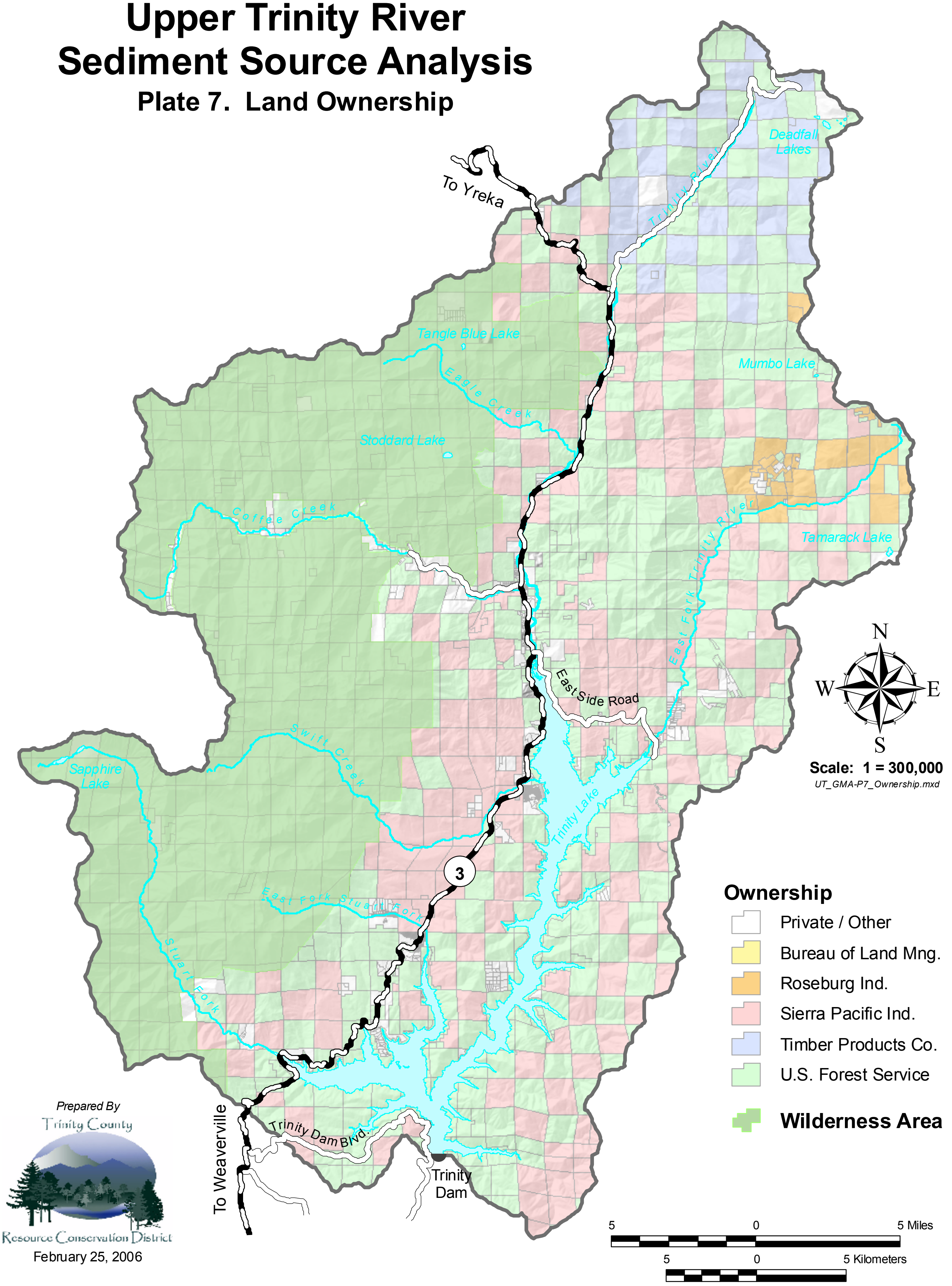
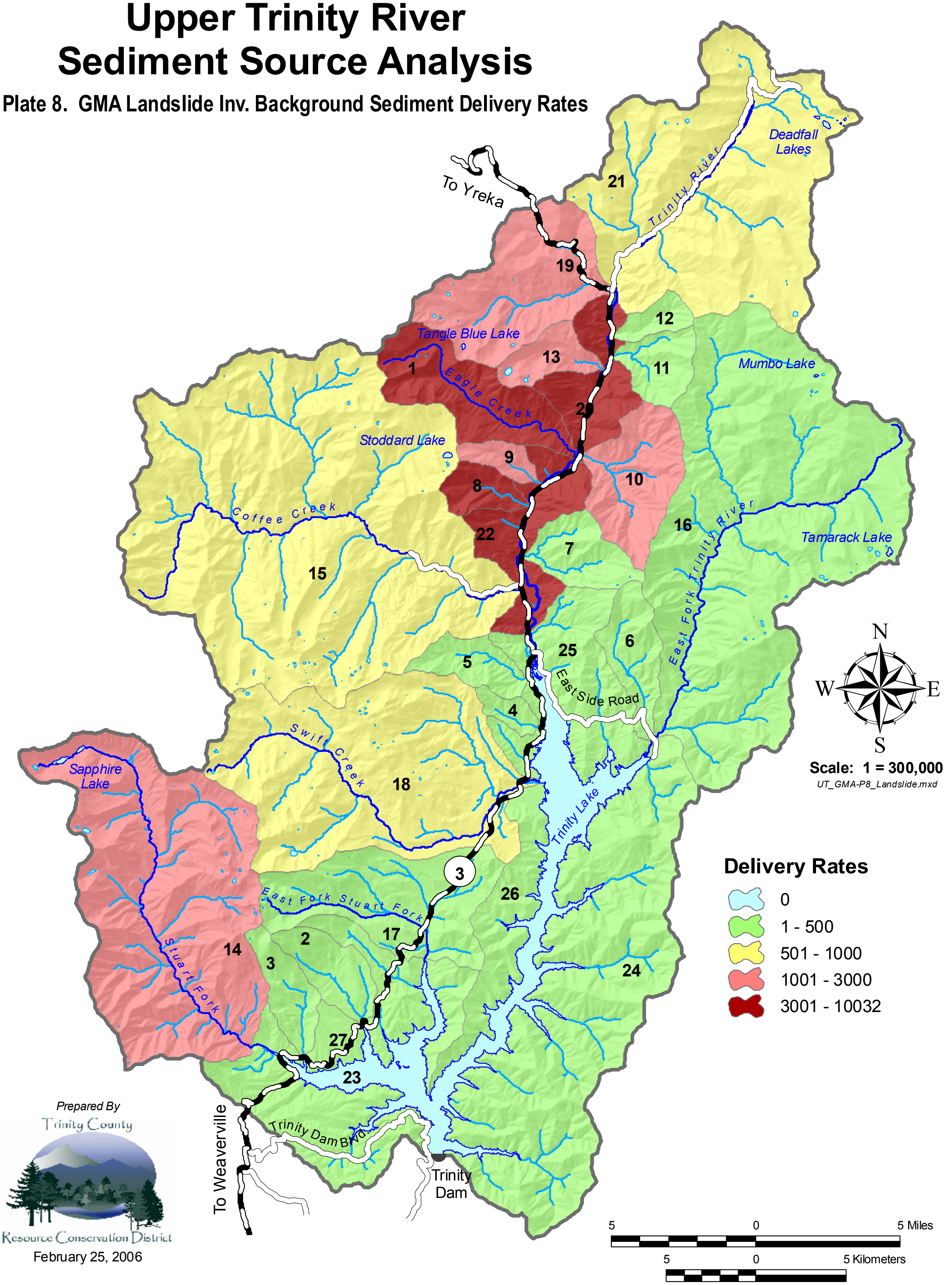
Upper Trinity River Sediment Source Analysis

Plate 7. Land Ownership



Upper Trinity River Sediment Source Analysis

Plate 8. GMA Landslide Inv. Background Sediment Delivery Rates



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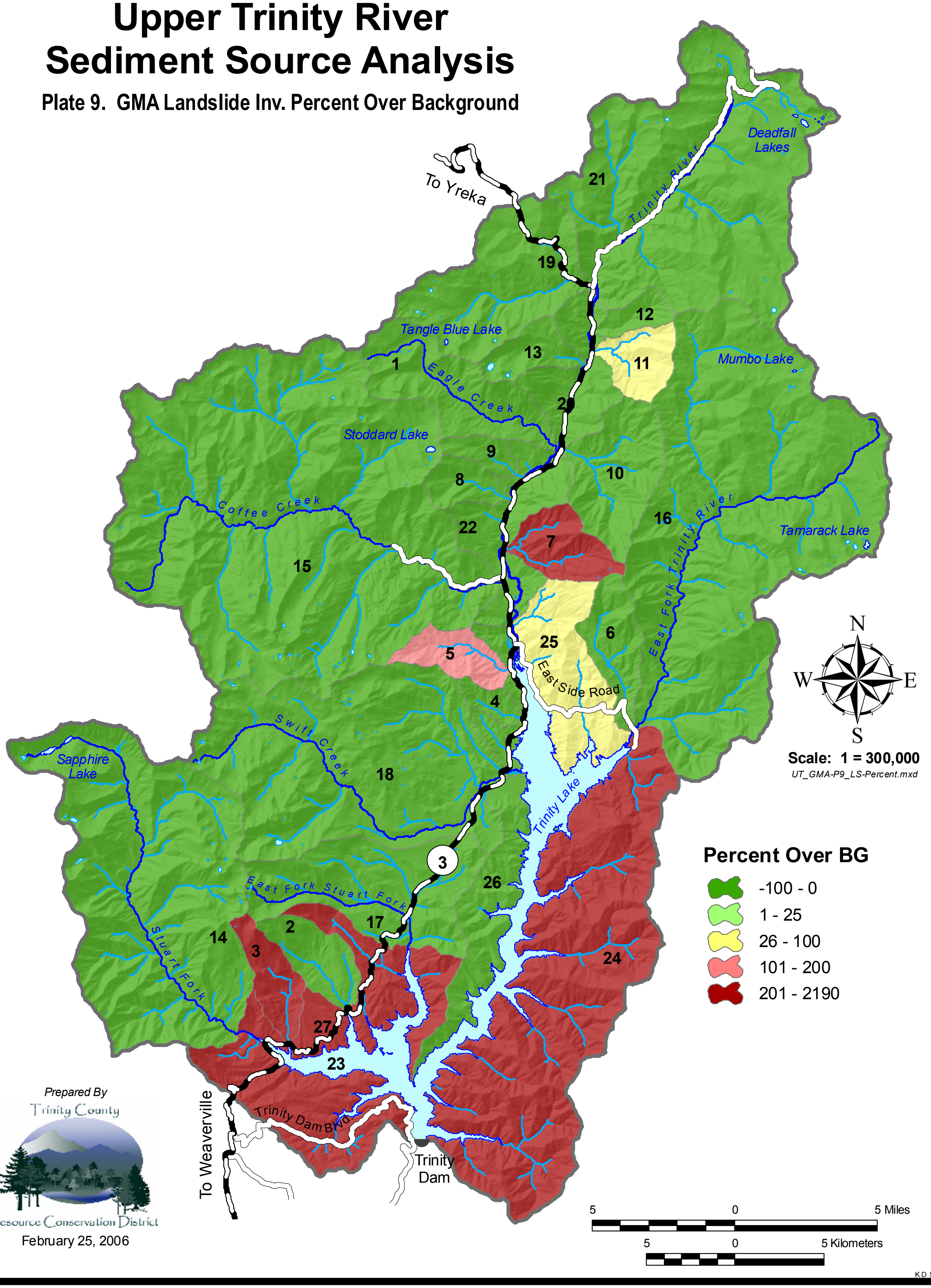
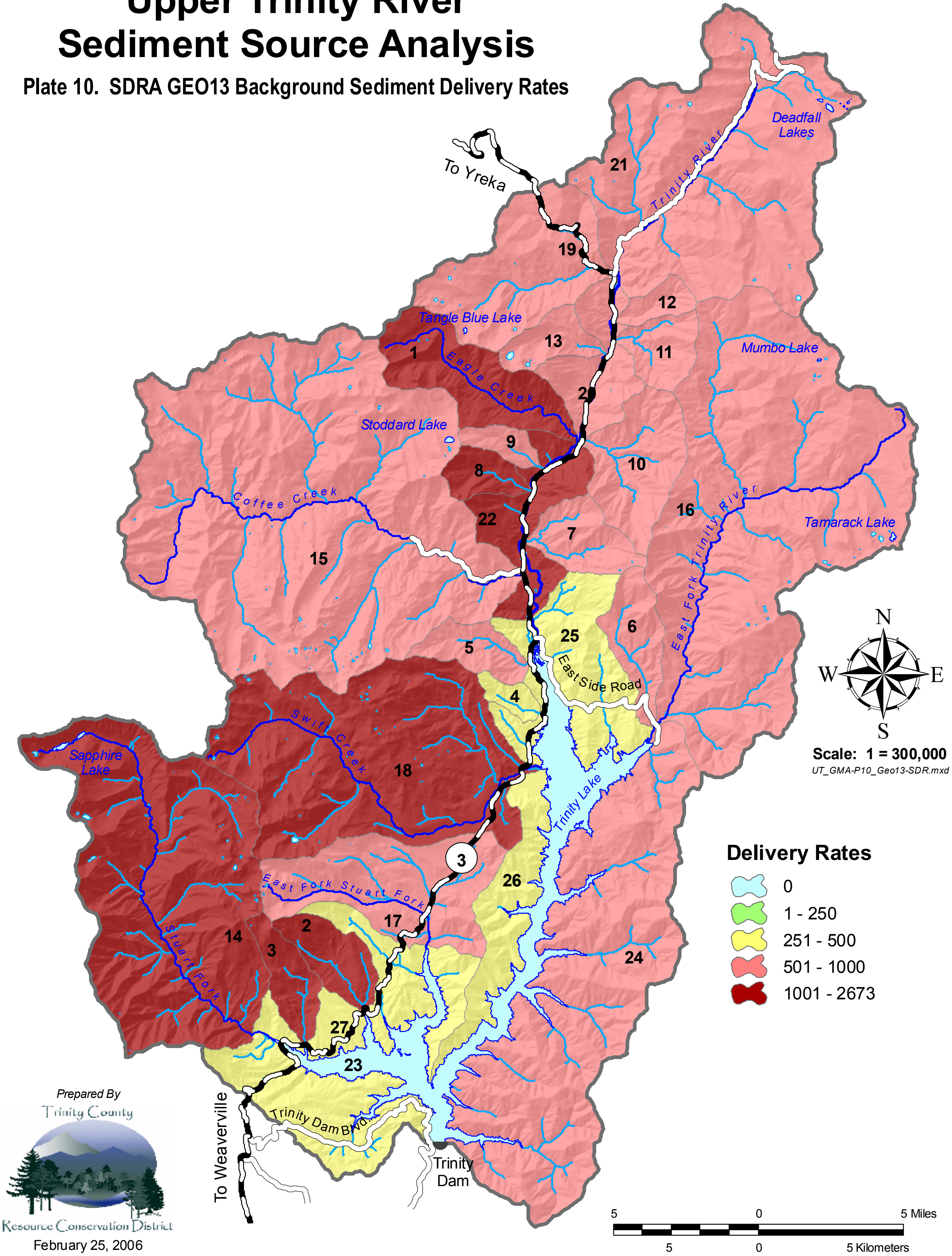
Upper Trinity River
Sediment Source Analysis

Plate 9. GMA Landslide Inv. Percent Over Background



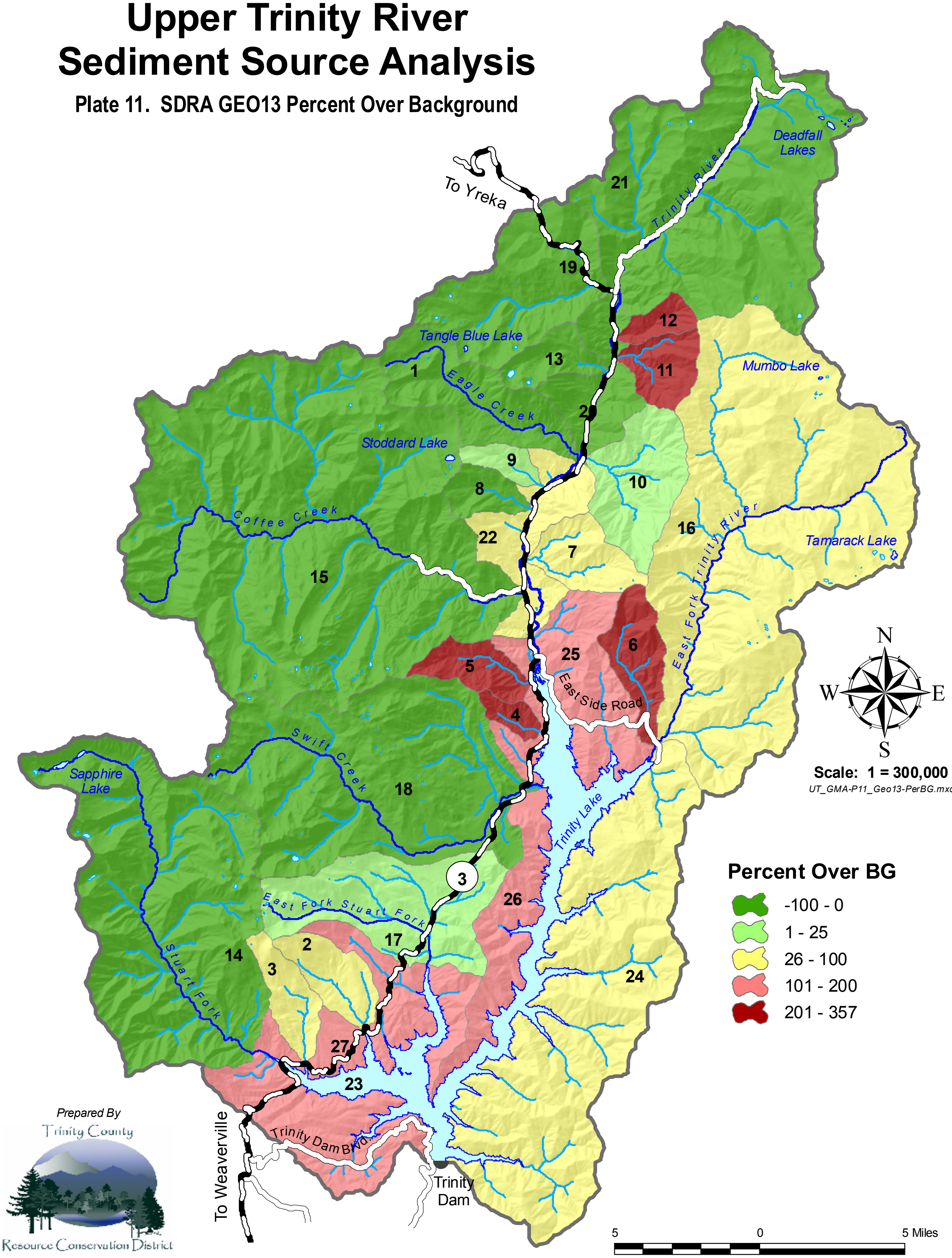
Upper Trinity River Sediment Source Analysis

Plate 10. SDRA GEO13 Background Sediment Delivery Rates



Upper Trinity River Sediment Source Analysis

Plate 11. SDRA GEO13 Percent Over Background



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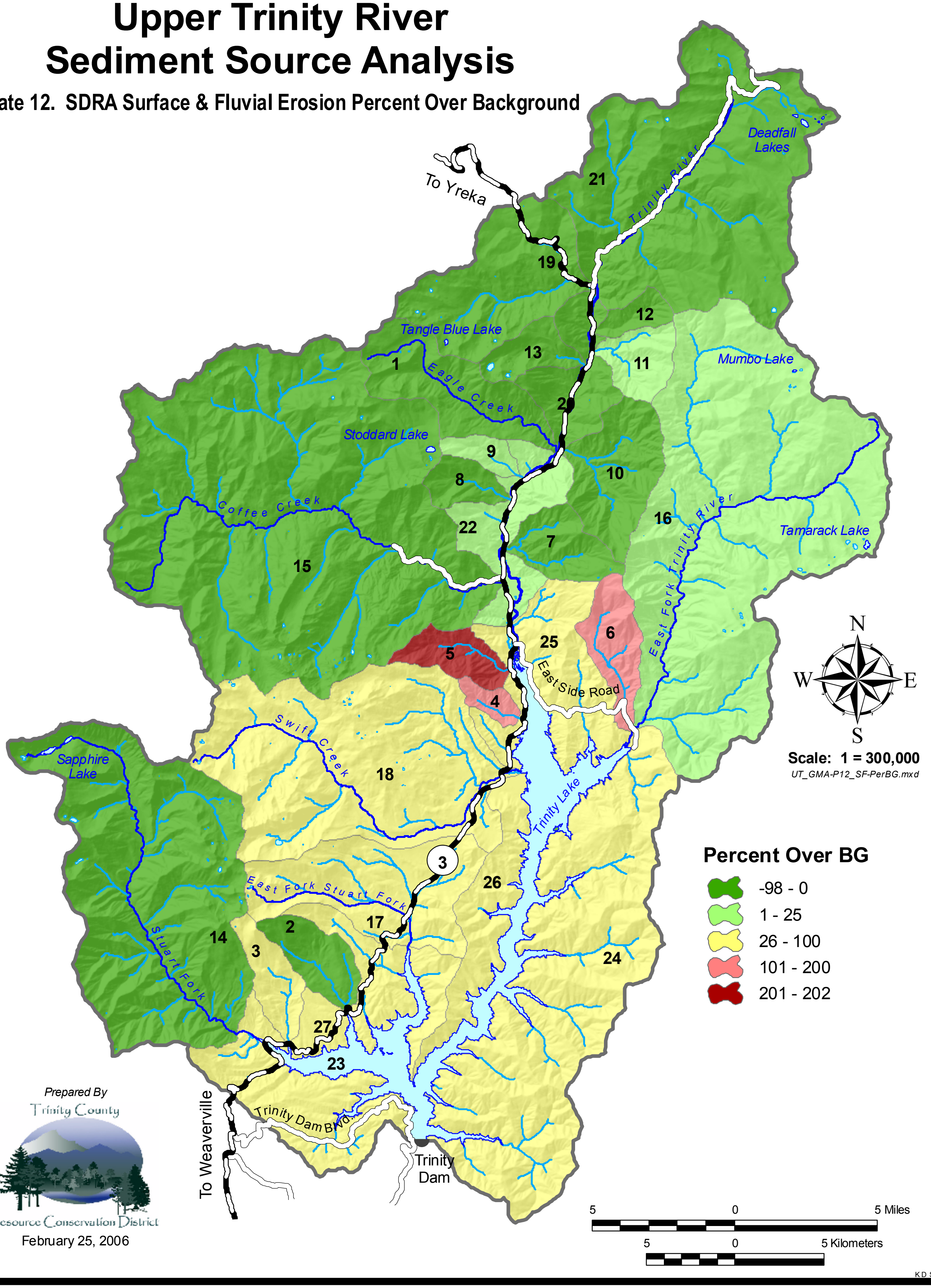
February 25, 2006

Upper Trinity River
Sediment Source Analysis

Plate 12. SDRA Surface & Fluvial Erosion Percent Over Background



APPENDIX 2

Upper Trinity River Streamflow and Sediment Transport Data

Table 1. WY 2000 and 2005 streamflow and sediment monitoring stations.

UPPER TRINITY WATERSHED

SUMMARY OF STREAMFLOW AND SEDIMENT DATA COLLECTION -- WY 2000

SITE #	SITE	STREAMFLOW # OF MSMTS	SEDIMENT # OF SAMPLES TURBIDITY (NTU)	SSC (mg/l)
4	Bear Creek at Bear Creek Loop		2	---
15	Buckeye Creek at Highway 3	2	6	2
19	Cedar Creek nr TC 106	3	8	3
22	Coffee Creek at Highway 3	4	8	4
25	Davis Creek at Highway 3		5	2
27	Diener Mine Creek at Highway 3		3	1
30	Eagle Creek at Eagle Creek Loop Road		3	2
32	East Fork of Stuart Fork at Guy Covington Drive		7	3
33	East Fork of the Trinity River at TC 106		6	3
41	Flume Creek at Highway 3		3	1
45	Graves Creek at Highway 3	2	5	3
47	Greenhorn Gulch at Greenhorn Drive		1	---
49	Halls Gulch at East Fork Trinity Road		1	---
50	Hatchet Creek at Highway 3	3	7	2
60	Little Bear Lake Creek at Highway 3		2	---
68	Little Trinity River at Parks Creek Rd		1	1
77	Minnehaha Creek at Eagle Creek Loop		3	1
78	Mule Creek at Highway 3	3	11	5
82	North Fork of Swift Creek at TC 123	4	7	3
89	Ramshorn Creek at Highway 3	2	6	4
92	Ripple Creek at Eagle Creek Loop Rd		3	1
113	Scorpion Creek at Highway 3	2	7	4
114	Scott Mountain Creek at Highway 3		1	---
120	Snow Gulch at TC 106		5	1
123	Squirrel Gulch at TC 106		6	2
124	Stoney Creek at Highway 3	3	5	1
125	Stoney Creek Parking Lot (roadside ditch)		1	---
126	Sunflower Creek at Highway 3	2	5	1
128	Tangle Blue Creek at Highway 3		7	3
130	Trinity River above Coffee Creek	USGS	4	3
133	Trinity River at Parks Creek Rd	4	7	3

UPPER TRINITY WATERSHED
SUMMARY OF STREAMFLOW AND SEDIMENT DATA COLLECTION -- WY 2005-2006

SITE #	SITE	STREAMFLOW # OF MSMTS	SEDIMENT # OF SAMPLES TURBIDITY (NTU)	SSC (mg/l)
4	Bear Creek at Bear Creek Loop		---	---
15	Buckeye Creek at Highway 3		8	8
19	Cedar Creek nr TC 106		3	3
22	Coffee Creek at Highway 3	6	10	10
25	Davis Creek at Highway 3		---	---
27	Diener Mine Creek at Highway 3		---	---
30	Eagle Creek at Eagle Creek Loop Road		---	---
32	East Fork of Stuart Fork at Guy Covington Drive		1	1
33	East Fork of the Trinity River at TC 106	4	10	10
41	Flume Creek at Highway 3		---	---
45	Graves Creek at Highway 3		5	5
47	Greenhorn Gulch at Greenhorn Drive		---	---
49	Halls Gulch at East Fork Trinity Road		---	---
50	Hatchet Creek at Highway 3		---	---
60	Little Bear Lake Creek at Highway 3		---	---
68	Little Trinity River at Parks Creek Rd		---	---
77	Minnehaha Creek at Eagle Creek Loop		---	---
78	Mule Creek at Highway 3		8	8
82	North Fork of Swift Creek at TC 123		7	7
89	Ramshorn Creek at Highway 3		9	9
92	Ripple Creek at Eagle Creek Loop Rd		3	3
113	Scorpion Creek at Highway 3		8	8
114	Scott Mountain Creek at Highway 3		1	1
120	Snow Gulch at TC 106		---	---
123	Squirrel Gulch at TC 106		---	---
124	Stoney Creek at Highway 3		7	7
134	Stuart Fork at Trinity Alps Resort	5	1	1
126	Sunflower Creek at Highway 3		2	2
128	Tangle Blue Creek at Highway 3		2	2
130	Trinity River above Coffee Creek		---	---
133	Trinity River at Parks Creek Rd	3	---	---
		18	85	85

Table 2. WY 2000 sediment monitoring results.

WATER YEAR 2000 UPPER TRINITY WATERSHED
TURBIDITY (>15 NTU) AND TSS RESULTS RANKED BY TURBIDITY

		Site		Turbidity	TSS
Date	Time	Acronym	Full Name	(NTU)	(mg/l)
2/22/2000	1101	DMH3	Diener Mine Creek at Highway 3	911	3630
2/13/2000	2039	DMH3	Diener Mine Creek at Highway 3	251	
2/22/2000	1051	MCH3	Mule Creek at Highway 3	122	187
2/13/2000	2033	MCH3	Mule Creek at Highway 3	106	
2/14/2000	1501	SQGU	Squirrel Gulch at TC 106	84.3	
2/14/2000	1205	SCH3	Stoney Creek at Highway 3	68.4	
2/14/2000	1217	MCH3	Mule Creek at Highway 3	66.3	
2/14/2000	1226	DMH3	Diener Mine Creek at Highway 3	64.0	
4/17/2000	1252	BCK3	Buckeye Creek at Highway 3	63.6	112
4/17/2000	1125	MCH3	Mule Creek at Highway 3	50.2	104
4/13/2000	1213	MNEC	Minnehaha Creek at Eagle Creek Loop	48.7	74
2/14/2000	1429	HCH3	Hatchet Creek at Highway 3	46.8	
2/22/2000	1208	BCK3	Buckeye Creek at Highway 3	46.1	57
4/13/2000	1220	TRCC	Trinity River above Coffee Creek	45.7	69
2/14/2000	1516	CEDC	Cedar Creek nr TC 106	45.4	
2/11/2000	1435	MCH3	Mule Creek at Highway 3	43.8	24
2/13/2000	2147	SQGU	Squirrel Gulch at TC 106	42.8	
4/17/2000	1155	CFH3	Coffee Creek at Highway 3	41.4	72
4/13/2000	929	MCH3	Mule Creek at Highway 3	40.3	102
2/14/2000	1442	BCK3	Buckeye Creek at Highway 3	39.2	
4/13/2000	1006	CFH3	Coffee Creek at Highway 3	38.6	62
2/13/2000	2023	SCH3	Stoney Creek at Highway 3	36.7	
2/14/2000	1531	SNGU	Snow Gulch at TC 106	35.2	
4/13/2000	1224	SPH3	Scorpion Creek at Highway 3	34.3	48
4/13/2000	1302	EFTR	East Fork of the Trinity River at TC 106	33.9	42
2/14/2000	1419	FCH3	Flume Creek at Highway 3	33.5	
4/13/2000	1149	ECEC	Eagle Creek at Eagle Creek Loop Road	33.1	76
2/13/2000	2138	SNGU	Snow Gulch at TC 106	32.1	
2/22/2000	1400	SNGU	Snow Gulch at TC 106	29.5	15
2/13/2000	2157	CEDC	Cedar Creek nr TC 106	28.9	
4/13/2000	1102	TBH3	Tangle Blue Creek at Highway 3	27.2	48
4/17/2000	1245	SPH3	Scorpion Creek at Highway 3	25.2	
2/22/2000	1142	NFSC	North Fork of Swift Creek at TC 123	24.3	29
4/17/2000	1259	HCH3	Hatchet Creek at Highway 3	24.1	119
2/12/2000	925	MCH3	Mule Creek at Highway 3	23.8	
2/22/2000	1037	SCH3	Stoney Creek at Highway 3	23.3	36
2/13/2000	2115	FCH3	Flume Creek at Highway 3	22.6	
2/14/2000	1330	EFSF	East Fork of Stuart Fork at Guy Covington Drive	21.6	
4/13/2000	1206	RPEC	Ripple Creek at Eagle Creek Loop Rd	21.0	25
4/17/2000	1115	SCH3	Stoney Creek at Highway 3	21.0	30
4/13/2000	1349	NFSC	North Fork of Swift Creek at TC 123	20.0	32
4/13/2000	1027	TRPC	Trinity River at Parks Creek Rd	20.0	25
2/14/2000	1734	SPH3	Scorpion Creek at Highway 3	19.9	
2/22/2000	1250	LBLC	Little Bear Lake Creek at Highway 3	19.6	27
4/16/2000	1254	MCH3	Mule Creek at Highway 3	19.6	32
2/22/2000	1110	EFSF	East Fork of Stuart Fork at Guy Covington Drive	19.4	18
2/22/2000	1333	SQGU	Squirrel Gulch at TC 106	19.3	13
2/22/2000	1158	HCH3	Hatchet Creek at Highway 3	18.5	15
2/13/2000	2048	EFSF	East Fork of Stuart Fork at Guy Covington Drive	18.3	
2/14/2000	1357	NFSC	North Fork of Swift Creek at TC 123	18.0	
2/22/2000	1127	ITH3	Intermittant Trib at Highway 3 N. of Davis Creek	17.3	5
2/22/2000	1340	CEDC	Cedar Creek nr TC 106	17.2	12
2/13/2000	2123	HCH3	Hatchet Creek at Highway 3	16.8	
2/22/2000	1150	FCH3	Flume Creek at Highway 3	16.7	10
4/14/2000	32	TRCC	Trinity River above Coffee Creek	16.2	21
2/22/2000	1216	CFH3	Coffee Creek at Highway 3	16.1	20
4/13/2000	2306	MCH3	Mule Creek at Highway 3	15.8	39
4/19/2000	1155	MCH3	Mule Creek at Highway 3	15.6	19
4/16/2000	1705	ITH3	Intermittant Trib at Highway 3 N. of Davis Creek	15.1	

Table 3. WY 2005 sediment monitoring results.

WATER YEAR 2005 AND 2006 UPPER TRINITY WATERSHED
TURBIDITY AND SUSPENDED SEDIMENT RESULTS RANKED BY TURBIDITY

Date Sampled	Time Sampled	Site Name	DIS or Grab	Turb NTU	SSC1 mg/l	Hydrograph Position
12/28/2005	850	Mule	GRAB	80	371	
12/28/2005	915	Buckeye	GRAB	55	445	
12/28/2005	833	Stoney	GRAB	50	250	
12/28/2005	935	East Fork TR	GRAB	38	120	
5/18/2005	0928	Mule	DIS	35	729	R
5/18/2005	1420	Mule	DIS	34	299	R
12/28/2005	1047	Scorpion	GRAB	31	140	
12/28/2005	1010	Ramshorn	GRAB	28	128	
12/28/2005	1115	EF Stuart Fork	GRAB	28	122	
5/18/2005	1917	Mule	DIS	22	131	F
5/18/2005	1433	Stoney	DIS	21	181	R
5/18/2005	1712	Graves	DIS	18	277	R
5/18/2005	0900	Stoney	DIS	18	112	R
12/28/2005	1255	Stuart Fork	GRAB	15	80.0	
5/18/2005	1021	Buckeye	DIS	14	39.2	R
5/18/2005	1351	Buckeye	DIS	14	50.0	R
12/26/2005	907	Mule	DIS	14	28.5	
12/28/2005	955	Coffee	GRAB	13	64.5	
12/28/2005	1025	Tangle Blue	GRAB	13	36.9	
5/19/2005	1221	Mule	DIS	12	182	S
5/18/2005	1931	Stoney	DIS	11	66.2	F
5/19/2005	1124	Cedar	DIS	9.6	16.3	S
5/18/2005	1852	Buckeye	DIS	8.4	37.3	R
5/18/2005	1201	Scorpion	DIS	8.4	82.7	R
12/26/2005	1050	Cedar	DIS	8.0	2.8	
12/26/2005	855	Stoney	DIS	7.7	20.7	
12/26/2005	1018	Buckeye	DIS	7.6	19.2	
5/18/2005	1312	Scorpion	DIS	7.4	17.2	R
11/7/2005	1530	Mule	DIS	7.2	12.1	R
5/18/2005	1815	East Fork TR	GRAB	6.9	10.4	R
2/28/2005	1606	Buckeye	DIS	6.2	10.0	R
5/18/2005	1815	East Fork TR	DIS	6.0	20.0	R
12/26/2005	1101	East Fork TR	GRAB	6.0	5.6	
12/26/2005	1215	Scorpion	DIS	5.9	12.4	
5/18/2005	1735	Scorpion	DIS	5.6	8.9	R
12/26/2005	1150	Tangle Blue	GRAB	5.6	6.0	
11/7/2005	755	Mule	DIS	5.5	10.4	R
12/26/2005	1137	Ramshorn	GRAB	5.3	3.2	
5/19/2005	1150	Buckeye	DIS	5.2	12.1	S
5/18/2005	1053	East Fork TR	DIS	4.2	3.3	R
5/18/2005	1240	Graves	DIS	4.1	8.6	R
11/7/2005	900	Cedar	DIS	3.9	5.4	R
12/26/2005	1120	Coffee	GRAB	3.9	4.6	
5/18/2005	1137	Coffee	DIS	3.8	7.2	R
5/19/2005	1234	Stoney	DIS	3.8	11.9	S
5/18/2005	1330	Coffee	DIS	3.5	7.5	R
11/7/2005	915	East Fork TR	DIS	3.5	10.5	R
5/18/2005	1722	Ramshorn	DIS	3.4	3.5	R
5/18/2005	1722	Ramshorn	DIS	3.2	4.5	R
5/18/2005	1748	Coffee	DIS	3.1	8.9	R
2/28/2005	1530	Graves	DIS	3.1	1.7	S
11/7/2005	1015	Ramshorn	DIS	3.1	7.9	R
5/19/2005	1107	East Fork TR	GRAB	3.0	1.7	S
11/7/2005	830	Buckeye	DIS	2.9	9.4	R
2/28/2005	1500	Scorpion	DIS	2.8	1.6	S
2/28/2005	1515	Ramshorn	DIS	2.8	3.4	F
5/19/2005	1107	East Fork TR	DIS	2.7	2.4	S
5/18/2005	1222	Ramshorn	DIS	2.7	3.2	R
5/18/2005	1255	Ramshorn	DIS	2.5	3.7	R
2/28/2005	1550	Coffee	DIS	2.4	2.8	R
2/28/2005	1440	Coffee	DIS	2.2	2.7	R
5/19/2005	1016	Scorpion	DIS	2.2	3.8	S
11/7/2005	935	Coffee	DIS	2.0	7.1	R

Figure 1. Coffee Creek at Highway 3 WY 2002-2005 hydrograph.

Figure 2. Coffee Creek at Highway 3 streamflow rating curve.

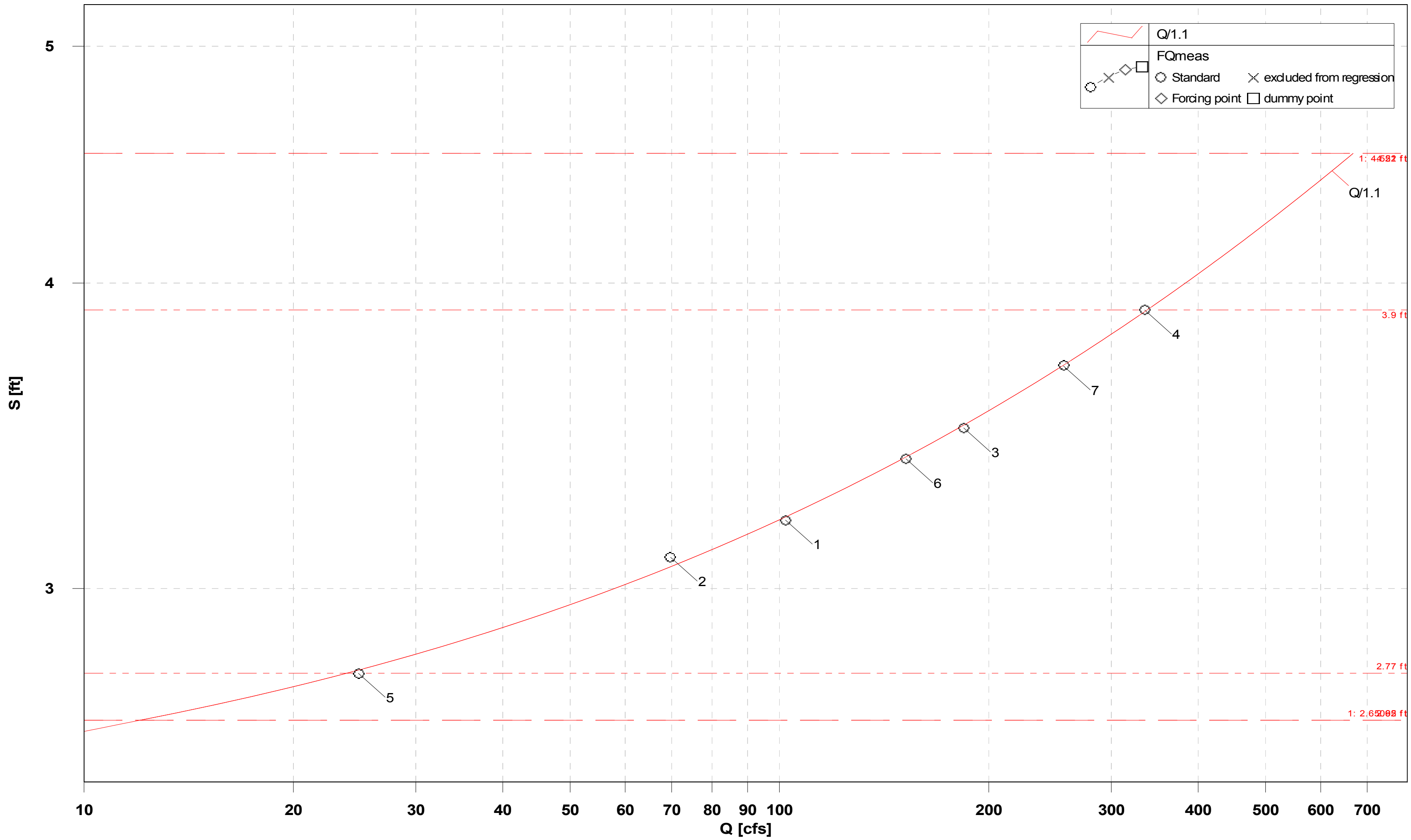


Figure 3. Coffee Creek at Highway 3 WY 2005 sediment rating curve.

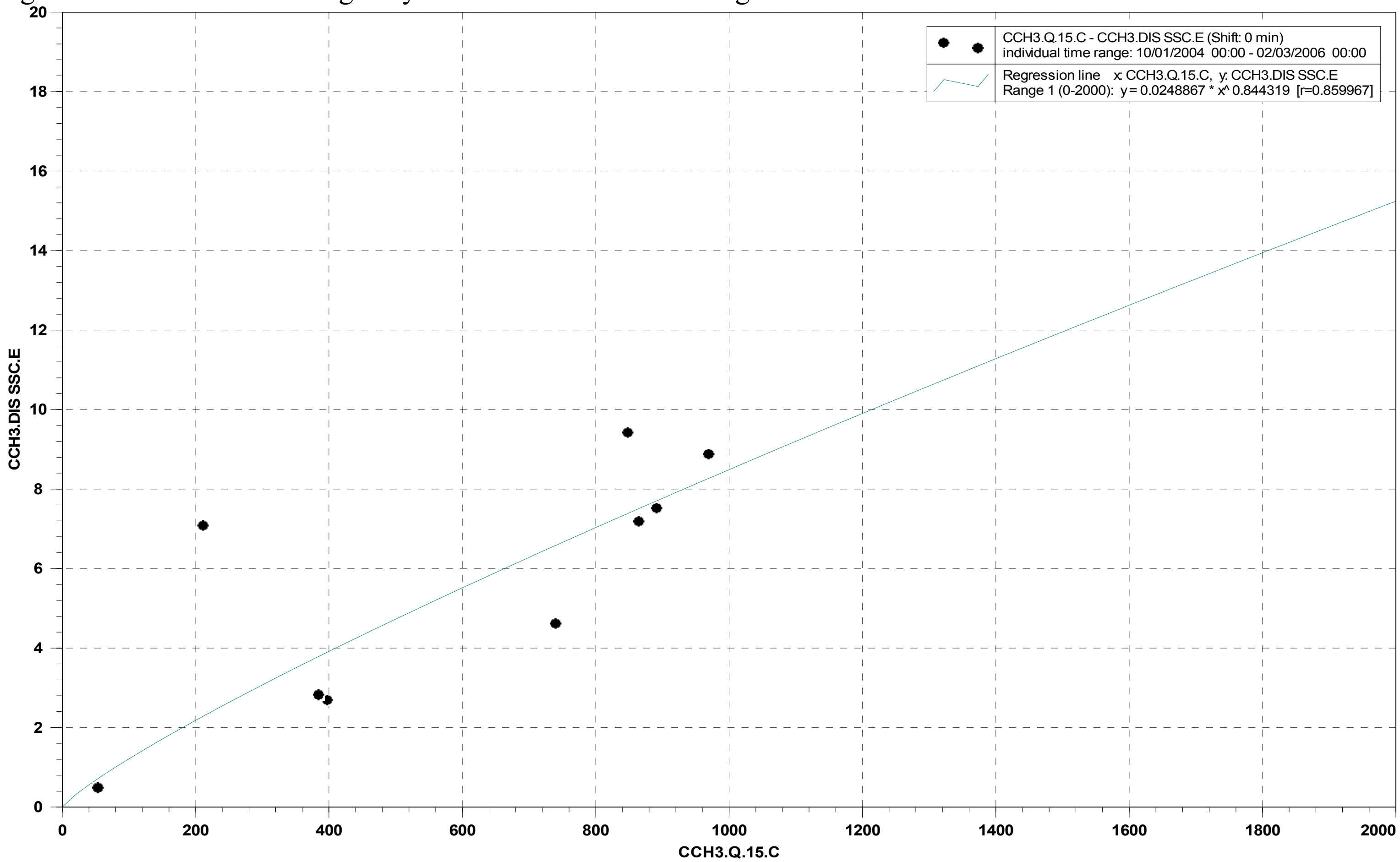


Figure 4. Coffee Creek at Highway 3 WY 2001 to 2005 suspended sediment discharge.

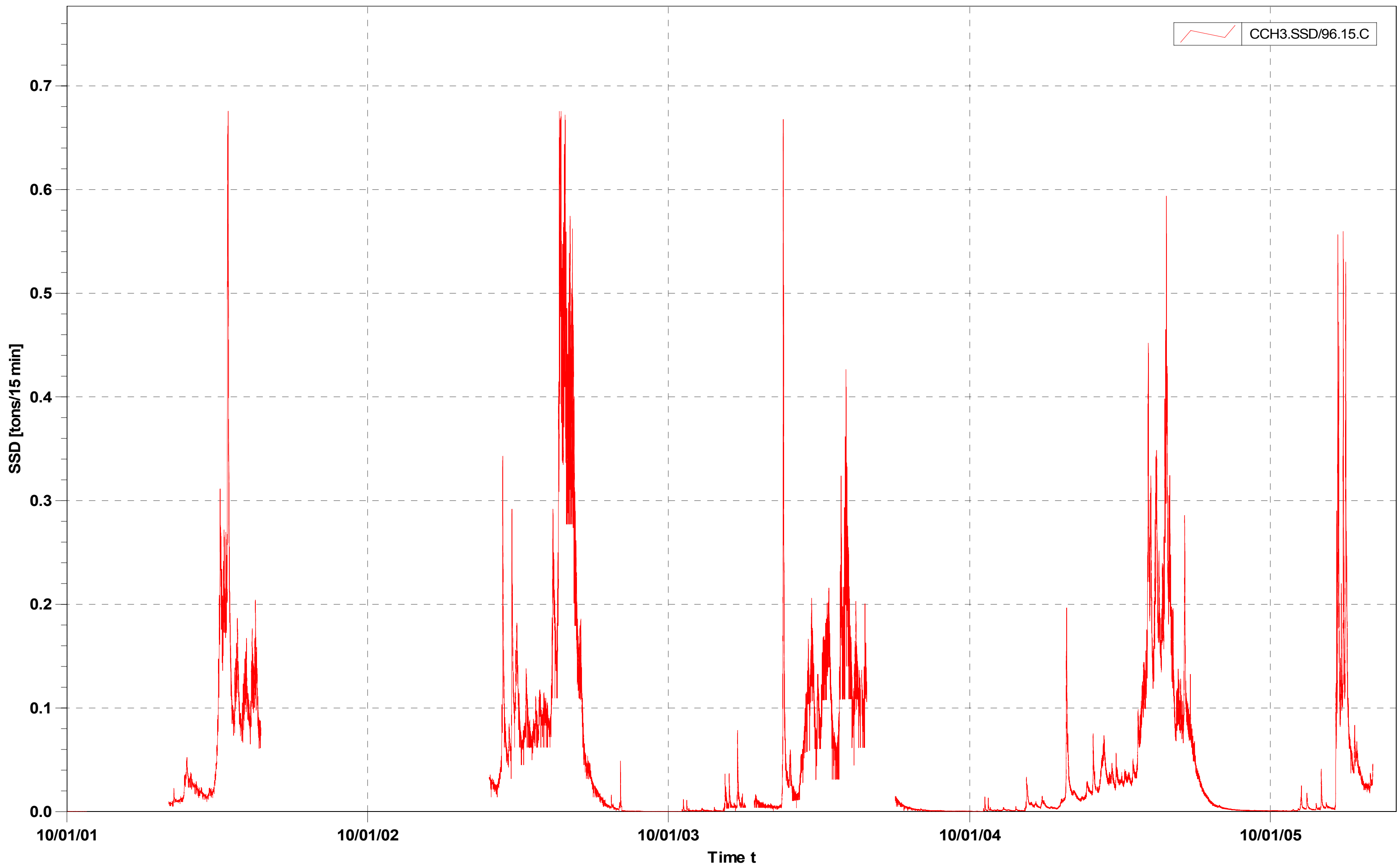


Table 4. Coffee Creek at Highway 3 discharge measurement summary.

DISCHARGE SUMMARY SHEET

LOCATION: Coffee Creek at Hwy 3 | **WATER YEAR:** 2000 - 2005

Measurement Number	WY Msmt #	Date	Made By:	Width (feet)	Mean Depth (feet)	Area (ft2)	Mean Velocity (ft/sec)	Gage Height (feet)	Discharge (cfs)	Rating 1.1 Shift Adj.	Percent Diff.	Method	No. of Msmt sections	Begin Time (hours)	End Time (hours)	Msmt Rating	PZF	Notes
1	**2000-01**	7/27/2000	C. Pryor	51.0	1.38	65.0	1.57	3.20	102		2	Wading	41	11:25	12:17	Fair		Some Poor Hydraulics
2	**2000-02**	8/10/2000	C. Pryor	47.4	1.21	56.7	1.23	3.09	69.7		-7	Wading	26	10:46	11:16	Poor		Poor Hydraulics
3	**2001-01**	3/8/2001	C. Pryor	50.0	1.64	81.9	2.25	3.49	184		2	Wading	35	14:24	15:07	Good		Mostly Good Hydraulics
4	**2001-02**	4/20/2001	S. Pittman	68.0	1.59	108.0	3.10	3.90	335		-1	Wading	26	10:50	11:41	Good		
5	**2001-03**	10/4/2001	C. Pryor	44.0	0.83	36.5	0.68	2.77	24.8		4	Wading	31	13:41	14:18	Poor		Large substrate compared to depth
6	**2002-01**	2/1/2002	K. Faucher	64.0	1.31	83.9	1.81	3.39	152		1	Wading	38	12:45	13:30	Good		
7	**2002-02**	3/28/2002	K. Faucher	71.0	1.44	102.0	2.51	3.70	256		0	Wading	36	14:15	15:27	Good		
8	**2003-01**	7/3/2003	L. Cornelius	66.5	1.97	131.0	2.18	3.56	285	0.19	4	Wading	40	12:53	13:32	Good		
9	**2003-02**	7/16/2003	L. Cornelius	50.0	2.20	110.0	1.47	3.25	162	0.19	-2	Wading	44	11:30	12:16	Fair		
10	**2003-03**	8/5/2003	L. Cornelius	63.5	1.48	93.9	1.33	3.08	125	0.19	7	Wading	31	15:33	16:02	Poor		
11	**2004-01**	1/13/2004	K. Grossman	55.0	2.35	129.0	1.39	3.31	179	0.19	-3	Wading	72	15:14	17:08	Fair		
12	**2005-01**	4/19/2005	L. Cornelius, JD	65.0	1.88	122.0	2.83	3.75	345	0.19	-3	Wading	42	13:35	14:15	Poor		
13	**2005-02**	9/14/2005	J. Hudman	46.0	0.91	42.00	1.31	2.65	55.2	0.33	1	Wading	31	12:58	13:29	Fair		

Table 5. Coffee Creek at Highway 3 streamflow rating table.

Graham Matthews & Associates

COFFEE CREEK AT HIGHWAY 3

RATING TABLE NO.1.1 ------ Begin Date 7/27/00

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1st Diff	2nd Diff
2.5	---	---	---	---	---	---	---	---	---	---	---	---
2.6	---	---	---	---	---	*12.0*	*12.9*	*13.7*	*14.6*	*15.5*	---	---
2.7	*16.5*	*17.4*	*18.4*	*19.5*	*20.5*	*21.6*	22.7	23.9	25.0	26.2	10.70	---
2.8	27.5	28.7	30.0	31.3	32.6	34.0	35.4	36.8	38.3	39.7	13.50	2.80
2.9	41.3	42.8	44.4	45.9	47.6	49.2	50.9	52.6	54.4	56.1	16.40	2.90
3.0	57.9	59.7	61.6	63.5	65.4	67.3	69.3	71.3	73.3	75.3	19.20	2.80
3.1	77.4	79.5	81.7	83.9	86.1	88.3	90.5	92.8	95.1	97.5	22.20	3.00
3.2	100	102	105	107	110	112	115	117	120	122	24.50	2.30
3.3	125	128	131	133	136	139	142	145	147	150	28.00	3.50
3.4	153	156	159	162	165	168	172	175	178	181	31.00	3.00
3.5	184	188	191	194	198	201	204	208	211	215	34.00	3.00
3.6	218	222	225	229	233	236	240	244	248	251	36.00	2.00
3.7	255	259	263	267	271	275	279	283	287	291	40.00	4.00
3.8	295	299	303	308	312	316	320	325	329	333	42.00	2.00
3.9	338	*342*	*347*	*351*	*356*	*360*	*365*	*369*	*374*	*379*	46.00	4.00
4.0	*383*	*388*	*393*	*398*	*402*	*407*	*412*	*417*	*422*	*427*	48.00	2.00
4.1	*432*	*437*	*442*	*447*	*452*	*457*	*463*	*468*	*473*	*478*	51.00	3.00
4.2	*484*	*489*	*494*	*500*	*505*	*510*	*516*	*521*	*527*	*532*	54.00	3.00
4.3	*538*	*544*	*549*	*555*	*561*	*566*	*572*	*578*	*584*	*590*	58.00	4.00
4.4	*595*	*601*	*607*	*613*	*619*	*625*	*631*	*637*	*644*	*650*	60.00	2.00
4.5	*656*	*662*	*668*	---	---	---	---	---	---	---	---	---
4.6	---	---	---	---	---	---	---	---	---	---	---	---
4.7	---	---	---	---	---	---	---	---	---	---	---	---
4.8	---	---	---	---	---	---	---	---	---	---	---	---
4.9	---	---	---	---	---	---	---	---	---	---	---	---

Values in italics are beyond the validated range of the rating

Figure 5. East Fork Trinity River at Trinity County Road 106 WY 2000 to 2005 hydrograph.

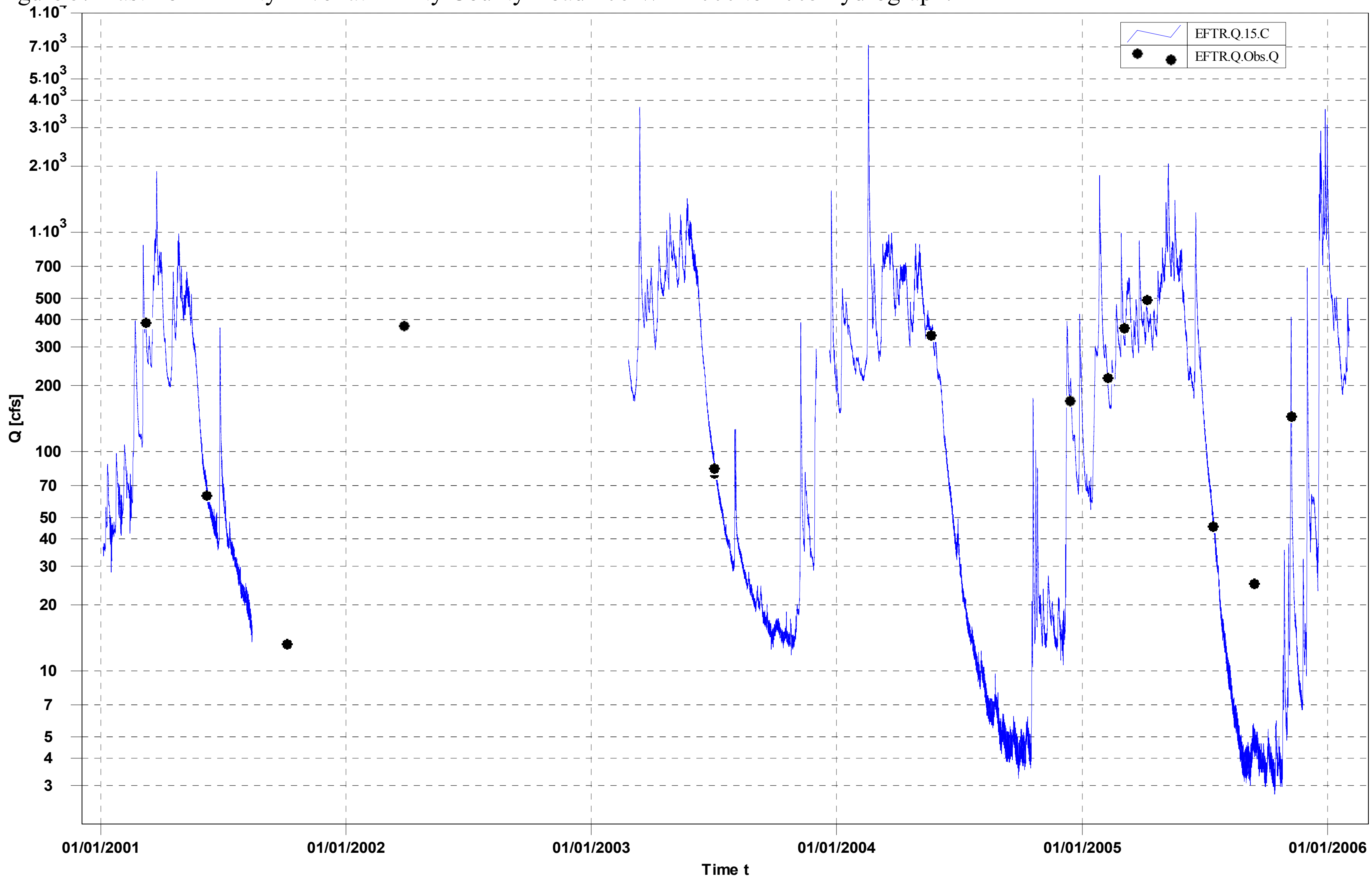


Figure 6. East Fork Trinity River at Trinity County Road 106 streamflow rating curve.

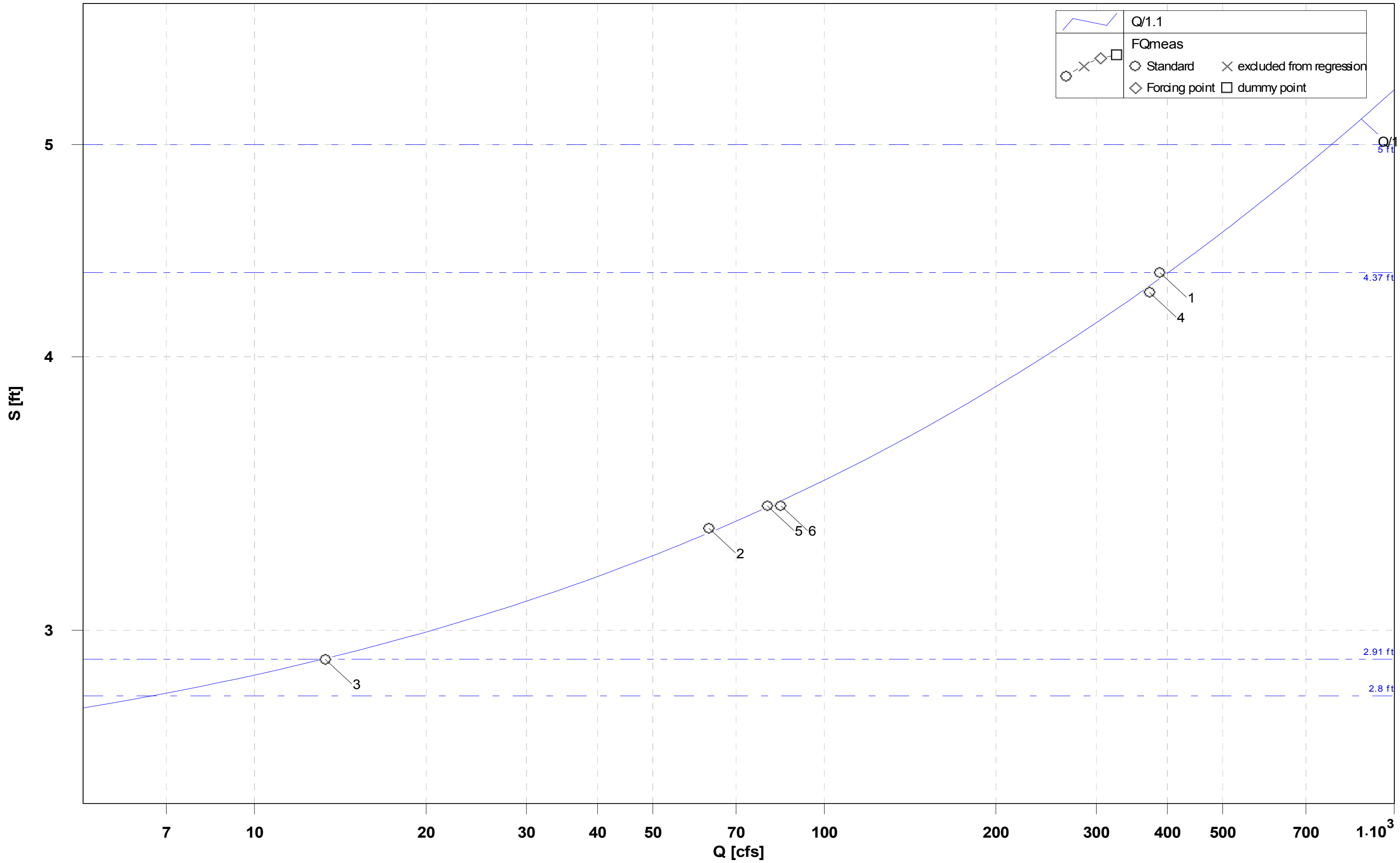


Figure 7. East Fork Trinity River at Trinity County Road 106 WY 2005 sediment rating curve.

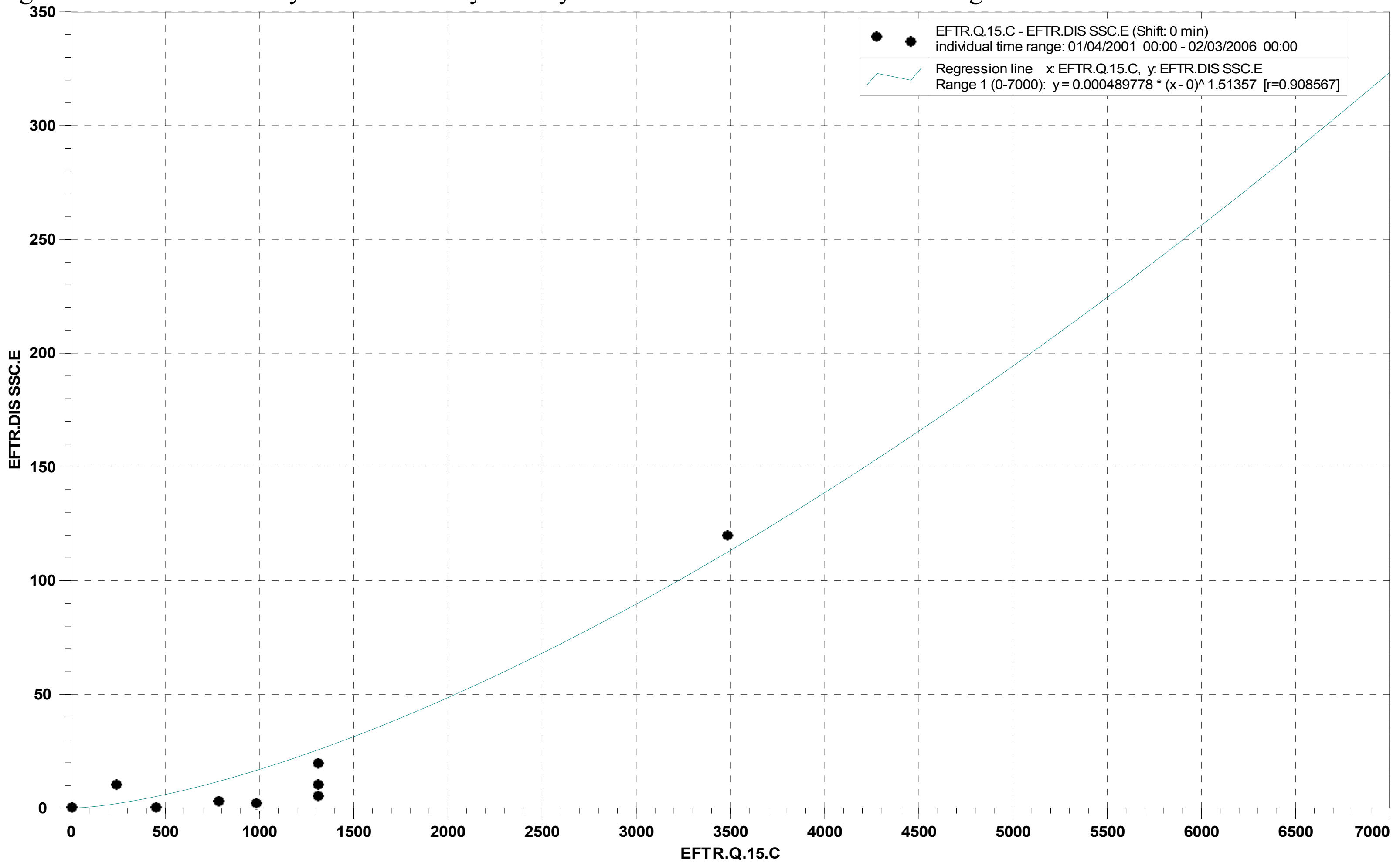


Figure 8. East Fork Trinity River at Trinity County Road 106 WY2000 to 2005 suspended sediment discharge.

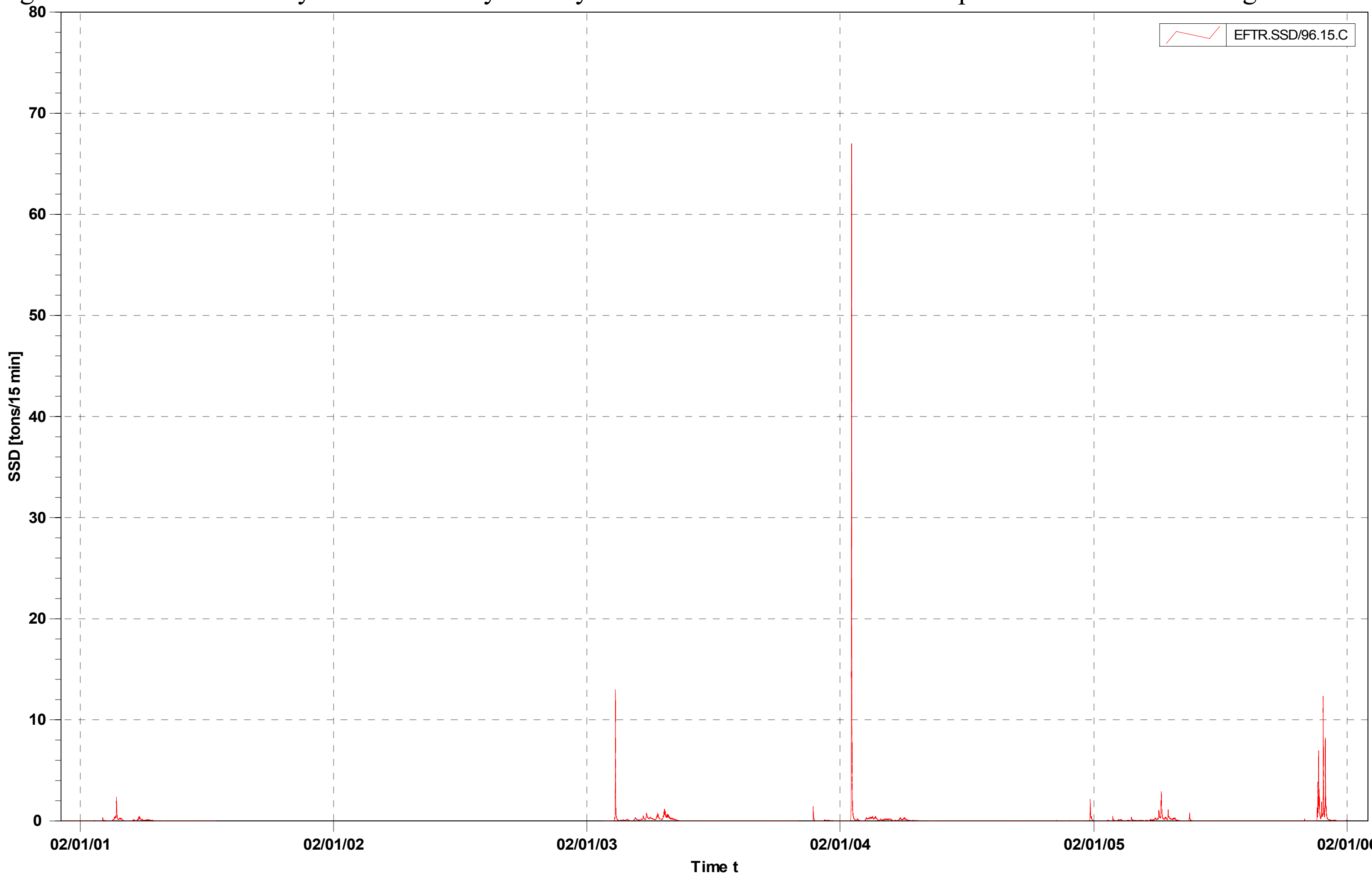


Table 6. East Fork Trinity River at Trinity County Road 106 discharge measurement summary.

Measurement Number	WY Msmt #	Date	Made By:	Width (feet)	Mean Depth (feet)	Area (ft2)	Mean Velocity (ft/sec)	Gage Height (feet)	Discharge (cfs)	Rating 1.1 Shift Adj.	Percent Diff.	Method	No. of Msmt sections	Begin Time (hours)	End Time (hours)	Msmt Rating	Recorder level	Notes
1	**2001-01**	3/8/2001	C. Pryor	90.0	2.63	237	1.64	4.37	388		-3	Wading	32	11:43	12:45	Good		
2	**2001-02**	6/8/2001	C. Pryor	86.7	1.65	143	0.44	3.34	62.7		-4	Wading	30	11:32	12:18	Good		
3	**2002-01**	10/4/2001	C. Pryor	83.5	1.21	101	0.13	2.91	13.3		2	Wading	27	15:07	15:52	Fair		Very low velocities
4	**2002-02**	3/28/2002	K. Faucher	94.0	2.39	225	1.65	4.28	372		4	wading	31	16:17	17:08	good		
5	**2003-02**	7/3/2003	L. Cornelius	84.5	1.76	149	0.53	3.42	79.4		-1	Wading	36	9:30	11:00	Fair		Very low velocities
6	**2003-01**	7/3/2003	L. Cornelius	53.5	1.39	74.8	1.12	3.42	83.9		4	Wading	34	11:30	12:05	Fair		1/4 mile upstream section
7	**2004-01**	5/21/2004	L. Cornelius	56.5	2.42	137	2.48	4.10	340	0.12	2	Wading	35	11:40	12:40	Good		1/4 mile upstream section
8	**2005-01**	12/13/2004	L. Cornelius	76.0	2.53	192	0.89	3.72	171	0.09	-4	Wading	28	11:20	12:00	Fair		
9	**2005-02**	2/8/2005	J. Hudman	84.2	2.09	176	1.23	3.76	217	0.10	11	Wading	34	14:26	15:43	Fair		
10	**2005-03**	3/4/2005	J. Hudman	85.1	2.43	207	1.76	4.17	365	0.12	1	Wading	38	13:25	14:16	Fair		
11	**2005-04**	4/7/2005	J. Hudman	68.0	2.29	156	3.14	4.34	490	0.13	8	Wading	41	11:57	12:53	Fair		
12	**2005-05**	7/15/2005	J. Hudman	85.0	1.35	115	0.39	3.17	45.4	0.06	-5	Wading	45	12:17	13:01	Fair		
13	**2005-06**	9/14/2005	J. Hudman	45.0	0.95	42.9	0.59	2.74	25.0	0.03	378	Wading	30	14:35	15:07	Good		
14	**2005-07**	11/8/2005	J. Hudman	84	1.73	145	0.99	3.55	144	0.07	15	Wading	40	12:16	12:58	Fair		

Table 7. East Fork Trinity River at Trinity County Road 106 streamflow rating table.

Graham Matthews & Associates

EAST FORK TRINITY RIVER

RATING TABLE NO.1.1 ------ Begin Date 1/4/2001

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1st Diff	2nd Diff
2.7	---	---	---	---	---	---	---	---	---	---	---	---
2.8	*6.60*	*7.10*	*7.61*	*8.15*	*8.70*	*9.28*	*9.88*	*10.5*	*11.1*	*11.8*	---	---
2.9	*12.4*	13.1	13.9	14.6	15.4	16.2	17.0	17.8	18.7	19.6	7.80	---
3.0	20.5	21.4	22.3	23.3	24.3	25.3	26.4	27.5	28.6	29.6	10.00	2.20
3.1	30.8	31.9	33.1	34.3	35.6	36.8	38.1	39.4	40.7	42.0	12.40	2.40
3.2	43.4	44.8	46.3	47.7	49.3	50.8	52.3	53.9	55.4	57.0	15.00	2.60
3.3	58.7	60.3	62.1	63.8	65.6	67.3	69.1	70.9	72.8	74.7	17.70	2.70
3.4	76.6	78.5	80.4	82.4	84.4	86.5	88.5	90.6	92.7	94.9	20.20	2.50
3.5	97.1	99.3	102	104	106	108	111	113	116	118	23.10	2.90
3.6	121	123	125	128	131	133	136	138	141	144	26.00	2.90
3.7	147	149	152	155	158	161	164	167	170	173	29.00	3.00
3.8	176	179	182	185	188	191	195	198	201	204	31.00	2.00
3.9	208	211	215	218	222	225	229	232	236	239	35.00	4.00
4.0	243	247	250	254	258	262	266	270	273	278	39.00	4.00
4.1	281	285	289	293	298	302	306	310	314	319	41.00	2.00
4.2	323	327	332	336	341	345	350	354	358	363	44.00	3.00
4.3	368	372	377	382	386	391	396	401	*406*	*411*	48.00	4.00
4.4	*416*	*421*	*426*	*431*	*436*	*441*	*446*	*452*	*457*	*462*	51.00	3.00
4.5	*467*	*473*	*478*	*483*	*489*	*494*	*500*	*505*	*511*	*517*	55.00	4.00
4.6	*522*	*528*	*533*	*539*	*545*	*550*	*556*	*562*	*568*	*574*	57.00	2.00
4.7	*580*	*586*	*592*	*598*	*604*	*610*	*616*	*623*	*629*	*635*	61.00	4.00
4.8	*642*	*648*	*655*	*661*	*668*	*674*	*681*	*687*	*694*	*700*	65.00	4.00
4.9	*707*	*714*	*721*	*727*	*734*	*741*	*748*	*755*	*762*	*769*	69.00	4.00
5.0	*776*	---	---	---	---	---	---	---	---	---	---	---
5.1	---	---	---	---	---	---	---	---	---	---	---	---

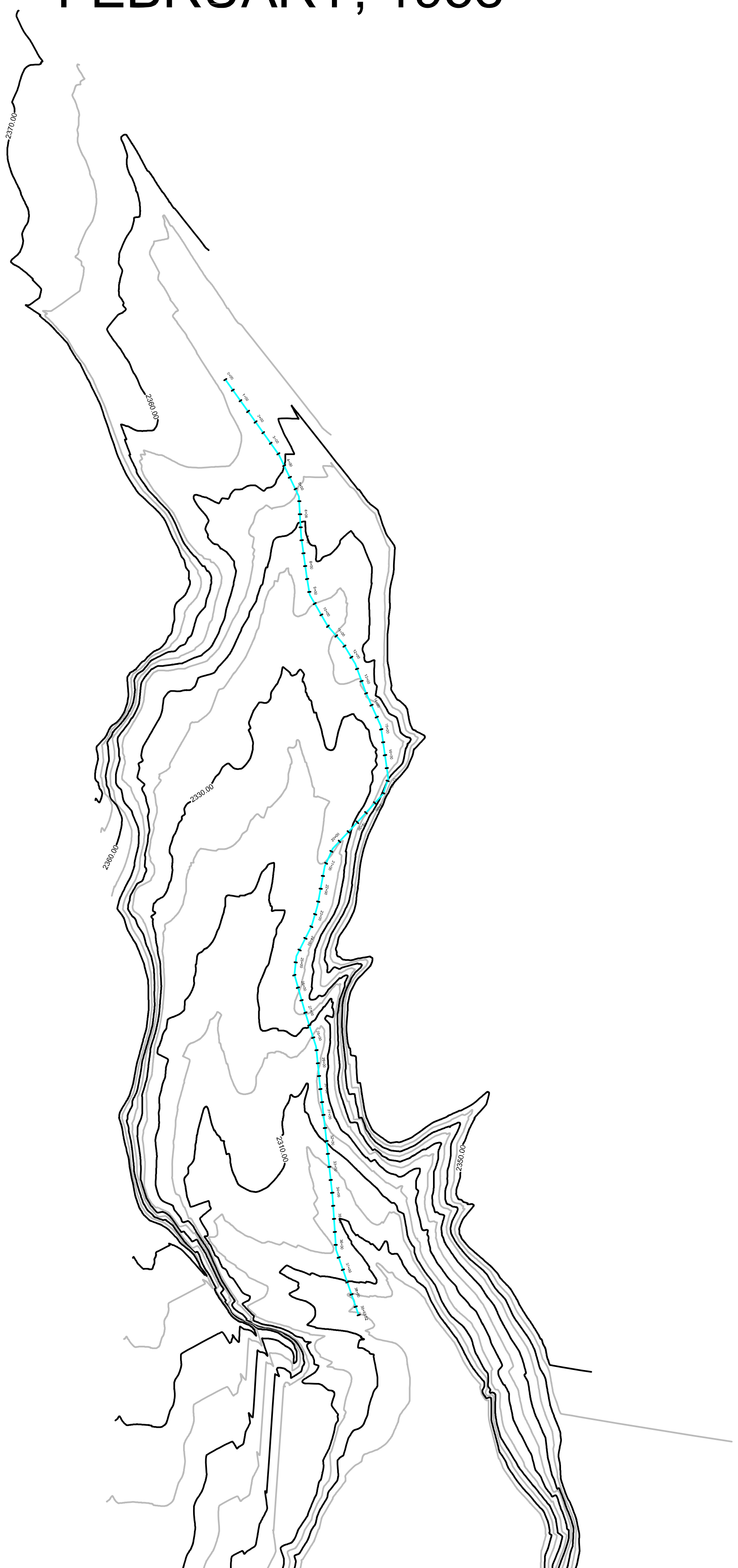
Values in italics are beyond the validated range of the rating

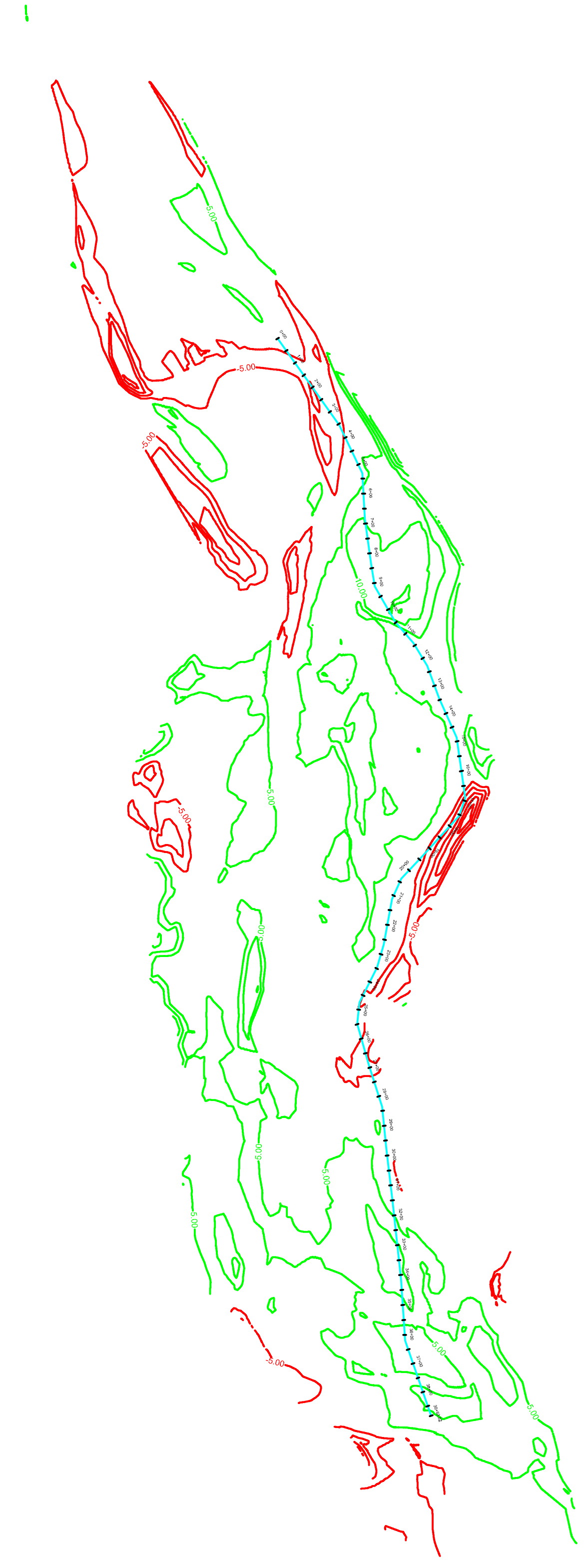
APPENDIX 3

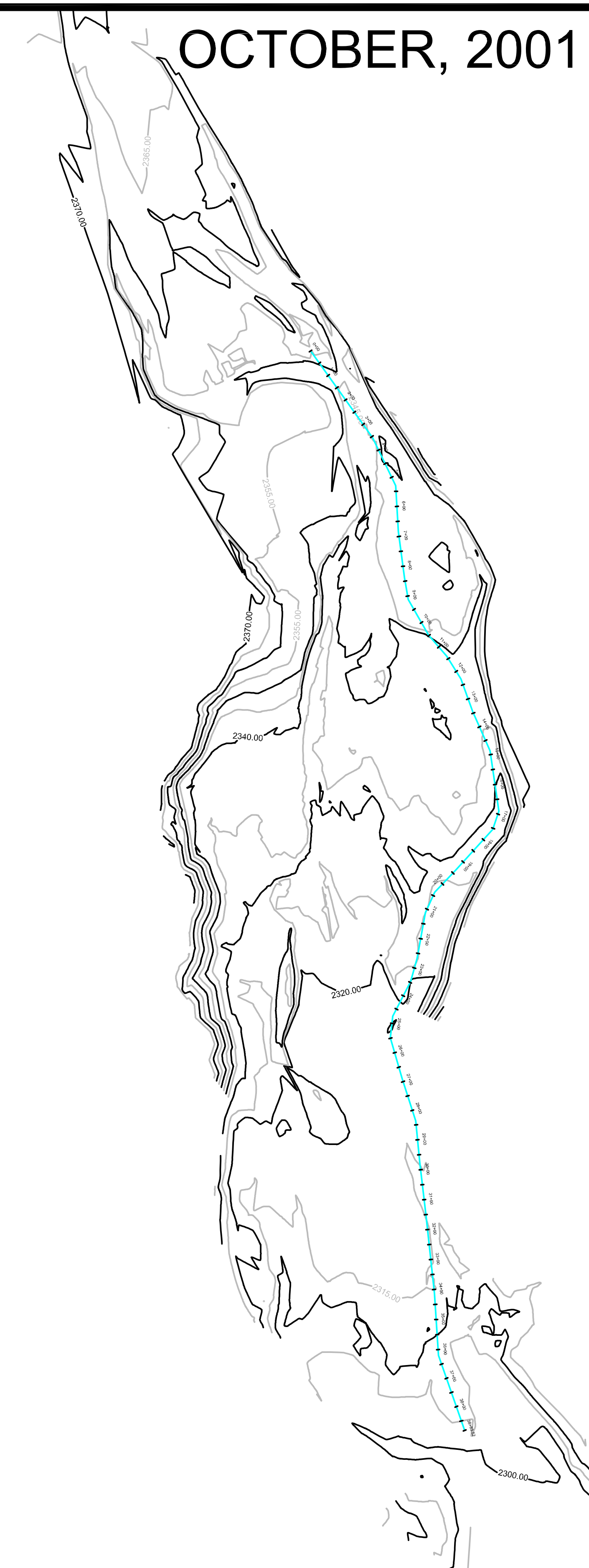
Upper Trinity River Watershed Delta Surveys

PLATE 1: Stuart Fork Delta: Comparison of 1958 and 2001 Surfaces
PLATE 2: Stuart Fork Delta: Cross Sections and Profiles
PLATE 3: Mule Creek Delta: Comparison of 1958 and 2005 Surfaces
PLATE 4: Mule Creek Delta: Cross Sections and Profiles
PLATE 5: East Fork Stuart Fork Delta: Comparison of 1958 and 2005 Surfaces
PLATE 6: East Fork Stuart Fork Delta: Cross Sections and Profiles

FEBRUARY, 1958	ISOPACH	OCTOBER, 2001







STUARTS FORK DELTA VOLUMES

212700 CY CUT   468600 CY FILL   255900 CY NET FILL

		DATE	REV. DATE	LEGEND	PREPARED FOR
PREPARED BY	BC	1/06		10' INDEX CONTOURS 5' INTERMEDIATE CONTOURS 5' FILL CONTOURS 5' CUT CONTOURS	
REVIEWED BY					

STUARTS FORK DELTA TOPOGRAPHY AND ISOPACH
FEBRUARY, 1958 AND OCTOBER, 2001
Trinity County, California

GMA
GRAHAM MATTHEWS & ASSOCIATES
Hydrology · Geomorphology · Stream Restoration
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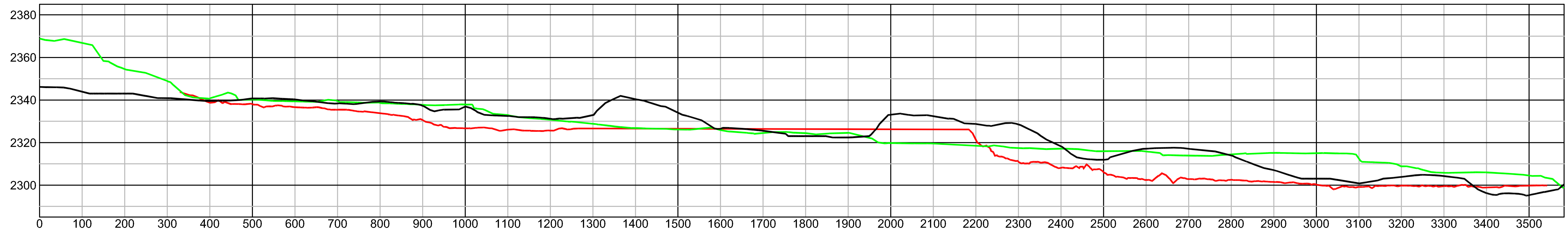
(530) 623-5327 ph (530) 623-5328 fax
graham@gmahydrology.com

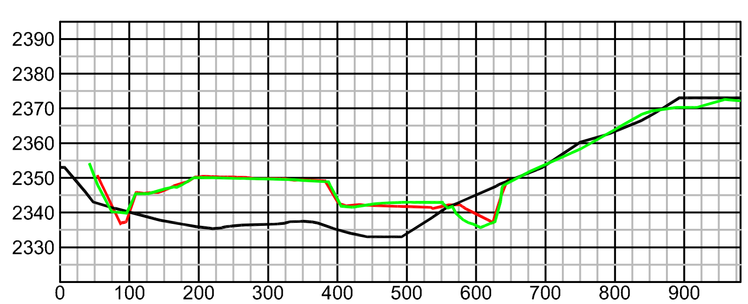
N

SCALE
0 250

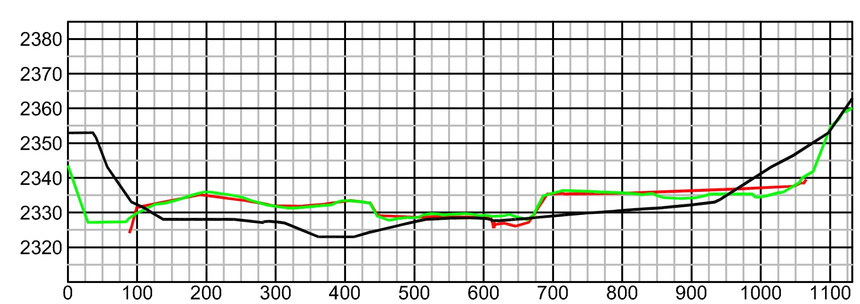
SHEET
1/3



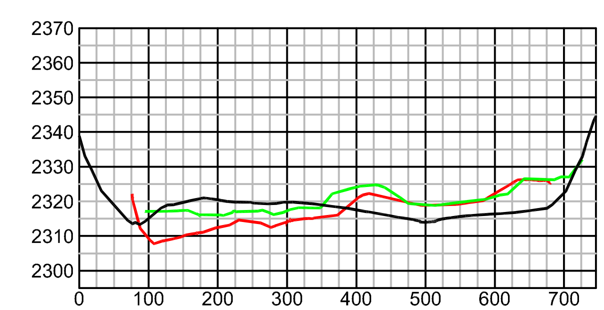
LONGITUDINAL PROFILE



CROSS SECTION A



CROSS SECTION B



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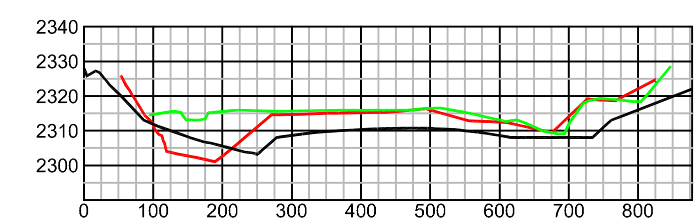

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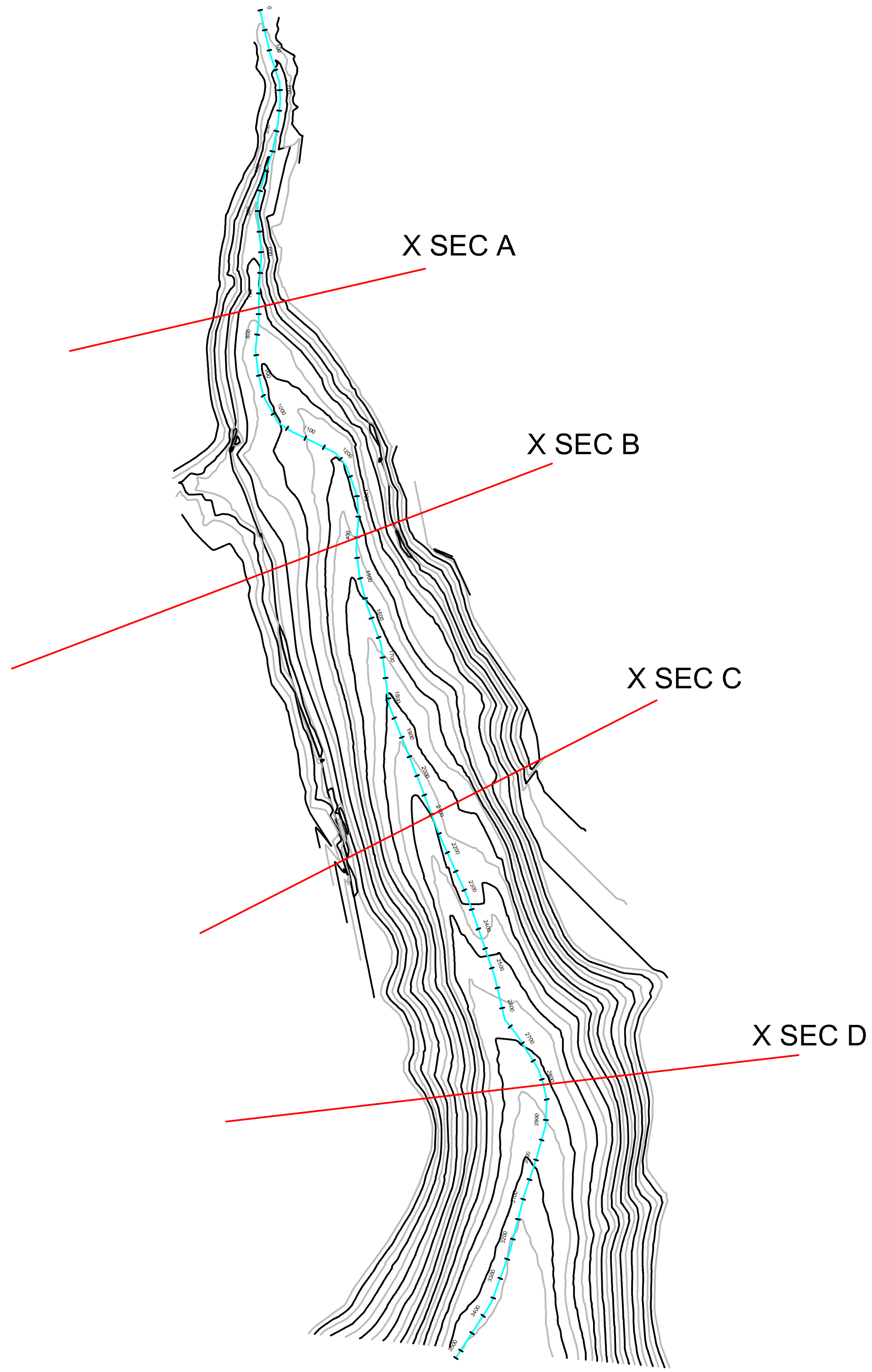
STUARTS FORK DELTA PROFILE AND CROSS SECTIONS
FEBRUARY 1958, OCTOBER 2001, AND NOVEMBER 2005
Trinity County, California

GMA
GRAHAM MATTHEWS & ASSOCIATES
Hydrology · Geomorphology · Stream Restoration
P.O. Box 1516 Weaverville, CA 96093-1516
(530) 623-5327 ph (530) 623-5328 fax
graham@gmahydrology.com

VERTICAL EXAGGERATION 5X

SHEET 1/

FEBRUARY, 1958



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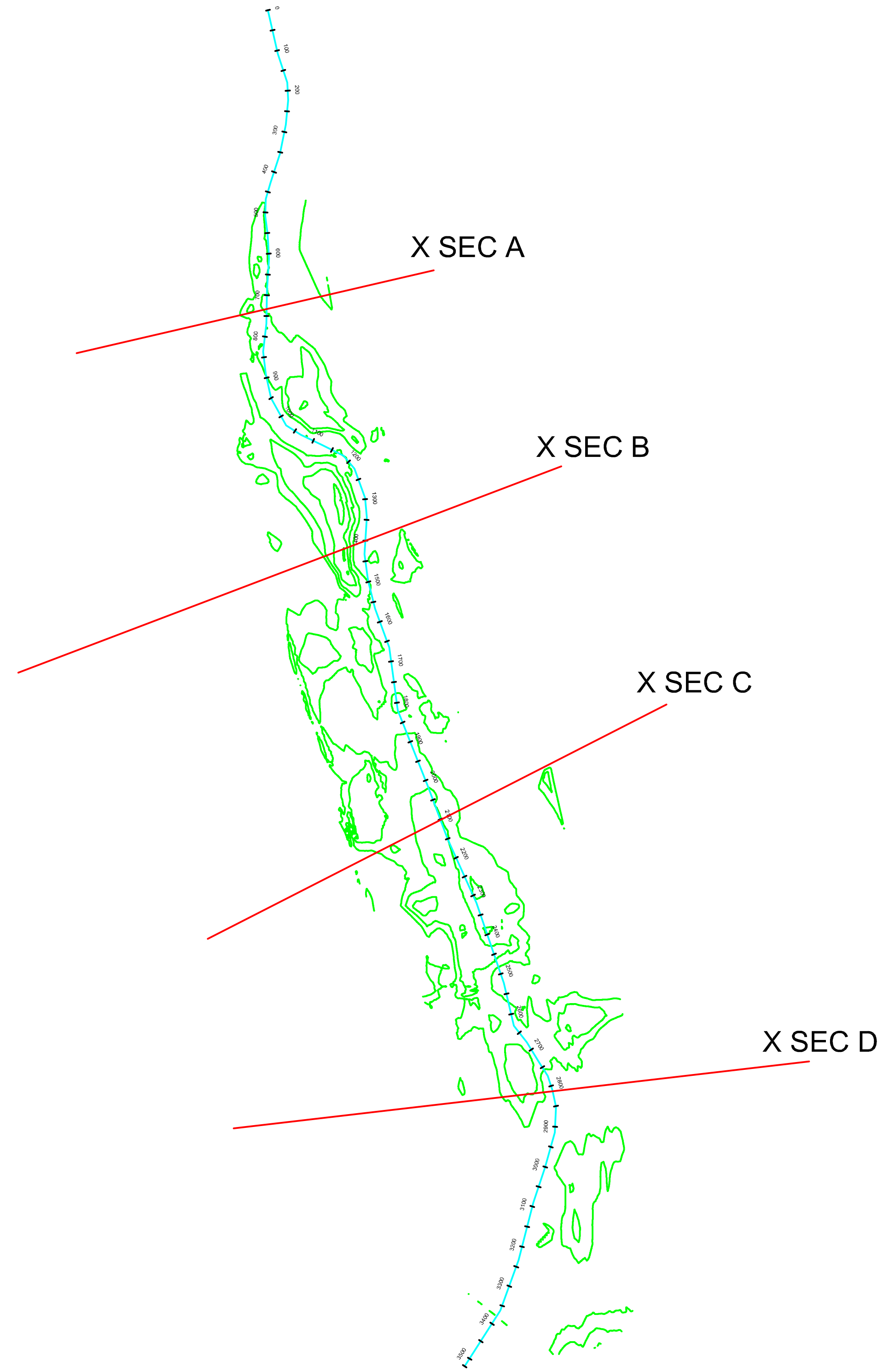
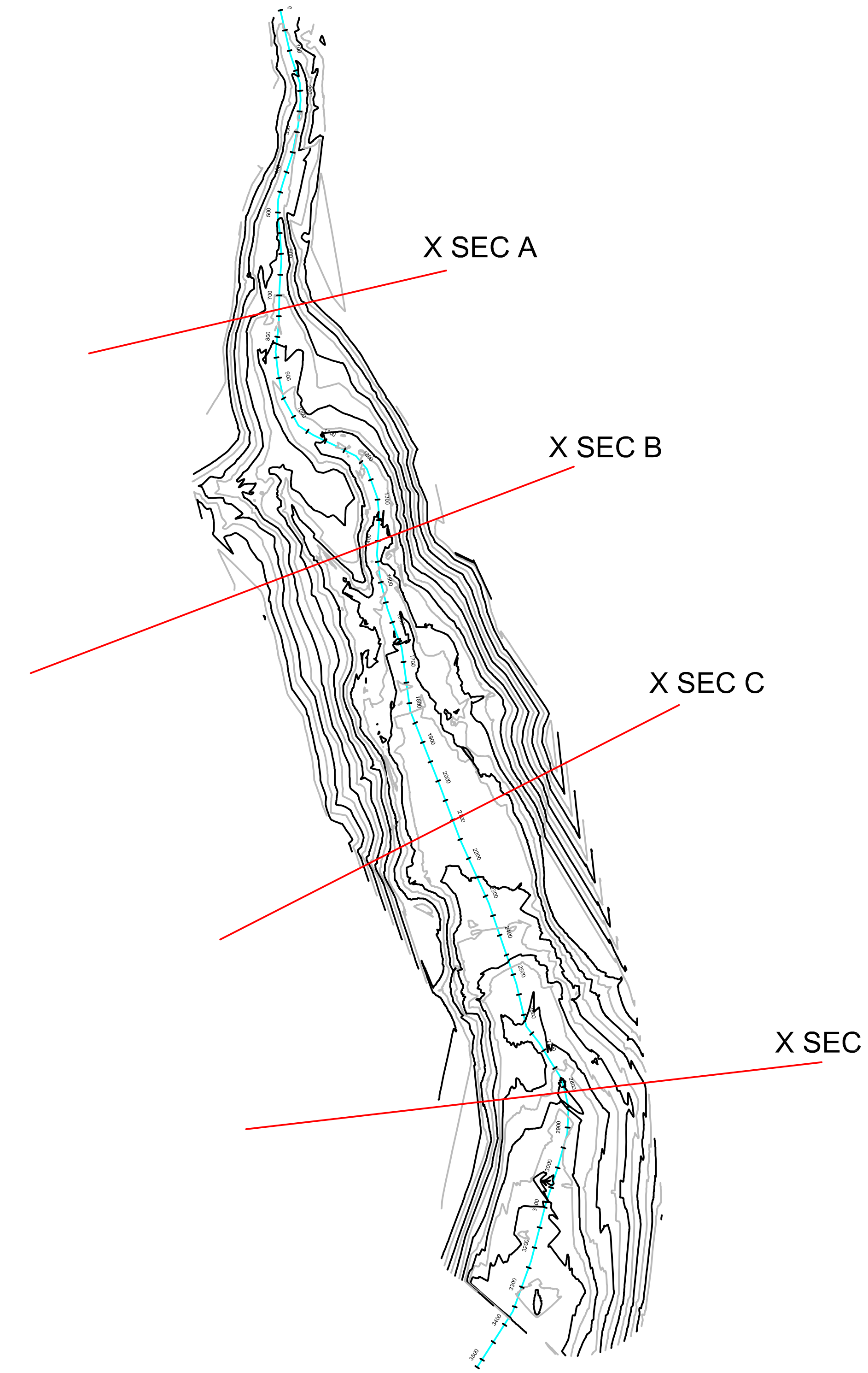


FEBRUARY & NOVEMBER, 2005



MULE CREEK DELTA VOLUMES

168500 CY FILL

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LEGEND
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- 5' INTERMEDIATE CONTOURS
- 5' FILL CONTOURS
- CROSS SECTIONS

PREPARED FOR

MULE CREEK DELTA TOPOGRAPHY AND ISOPACH
FEBRUARY, 1958 AND NOVEMBER, 2005
Trinity County, California

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graham@gmahydrology.com

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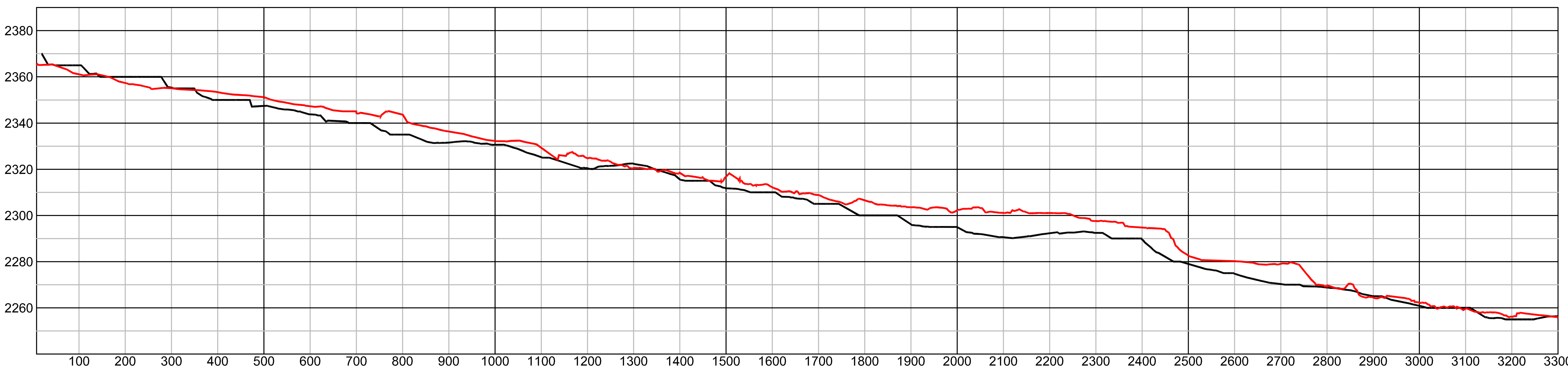

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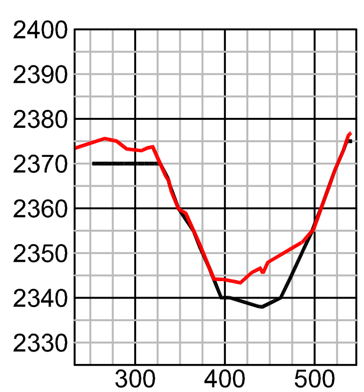

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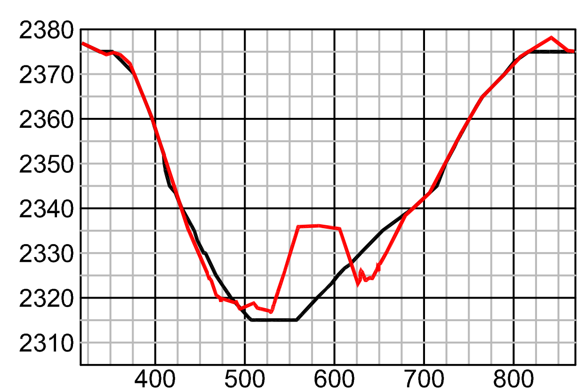

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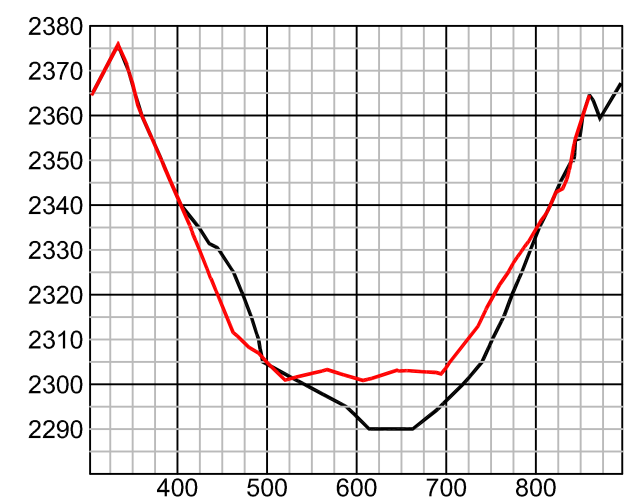

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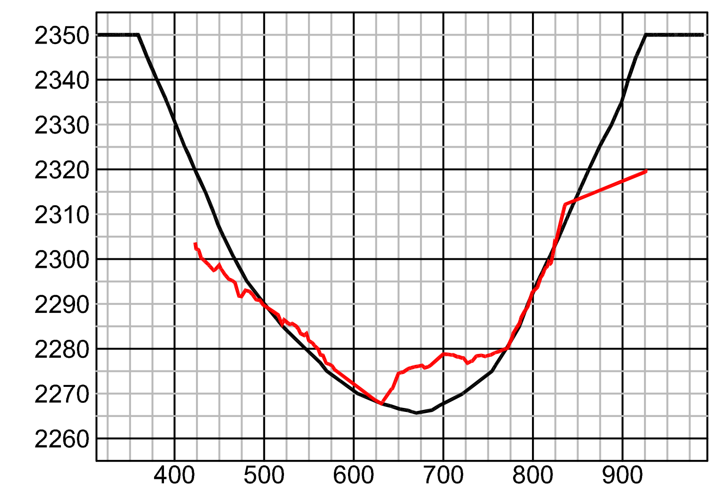

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REVIEWED BY					

MULE CREEK DELTA PROFILE AND CROSS SECTIONS
FEBRUARY 1958 AND NOVEMBER 2005
Trinity County, California

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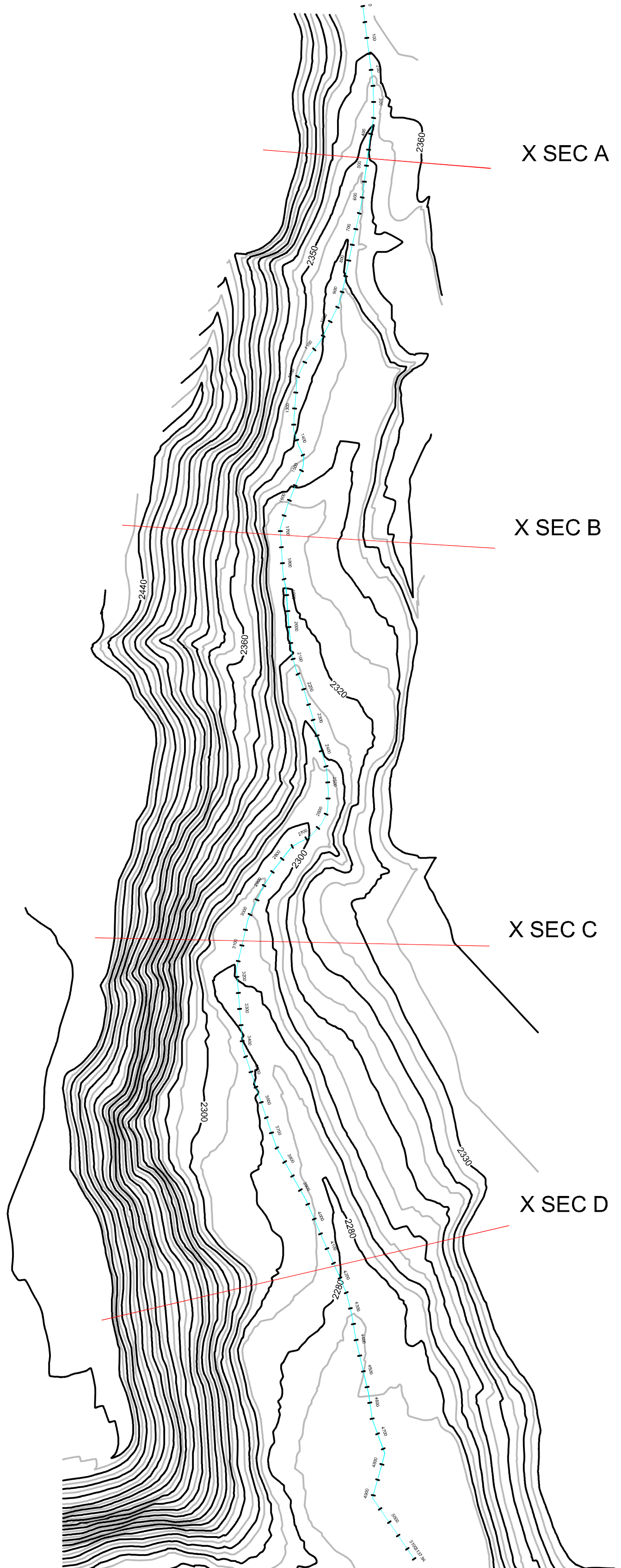
VERTICAL EXAGGERATION 5X

SHEET 1/

FEBRUARY, 1958



ISOPACH

EAST FORK STUART FORK DELTA VOLUMES

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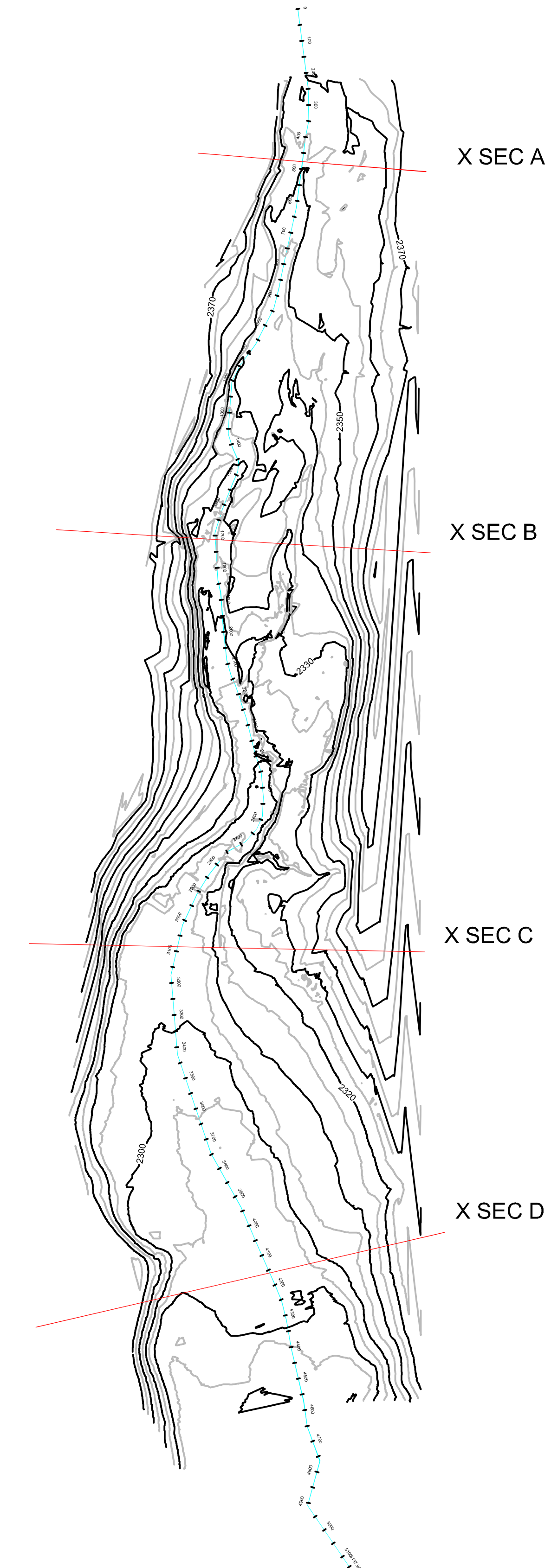
FEBRUARY & NOVEMBER, 2005



		DATE	REV. DATE
PREPARED BY	BC	1/06	
REVIEWED BY			

LEGEND

- 10' INDEX CONTOURS
- 5' INTERMEDIATE CONTOURS
- 5' FILL CONTOURS
- 5' CUT CONTOURS
- THALWEG
- CROSS SECTIONS

PREPARED FOR

EAST FORK STUART FORK DELTA TOPOGRAPHY AND ISOPACH
FEBRUARY, 1958 AND NOVEMBER, 2005
Trinity County, California

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graham@gmahydrology.com

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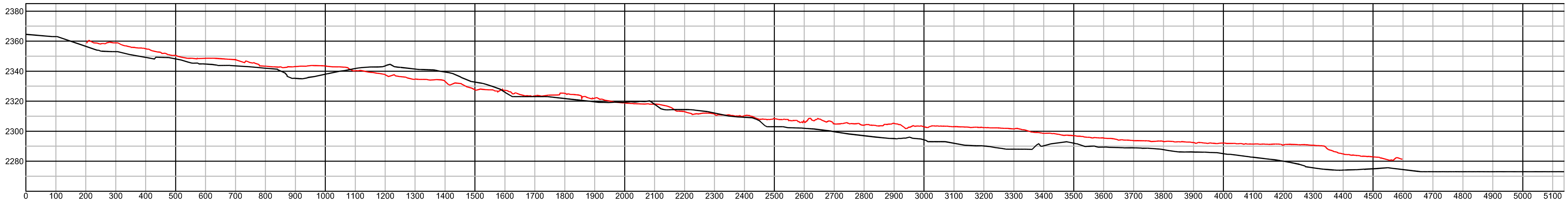
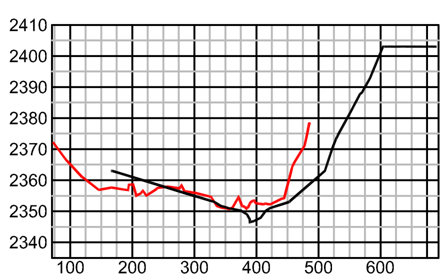


LONGITUDINAL PROFILE



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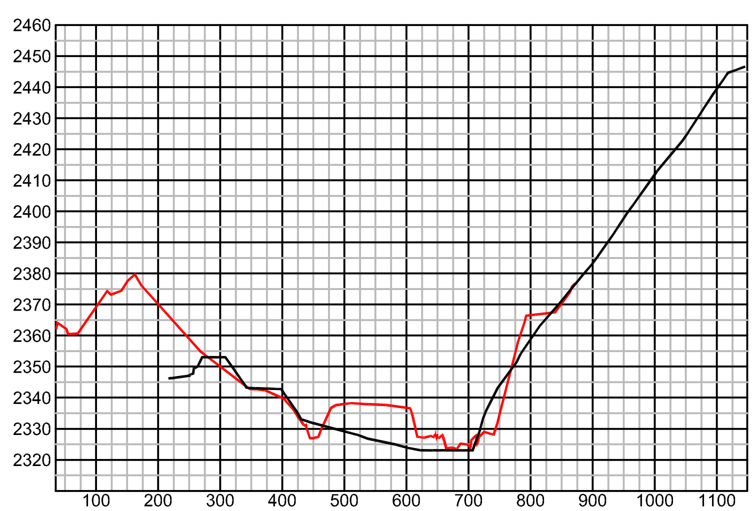

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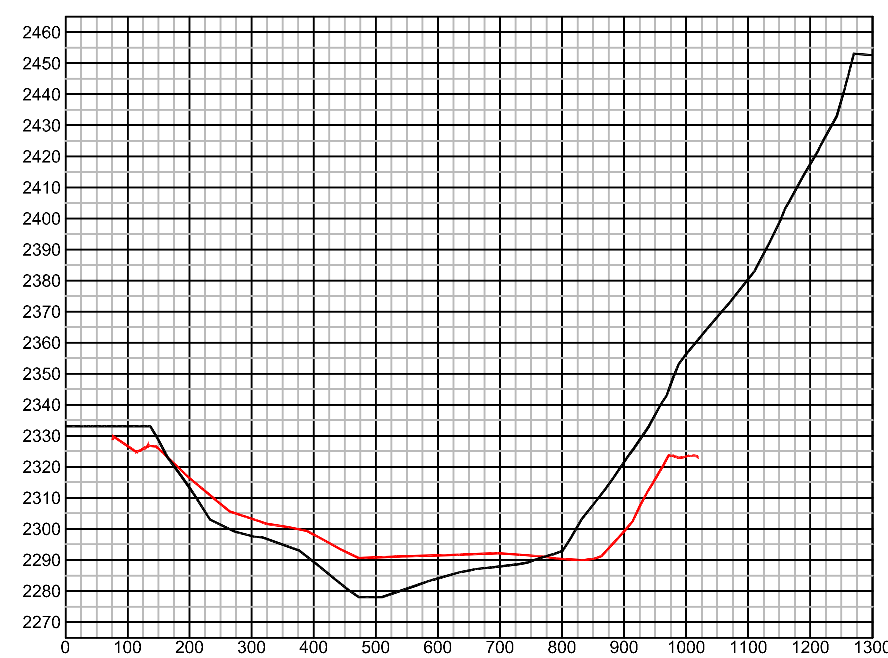

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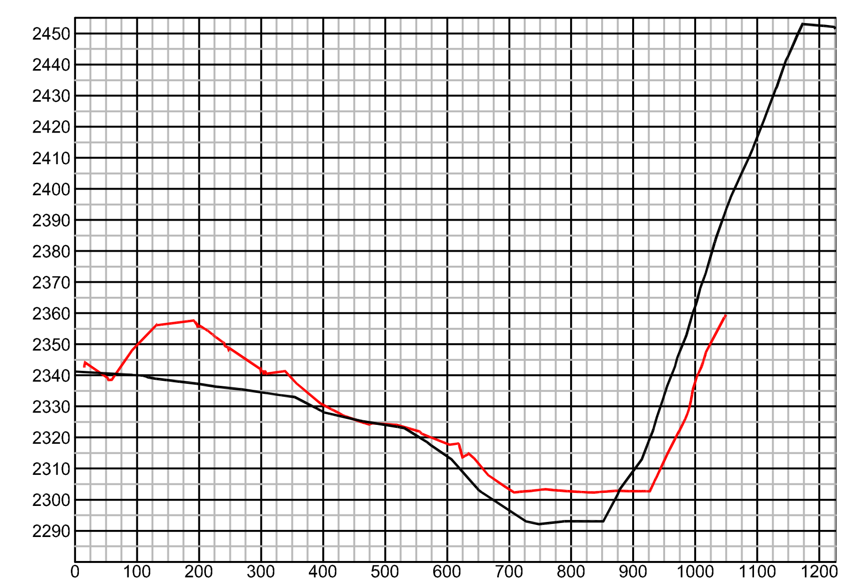

CROSS SECTION D

PREPARED BY	BC	DATE 1/06	REV. DATE	PREPARED FOR
REVIEWED BY				

LEGEND

- 2005 SURFACE CROSS SECTIONS
- 1958 SURFACE CROSS SECTIONS
- 2005 LONGITUDINAL PROFILE
- 1958 LONGITUDINAL PROFILE

EAST FORK OF STUARTS FORK PROFILE AND CROSS SECTIONS
FEBRUARY 1958 AND NOVEMBER 2005
Trinity County, California

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VERTICAL EXAGGERATION 5X

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APPENDIX 4

Upper Trinity River Watershed Assessment

Landslide Inventory Report prepared by McBain & Trush

A Landslide Inventory for the Upper Trinity River Watershed

Summary of Identification Methods and Results

Prepared for:

Graham Matthews and Associates

Prepared by:

McBain and Trush, Inc.
980 7th Street
Arcata, CA 95521

October 18, 2005

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FIGURES

TABLES

APPENDICES

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1 INTRODUCTION

1.1 Purpose and Scope of Work

The Upper Trinity River landslide inventory was performed in two phases. The first phase identified and inventoried landslides discernable on 2003 aerial photographs. The second phase consisted of field-verifying approximately 15 percent of the mapped landslides to validate the aerial photograph interpretation and to estimate slide thickness, which will be used by Graham Matthews and Associates (GMA) for future estimates of sediment yield. Additional tasks performed for this investigation included delivering the landslide inventory maps and electronic database to the Trinity County Resource Conservation District (TCRCD), and preparing this report. The purpose of this report is to summarize landslide identification methods, present results, and provide a brief discussion.

1.2 Location

Landslide mapping was performed within the upper Trinity River watershed, defined herein as the portion of the watershed above Trinity Lake Dam (Figure 1). This drainage area encompasses approximately 692 square miles.

1.3 Previous investigations

Prior to this investigation, landslide mapping within the upper Trinity River watershed was performed by the California Department of Water Resources (CDWR) as part of a 1980 erosion inventory (CDWR 1980), and then by GMA in 2001 as part of a sediment source analysis in support of the Total Maximum Daily Load (TMDL) established by the United States Environmental Protection Agency (USEPA 2001). The portions of the upper Trinity River watershed mapped for the 2001 TMDL study were located in the southwestern and northern portion of the watershed (shown as shaded areas on Figure 1), and were not re-mapped as part of this investigation.

2 INVESTIGATION METHODS

2.1 Aerial photograph investigation

Landslides were identified from stereographic pairs of color aerial photographs. The aerial photographs were taken in 2003 and are a scale of approximately 1:18,000 (1 inch equals 1,500 feet). A mirror stereoscope was used to identify slides on the photographs. After a slide was identified on a photograph, its location was found on the corresponding USGS 7.5-minute topographic map (1:24,000, or 1 inch equals 2,000 ft). The slide was then measured (length and width), scaled from 1:18,000 to 1:24,000 (a 25 percent size reduction), and its outline was then hand-drawn on an acetate sheet overlaid on the topographic map. After being mapped on the acetate overlay, the slide was measured a second time to check the scaling. The landslide was then numbered and classified based on attributes visible on the photograph.

Landslide classification followed Crudden and Varnes (1996) (Table 1), which describes the material type, movement type, and activity level. In addition to these parameters, additional information was recorded including:

- Aerial photograph number and flight line: Over 500 aerial photographs within 21 flight lines covered the watershed area mapped for this investigation. The flight line and aerial photograph that best illustrates each mapped landslide was recorded.
- USGS topographic quadrangle map: The mapping area covered 22 7.5-minute topographic maps. Landslide mapping was performed by quad sheet, and the quad sheet fro each landslide was recorded.
- Certainty of identification was recorded as Definite, Probable, or Questionable. A Definite classification was assigned to landslides that displayed distinct features on the aerial photograph, such as well-defined scarps and flanks. Probable landslides exhibited defined scarps and flanks, however these features are either more subtle (e.g., rounded scarps) or the feature may be obscured in the photograph due to vegetation or shadows. Questionable landslides exhibited enough geomorphic expression suggestive of landsliding, but the photograph shows insufficient evidence to increase the certainty level to Probable.
- Landslide activity level also followed the criteria defined by Crudden and Varnes (1996). Landslides were classified as Active, Inactive Dormant, or Inactive Relict. Active landslides are those that are inferred as currently moving (either as a whole or smaller portions nested within the larger landslide body), or have moved within the last annual cycle of seasons (e.g., within the last year from when the photograph was taken). Inactive landslides are those that have last moved more than one annual cycle of seasons ago, and for this investigation were subdivided into Inactive Dormant and Inactive Relict classes. Inactive Dormant landslides are those where the causes of movement remain apparent, but movement may have occurred as recent as just prior to the last annual cycle of seasons, or as long as several hundred years ago. Inactive Relict landslides are those interpreted to have clearly developed under different climatic or geomorphic conditions. Crudden and Varnes (1996) offer further subdivisions of activity level; however, this additional detail could generally not be determined from the aerial photographs.
- Sediment delivery to a watercourse and percent delivered: If a landslide appeared to deliver sediment to a watercourse, the percentage of sediment delivered was estimated as one of three volume classifications (0% – 33%, 34% – 66%, or 67% – 100%). If a landslide's activity level was classified as Inactive Relict, no estimate of whether sediment was delivered to a watercourse (or how much) was made because it is assumed that these landslides occurred under different climatic or geomorphic conditions, and are not presently generating sediment by landsliding.
- Whether the slide or slide area exhibited inner gorge morphology: An inner gorge is a geomorphic feature formed by coalescing scars originating from landsliding and erosional processes caused by stream erosion, typically having side slopes greater than 65 percent (CDMG 1999). The primary criterion used to identify inner gorge morphology on the aerial photographs was coalescing scars or channels within a larger slide body. However, some landslides that had only single channels were also considered to have inner gorge morphology based on extremely steep slopes adjacent to the stream channel.
- Land use activity in the immediate vicinity of where the slide occurred: Land use activity interpreted from the aerial photographs fell into one of two general categories: natural, or roads + timber harvest. The vast majority of mapped landslides falls into one of these two

categories; however, other land use types were identified when apparent on the aerial photographs, including: roads or timber harvest (when either could be separated based on obvious expression), mining, or quarrying. These classifications are not an attempt to identify causes of landslides; rather, they simply attempt to identify the contemporary or recent historic land use in the immediate vicinity.

It is important to note that the precision to which any of the above attributes can be classified is limited to the method being used, i.e., basing an interpretation from a 1 inch = 1,500 ft scale aerial photograph. Additional limitations and challenges to the aerial photograph mapping in this study area include (but are not limited to): the minimum size of visible landslides (typically, slides with a length or width less than 120 ft – approximately 2 mm on the aerial photographs – were not mapped due to their difficulty to be seen); identifying landslides in forested areas (difficulty or impossibility of identifying landslides obscured by tree canopy cover); and identifying landslides in logged areas (e.g., uneven-age timber stands, dense road networks, and logging operations impacts to land surface such as skidding and yarding). An additional limitation to the mapping can be attributed to the width of the pen used to plot the landslides on the acetate overlay, which was approximately 60 ft at map scale; however, this error is likely offset by the accuracy to which the landslide was hand-drawn onto the overlay.

Movement Type	***Material Type***		
	Bedrock	*Predominantly coarse soils*	*Predominantly fine soils*
Fall	Rock fall	Debris fall	Earth fall
Topple	Rock topple	Debris topple	Earth topple
Slide	Rock side	Debris slide	Earth slide
Spread	Rock spread	Debris spread	Earth spread
Flow	Rock flow	Debris flow	Earth flow

Table 1. Abbreviated classification of slope movements, from Crudden and Varnes (1996). Landslide material types identified in the mapping area were interpreted as either bedrock or as predominantly coarse soils (Rock and Debris, no Earth). Landslide movement types interpreted from the photographs included Falls, Slides, and Flows; Falls and Topples are similar movement mechanisms and could not be distinguished on the aerial photographs, and only Fall was used for this inventory. No Spreads were interpreted in the mapping area. In addition, movement types were combined where a landslide appeared to exhibit a transition from one movement type to another. For example, a Rock Fall that transitions to a Rock Slide was recorded as Rock Fall + Slide.

2.2 Field verification

Following the aerial photograph investigation, 52 landslides (approximately 15 percent of the total number of landslides mapped) were visited in the field for mapping verification. Objectives of the field verification were to drive and/or hike to a landslide location, review the attributes identified from the aerial photographs, make any necessary corrections, and estimate landslide thickness. Landslides selected for field verification were based on their distribution throughout the watershed, proximity to mapped roads, and on landslide type in an attempt to field-verify a representative number from the total landslide population mapped. In addition to the landslides pre-selected for field verification, additional landslides that could not be directly visited but could be observed from clear vantage points were also inventoried (via naked eye and with binoculars).

Following verification of the mapped landslide attributes, landslide thickness was estimated for future sediment volume estimates. Landslide thickness was visually estimated for all slides that were visited using relative indices (e.g., estimated tree height or boulder diameter) and slide scar morphology to estimate an average thickness for the mapped slide area. Because these estimates were largely qualitative, thickness estimates were made using 2.5 ft intervals to 5 ft, and then 5 ft intervals there on. Average landslide thicknesses were commonly recorded as a range, such as 5-10 ft.

3 <u>RESULTS AND DISCUSSION</u>

3.1 Aerial photograph interpretation vs. field verification

Initially, 343 landslides were identified from the aerial photographs. Of these 343 total landslides inventoried, 43 were selected for field verification. During the field verification:

- Nine "new" landslides were discovered during the field verification. These slides were not identified during the aerial photograph mapping but were plotted on the acetate overlays in the field and added to the overall inventory. For tracking purposes, new landslides identified in the field were labeled alphabetically rather than numerically. These new slides increased the number of verified slides to 52 and the overall number of identified landslides within the watershed mapping area to 352.
- Seven landslides identified from the aerial photographs were determined not to be landslides; rather, they were discovered to be disturbed areas (e.g., by mining or timber harvesting) or areas with enough suggestive geomorphology to be considered landslides on the aerial photographs, but having insufficient evidence in the field to infer actual landsliding. Removing these landslides from the inventory reduced the overall final number of identified landslides within the watershed mapping area to 345.

In total, 345 landslides were identified in the upper Trinity River watershed mapping area. A summary of the number and type of landslides identified for this investigation is presented in Table 2, and a complete landslide inventory is presented in Appendix A.

Field verification proved to be very important by illustrating the limitations of interpretation solely from the aerial photographs. In addition to identifying new slides and rejecting others, field verification commonly changed one or more of the attributes assigned from the aerial photograph interpretation inventory. Of the 52 field-verified landslides, only 15 had their initial classification unchanged; the remaining 37 had at least one change made. Complete results of the field verification compared with the initial aerial photograph interpretation are presented in Appendix B, and are summarized in Table 3.

The significance of changes in landslide classification resulting from the field verification is broad, particularly with respect to sediment production and sediment yield; for example, changes in interpreted land use activity may have little bearing on the sediment yield by a landslide, whereas other changes such as material type or activity state may be quite significant. Moreover, multiple changes can have an additive effect. Interpreting the effects of these changes, or interpreting how these changes impact extrapolation to the entire watershed, is beyond the scope of this report.

3.2 Landslide thickness estimates

When it could be reasonably estimated from the field vantage point, landslide thickness was noted for the majority of field-verified landslides. No clear relationship or trend is present based on landslide type or attributes and estimated slide thickness. For example, thickness estimates were made for 21 debris slides. Of these 21, three were recorded as having an estimated average thickness of 2.5 ft, eight were estimated at 5 ft, four were estimated at 5-10 ft (average 7.5 ft), four were estimated at 10 ft, one was estimated at 15 ft, and one was estimated at 15-20 ft (average = 17.5 ft). Attempts at defining trends based on stratifying the landslides by attributes were not made.

Thickness estimates are necessary if yield estimates will be made for the identified landslides. Because no clear trend was established from the field observations, landslide thickness could be estimated from the data collected during this investigation, at minimum, by weighted average. Using the recorded debris slide depth estimates, the weighted average debris slide thickness is 7.1 feet. However, other data and research should be considered, including estimates made by GMA for the 2001 TMDL, estimates made by CDWR for the 1980 erosion study (if available), or other available regional data.

Thickness estimates were recorded as an average for the entire slide and therefore volume estimates should be made by applying the thickness estimate to the entire mapped slide area. This criterion is true for all slide types except for those classified as a *rock fall* or *rock fall + slide*. Field observation of these landslide types showed a significant portion of the mapped slide area was exposed bedrock, and it is assumed that only 50 percent of the slide area has fallen, slid, or otherwise been associated with downslope movement.

Finally, sediment yield estimates should not be made for landslides with an *inactive relict* activity state, because it is assumed that these landslides occurred under different geomorphic and/or climatic conditions, and therefore have no sediment yield to the contemporary sediment budget.

Landslide type	*Number identified in watershed mapping area*	*Percent of total*
Debris slide	147	42.6 %
Debris flow	22	6.4 %
Debris slide + flow	12	3.5 %
Rock fall	48	13.9 %
Rock slide	57	16.5 %
Rock fall + slide	59	17.1 %
TOTAL	**345**	**100.0 %**

Table 2. Summary table showing the type and number of mapped landslides. A complete inventory is presented in Appendix A.

Landslide attribute	*Number of landslides (out of 52 total) where this attribute changed following field verification*
Material type	2
Movement type	4
Activity state	4
Certainty of identification	8
Sediment delivery to a watercourse	5
Percentage of sediment delivered to a watercourse	4
Inner gorge morphology	2
Land use activity	4

Table 3. Summary table showing the number of attributes changed for the 52 field-verified landslides. In addition to the attribute changes, nine "new" landslides were discovered during the field verification, and seven landslides identified from the aerial photographs were rejected as being landslides. A complete inventory of all field-verified landslides and a comparison with their initial aerial photograph-mapped classifications is presented in Appendix B.

4 SUMMARY

This landslide inventory identified 345 landslides in the upper Trinity River watershed mapping area. Approximately 15 percent of these slides have been field verified; however, numerous changes were made to the attributes assigned during initial aerial photograph interpretation. The significance of these changes is broad, and any future analyses using the inventory presented in this report should take this into consideration. However, a 100 percent field verification (visiting all landslides mapped) is neither practical nor cost effective, and the landslides mapped solely from the aerial photographs were analyzed to the best available detail. Users of the data presented in this report must be aware of the differences in landslide interpretation based on the resolution of the observation.

Because future interpretations or analyses using the data presented in this report will be performed, additional information, details, or interpretation not presented herein may be required. If any additional information is needed, please feel free to contact the undersigned.

Respectfully submitted,

Geoffrey M. Hales, P.G.
California Professional Geologist #7060

REGISTERED GEOLOGIST
GEOFFREY M. HALES
No. 7060
Exp 5/06
STATE OF CALIFORNIA

5 REFERENCES

CDMG (California Department of Conservation, Division of Mines and Geology). 1999. Factors Affecting Landslides in Forested Terrain. California Department of Conservation, Division of Mines and Geology Note 50. 5 p.

CDWR (Department of Water Resources). 1980. Mainstem Trinity River Watershed Erosion Investigation. 35 p.

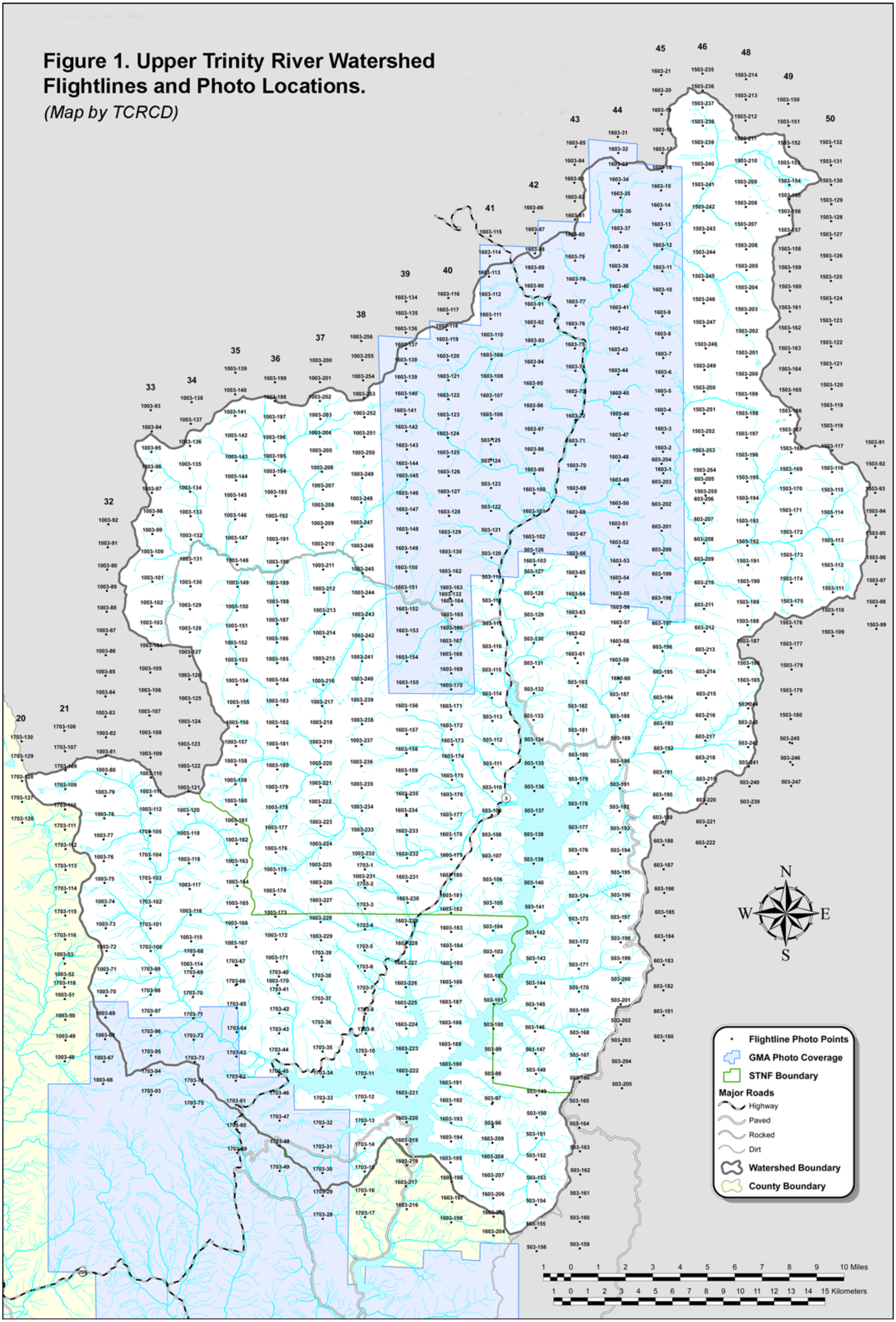
Crudden, D.M., and D.J. Varnes. 1996. Landslide Types and Processes. pp. 36-75. In: Turner, A.K., and R.L. Schuster (eds). 1996. *Landslides, Investigation and Mitigation*, Special Report 247. National Research Council, Transportation Research Board. 673 p.

GMA (Graham Matthews and Associates). 2001b. Trinity River sediment source analysis for the Trinity River, Trinity County, CA. Prepared for Tetra Tech, Inc.

USEPA (United States Environmental Protection Agency) 2001. Trinity River Total Maximum Daily Load for Sediment. USEPA, Region IX, December 20, 2001.

Figure 1. Upper Trinity River Watershed Flightlines and Photo Locations.

(Map by TCRCD)



APPENDIX A. 2005 Upper Trinity River Landslide Inventory

Air photo analysis by G. Hales, McBain and Trush, Inc.
Landslides identified on 2003 aerial photographs 9/2005 and field verified 10/2005. Red text denotes a change from initial aerial photograph interpretation following field verification.

Total Landslide Count	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Criteria by Crudden and Varnes (1996): Material Type (R, D, E)	Movement type (FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No if activity state = A or ID, blank if IR.	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with slide and adjacent area	Additional notes
1	1	20	1703-128	Thompson Peak	R	FA + SL	RFA + SL	ID	D	N		y	Natural	Bedrock inner gorge. Two main feeder chutes lead to colluvial fan. Arrows on map show flow direction
2	2	21	1703-109	Thompson Peak	R	FA + SL	RFA + SL	IR	Q			y	Natural	Bedrock inner gorge.
3	3	21	1703-109	Thompson Peak	R	FA + SL	RFA + SL	IR	Q			y	Natural	Bedrock inner gorge.
4	1	21	1703-108	Mt. Hilton	R	FA	RFA	ID	D	Y (lake)	0-33%	N	Natural	
5	2	21	1703-108	Mt. Hilton	R	FA	RFA	ID	D	N		N	Natural	
6	3	20	1703-127	Mt. Hilton	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
7	4	20	1703-127	Mt. Hilton	R	FA	RFA	ID	D	Y	0-33%	N	Natural	
8	5	20	1703-127	Mt. Hilton	R	FA	RFA	ID	D	N		N	Natural	
9	1	33	1003-96	Deadman Peak	R	FA	RFA	ID	D	N		N	Natural	
10	2	34	1003-137	Deadman Peak	R	FA	RFA	ID	D	N		N	Natural	
11	3	35	1003-141	Deadman Peak	R	FA	RFA	ID	D	Y (lake)	34-66%	N	Natural	
12	1	35	1003-149	Caribou Lake	D	SL	DSL	ID	P	Y	67-100%	N	Natural	Stream erosion at toe
13	2	35	1003-150	Caribou Lake	D	SL	DSL	A	D	N		N	Natural	
14	3	35	1003-151	Caribou Lake	D	FL	DFL	ID	P	Y	34-66%	Y	Natural	
15	4	35	1003-151	Caribou Lake	D	FL	DFL	IR	P			Y	Natural	
16	5	35	1003-151	Caribou Lake	D	SL	DSL	ID	P	N		N	Natural	
17	6	35	1003-155	Caribou Lake	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
18	7	35	1003-155	Caribou Lake	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
19	8	35	1003-155	Caribou Lake	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
20	9	35	1003-155	Caribou Lake	R	FA + SL	RFA + SL	ID	D	Y (lake)	0-33%	N	Natural	
21	10	35	1003-156	Caribou Lake	R	FA + SL	RFA + SL	ID	D	Y (lake)	0-33%	N	Natural	
22	11	35	1003-156	Caribou Lake	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
23	12	35	1003-157	Caribou Lake	D	SL	DSL	ID	P	N		N	Natural	
24	13	34	1003-121	Caribou Lake	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
25	14	34	1003-121	Caribou Lake	R	FA	RFA	ID	D	N		N	Natural	
26	15	34	1003-125	Caribou Lake	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
27	16	34	1003-126	Caribou Lake	D	SL	DSL	ID	Q	N		N	Natural	
28	17	34	1003-127	Caribou Lake	D	SL	DSL	IR	Q			N	Natural	
29	18a	34	1003-131	Caribou Lake	D	FL	DFL	ID	P	Y	67-100%	N	Natural	Slide was mapped in office as a single failure; field inspection revealed two separate slides.
30	18b	34	1003-132	Caribou Lake	D	SL	DSL	A	D	Y	67-100%	N	Natural	Slide was mapped in office as a single failure; field inspection revealed two separate slides.
31	19	33	1003-102	Caribou Lake	D	SL	DSL	ID	Q	Y	0-33%	N	Natural	Streamside failure (toeslope erosion by Coffee Creek)
32	A			Caribou Lake	D	SL	DSL	ID	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis). Streamside failure (toeslope erosion by Coffee Creek)
33	B			Caribou Lake	D	SL	DSL	ID	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis). Streamside failure (toeslope erosion by Coffee Creek)
34	C			Caribou Lake	D	SL	DSL	ID	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis). Streamside failure (toeslope erosion by Coffee Creek)
35	D			Caribou Lake	D	SL	DSL	A	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis). Streamside failure (toeslope erosion by Coffee Creek)
36	1	32	1003-70	Siligo Peak	R	SL	RSL	ID	D	Y	0-33%		Natural	Possibly road runoff
37	2	32	1003-70	Siligo Peak	R	SL	RSL	ID	D	Y	67-100%		Natural	
38	3	32	1003-70	Siligo Peak	R	SL	RSL	ID	D	Y	0-33%		Natural	Group of 4 small slides
39	4	32	1003-70	Siligo Peak	R	SL	RSL	ID	P	Y	34-66%		Natural	
40	5	32	1003-71	Siligo Peak	R	SL	RSL	ID	D	Y	67-100%		Natural	
41	6	32	1003-71	Siligo Peak	R	SL	RSL	ID	P	N			Natural	
42	7	32	1003-72	Siligo Peak	R	SL	RSL	ID	D	Y	67-100%		Natural	
43	8	32	1003-72	Siligo Peak	D	SL	DSL	ID	P	Y	67-100%		Natural	
44	9	32	1003-75	Siligo Peak	R	SL	RSL	ID	P	Y	67-100%		Natural	
45	10	32	1003-75	Siligo Peak	R	FA	RFA	ID	D	N			Natural	
46	11	32	1003-77	Siligo Peak	R	FA	RFA	ID	D	N			Natural	
47	12	32	1003-76	Siligo Peak	R	FA	RFA	ID	D	N			Natural	
48	13	32	1003-77	Siligo Peak	R	FA	RFA	ID	D	N			Natural	
49	14	32	1003-79	Siligo Peak	R	FA	RFA	ID	D	N			Natural	
50	15	33	1703-105	Siligo Peak	D	SL	DSL	A	D	Y	67-100%		Natural	
51	16	33	1703-105	Siligo Peak	D	SL	DSL	A	D	Y	67-100%		Natural	
52	17	33	1703-105	Siligo Peak	D	SL	DSL	ID	D	Y	0-33%		Natural	
53	18	33	1703-105	Siligo Peak	D	SL	DSL	IR	P				Natural	
54	19	33	1703-101	Siligo Peak	D	SL	DSL	A	D	Y	67-100%		Natural	Toe eroded by stream
55	20	33	1703-98	Siligo Peak	D	SL	DSL	ID	P	Y	34-66%		Natural	Buckeye ditch
56	21	34	1703-68	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
57	22	34	1003-116	Siligo Peak	D	SL	DSL	A	D	Y	67-100%		Natural	Toe eroded by stream
58	23	34	1003-116	Siligo Peak	D	SL	DSL	A	D	Y	67-100%		Natural	Toe eroded by stream

Total Landslide Count	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Material Type (R, D, E)	Movement type (FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No if activity state = A or ID, blank if IR.	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with slide and adjacent area	Additional notes
59	24	34	1003-116	Siligo Peak	D	SL	DSL	A	D	Y	67-100%		Natural	Toe eroded by stream
60	25	34	1003-116	Siligo Peak	R	SL	RSL	ID	D	Y	0-33%		Natural	
61	26	34	1003-116	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
62	27	34	1003-117	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
63	28	34	1003-118	Siligo Peak	R	SL	RSL	ID	D	Y	0-33%		Natural	
64	29	34	1003-119	Siligo Peak	R	SL	RSL	ID	D	N			Natural	Starts as rock fall, then becomes slide
65	30	34	1003-119	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
66	31	34	1003-119	Siligo Peak	R	SL	RSL	ID	Q	Y	34-66%		Natural	Possible runout from rockfall/slide above #29
67	32	35	1003-160	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
68	33	35	1003-160	Siligo Peak	R	SL	RSL	ID	D	Y	0-33%		Natural	
69	34	35	1003-160	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
70	35	35	1003-160	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
71	36	35	1003-160	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
72	37	35	1003-160	Siligo Peak	D	FL	DFL	ID	D	Y	0-33%		Natural	Funnel morphology suggests channelized flow of rock or debris
73	38	35	1003-160	Siligo Peak	R	FA + SL	RFA + SL	ID	D	Y	0-33%		Natural	
74	39	35	1003-161	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
75	40	35	1003-161	Siligo Peak	R	FA + SL	RFA + SL	ID	D	Y	0-33%		Natural	
76	41	35	1003-161	Siligo Peak	R	SL	RSL	ID	D	Y	34-66%		Natural	
77	42	35	1003-161	Siligo Peak	R	SL	RSL	ID	P	N			Natural	
78	43	35	1003-161	Siligo Peak	R	SL	RSL	ID	P	N			Natural	
79	44	35	1003-163	Siligo Peak	R	SL	RSL	ID	P	Y	0-33%		Natural	
80	45	35	1003-163	Siligo Peak	R	SL	RSL	ID	D	Y	0-33%		Natural	
81	46	35	1003-163	Siligo Peak	R	FA	RFA	ID	D	N			Natural	
82	47	35	1003-163	Siligo Peak	R	FA	RFA	ID	P	Y	0-33%		Natural	
83	48	35	1003-163	Siligo Peak	R	SL	RSL	ID	P	Y	0-33%		Natural	
84	49	35	1003-163	Siligo Peak	R	FA + SL	RFA + SL	ID	D	Y	0-33%		Natural	This is a nested group of slides and chutes in bedrock
85	50	35	1003-163	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
86	51	35	1003-164	Siligo Peak	R	FA + SL	RFA + SL	ID	P	Y	0-33%		Natural	
87	52	35	1003-164	Siligo Peak	R	FA	RFA	ID	P	N			Natural	
88	53	35	1003-165	Siligo Peak	R	SL	RSL	ID	Q	N			Natural	
89	54	35	1003-165	Siligo Peak	R	SL	RSL	ID	D	N			Natural	
90	55	35	1003-165	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
91	56	35	1003-166	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
92	57	35	1003-166	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
93	58	35	1003-166	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
94	59	35	1003-166	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
95	60	35	1003-166	Siligo Peak	R	FA + SL	RFA + SL	ID	D	N			Natural	
96	61	35	1003-167	Siligo Peak	R	SL	RSL	ID	P	N			Natural	
97	62	35	1003-167	Siligo Peak	R	FA + SL	RFA + SL	ID	P	N			Natural	
98	63	35	1003-167	Siligo Peak	R	FA + SL	RFA + SL	ID	D	Y	0-33%		Natural	
99	64	35	1003-167	Siligo Peak	R	FA + SL	RFA + SL	ID	D	Y	0-33%		Natural	
		35	1703-65 thru 1703-62	Rush Creek Lakes										Small portion of quad was mapped (most was already done for 2001 TMDL by GMA and those coverage areas are excluded from this analysis). Within the mapping area (shown by green border on acetate overlay), no slides found. Heavily logged area in SW portion
100	1	36	1003-193	Billys Peak	D	SL	DSL	A	P	N		N	Natural	
101	2	36	1003-193	Billys Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	Toeslope erosion by N. Fork Coffee Creek
102	3	36	1003-192	Billys Peak	D	SL	DSL	ID	D	Y	67-100%	N	Natural	Toeslope erosion by unnamed trib
103	4	36	1003-192	Billys Peak	D	SL	DSL	ID	P	Y	67-100%	Y	Natural	
104	5	36	1003-192	Billys Peak	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
105	6	36	1003-191	Billys Peak	D	SL	DSL	ID	P	Y	34-66%	N	Natural	
106	7	37	1003-203	Billys Peak	D	SL	DSL	ID	Q	N		N	Natural	
107	8	37	1003-208	Billys Peak	D	SL	DSL	ID	Q	N		N	Natural	
108	9	37	1003-209	Billys Peak	D	SL	DSL	ID	P	Y	34-66%	N	Natural	
109	10	37	1003-210	Billys Peak	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
110	11	38	1003-247	Billys Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	Toeslope erosion by E. Fork Coffee Creek
111	12	38	1003-247	Billys Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	
112	13	38	1003-249	Billys Peak	D	SL	DSL	IR	P			N	Natural	
113	14	38	1003-250	Billys Peak	R	FA	RFA	ID	D	N		N	Natural	
114	15	38	1003-250	Billys Peak	R	FA	RFA	ID	D	N		N	Natural	
115	16	38	1003-250	Billys Peak	R	FA	RFA	ID	D	N		N	Natural	
116	17	38	1003-251	Billys Peak	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
117	1	38	1003-245	Ycatapom Peak	D	SL + FL	DSL + FL	ID	P	Y	67-100%	N	Natural	
118	2	38	1003-245	Ycatapom Peak	D	SL	DSL	ID	Q	N		N	Natural	
119	3	38	1003-244	Ycatapom Peak	D	SL	DSL	IR	Q			N	Natural	
120	4	38	1003-238	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
121	5	38	1003-238	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
122	6	38	1003-238	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
123	7	38	1003-238	Ycatapom Peak	R	SL	RSL	ID	D	N		N	Natural	
124	8	38	1003-238	Ycatapom Peak	R	FA	RFA	IR	P			N	Natural	
125	9	38	1003-238	Ycatapom Peak	R	FA	RFA	ID	D	Y (lake)	0-33%	N	Natural	
126	10	38	1003-238	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
127	11	37	1003-210	Ycatapom Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	Toe erosion by Coffee Creek

Total Landslide Count	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Material Type (R, D, E)	Movement type (FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No if activity state = A or ID, blank if IR.	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with slide and adjacent area	Additional notes
128	12	37	1003-212	Ycatapom Peak	R	FA	RFA	IR	D			N	Natural	
129	13	37	1003-216	Ycatapom Peak	R	FA	RFA	IR	D			N	Natural	
130	14	37	1003-216	Ycatapom Peak	R	FA	RFA	IR	D			N	Natural	
131	15	37	1003-216	Ycatapom Peak	R	FA	RFA	IR	D			N	Natural	
132	16	37	1003-216	Ycatapom Peak	R	FA	RFA	IR	D			N	Natural	
133	17	37	1003-216	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
134	18	37	1003-217	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
135	19	37	1003-217	Ycatapom Peak	R	SL	RSL	ID	D	N		N	Natural	
136	20	37	1003-217	Ycatapom Peak	R	SL	RSL	ID	P	N		N	Natural	Runout looks like alpine glacier moraine (excluded from mapping)
137	21	37	1003-217	Ycatapom Peak	R	FA + SL	RFA + SL	ID	P	N		N	Natural	
138	22	37	1003-218	Ycatapom Peak	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
139	23	37	1003-219	Ycatapom Peak	D	FL	DFL	ID	D	Y	67-100%	N	Natural	
140	24	37	1003-219	Ycatapom Peak	D	FL	DFL	ID	D	Y	67-100%	N	Natural	
141	25	37	1003-219	Ycatapom Peak	D	SL	DSL	ID	D	Y	67-100%	N	Natural	
142	26	36	1003-180	Ycatapom Peak	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
143	27	36	1003-180	Ycatapom Peak	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
144	28	36	1003-180	Ycatapom Peak	D	SL	DSL	ID	P	N		N	Natural	
145	29	36	1003-180	Ycatapom Peak	D	SL	DSL	ID	Q	N		N	Natural	
146	30	36	1003-181	Ycatapom Peak	D	SL	DSL	ID	Q	N		N	Natural	
147	31	36	1003-181	Ycatapom Peak	D	FL	DFL	ID	P	N		N	Natural	
148	32	36	1003-183	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
149	33	36	1003-183	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
150	34	36	1003-183	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
151	35	36	1003-185	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
152	36	36	1003-185	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
153	37	36	1003-185	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	N		Y	Natural	Multiple feeder chutes/gorges in continuous colluvial apron at toe slope
154	38	36	1003-185	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	Y	0-33%	N	Natural	Feeder chute in colluvial apron at toeslope. Material in apron also from non-chute supply
155	39	36	1003-185	Ycatapom Peak	R	FA	RFA	ID	D	N		N	Natural	
156	40	36	1003-187	Ycatapom Peak	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
157	41	36	1003-189	Ycatapom Peak	D	SL	DSL	ID	D	Y	67-100%	N	Road	Fantastic fresh slide!
158	42	36	1003-190	Ycatapom Peak	D	SL	DSL	A	P	Y	67-100%	N	Natural	Streambank erosion by Coffee Creek
159	43	36	1003-190	Ycatapom Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	Streambank erosion by Coffee Creek. Stumps (selective logging) at crown scarp.
160	44	36	1003-190	Ycatapom Peak+ Caribou Lake	R	SL	RSL	IR	P			N	Natural	
161	A			Ycatapom Peak	D	SL	DSL	ID	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis). Streamside failure (toeslope erosion by Coffee Creek)
162	B			Ycatapom Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis). Streamside failure (toeslope erosion by Coffee Creek)
163	1	36	1703-41	Covington Mill	D	SL	DSL	IR	P			N	Historic logging	
164	2	36	1003-171	Covington Mill	R	FA + SL	RFA + SL	A	D	N		N	Natural	
165	3	36	1003-171	Covington Mill	R	FA + SL	RFA + SL	ID	P	N		N	Natural	
166	4	36	1003-171	Covington Mill	R	FA	RFA	ID	D	N		N	Natural	
167	5	36	1003-172	Covington Mill	R	FA + SL	RFA + SL	IR	P			Y	Natural	
168	6	36	1003-173	Covington Mill	R	SL	RSL	A	D	Y	67-100%	Y	Natural	
169	7	36	1003-173	Covington Mill	R	SL	RSL	A	D	N		N	Natural	
170	8	36	1003-173	Covington Mill	R	SL	RSL	ID	D	Y	0-33%	Y	Natural	
171	9	36	1003-173	Covington Mill	R	SL	RSL	ID	D	N		N	Natural	
172	10	36	1003-173	Covington Mill	D	SL	DSL	IR	P			N	Natural	
173	11	36	1003-173	Covington Mill	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
174	12	36	1003-173	Covington Mill	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
175	13	36	1003-173	Covington Mill	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
176	14	36	1003-174	Covington Mill	R	FA	RFA	ID	D	N		N	Natural	
177	15	36	1003-175	Covington Mill	R	SL	RSL	ID	P	N		N	Natural	
178	16	36	1003-175	Covington Mill	D	SL	DSL	ID	D	N		N	Natural	
179	17	36	1003-175	Covington Mill	D	SL	DSL	ID	D	N		N	Natural	
180	18	36	1003-175	Covington Mill	R	FA	RFA	IR	D			N	Natural	
181	19	36	1003-175	Covington Mill	R	FA	RFA	IR	D			N	Natural	
182	20	36	1003-176	Covington Mill	D	SL	DSL	IR	P			N	Natural	
183	21	36	1003-176	Covington Mill	R	FA	RFA	ID	D	N		N	Natural	
184	22	36	1003-176	Covington Mill	R	FA	RFA	ID	D	N		N	Natural	
185	23	36	1003-176	Covington Mill	R	SL	RSL	A	D	Y	67-100%	Y	Natural	
186	24	36	1003-176	Covington Mill	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
187	25	36	1003-176	Covington Mill	R	SL	RSL	ID	D	Y	0-33%	N	Natural	
188	26	36	1003-176	Covington Mill	R	SL	RSL	ID	D	Y	0-33%	N	Natural	
189	27	36	1003-176	Covington Mill	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
190	28	36	1003-177	Covington Mill	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
191	29	36	1003-178	Covington Mill	R	FA	RFA	ID	D	N		N	Natural	
192	30	36	1003-178	Covington Mill	R	FA + SL	RFA + SL	ID	D	Y	34-66%	N	Natural	

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193	31	36	1003-178	Covington Mill	R	FA	RFA	ID	D	N		N	Natural	
194	32	36	1003-178	Covington Mill	R	FA + SL	RFA + SL	ID	P	N		N	Natural	
195	33	36	1003-178	Covington Mill	R	FA + SL	RFA + SL	ID	D	Y	0-33%	N	Natural	
196	34	36	1003-178	Covington Mill	R	SL	RSL	ID	P	N		N	Natural	
197	35	36	1003-179	Covington Mill	R	FA + SL	RFA + SL	ID	D	Y	34-66%	N	Natural	
198	36	36	1003-179	Covington Mill	R	SL	RSL	IR	P	N		N	Natural	
199	37	36	1003-178	Covington Mill	D	SL	DSL	ID	D	N		N	Natural	
200	38	36	1003-177	Covington Mill	R	FA + SL	RFA + SL	ID	P	N		N	Natural	
201	39	36	1003-178	Covington Mill	D	SL	DSL	IR	P	N		N	Natural	
202	40	36	1003-179	Covington Mill	D	SL	DSL	A	D	Y	67-100%	Y	Natural	
203	41	37	1003-221	Covington Mill	D	FL	DFL	ID	D	Y	67-100%	Y	Natural	Spectacular runout
204	42	37	1003-221	Covington Mill	D	SL	DSL	ID	P	Y	34-66%	N	Natural	Stream erosion at toe
205	43	37	1003-221	Covington Mill	D	SL	DSL	ID	Q	Y	67-100%	N	Natural	Stream erosion at toe
206	44	37	1003-221	Covington Mill	D	SL	DSL	IR	Q			N	Natural	
207	45	37	1003-221	Covington Mill	D	SL	DSL	ID	P	Y	67-100%	N	Natural	Stream erosion at toe
208	46	37	1003-222	Covington Mill	D	SL	DSL	ID	Q	Y	0-33%	N	Natural	
209	47	37	1003-225	Covington Mill	R	FA + SL	RFA + SL	ID	D	Y (lake)	0-33%	N	Natural	
210	48	37	1003-225	Covington Mill	R	FA + SL	RFA + SL	ID	D	Y (lake)	0-33%	N	Natural	
211	49	37	1003-228	Covington Mill	D	SL	DSL	ID	P	N		N	Natural	
212	50	37	1703-38	Covington Mill	D	SL	DSL	IR	Q			?	Road	Slide crown on outboard edge
213	51	37	1703-36	Covington Mill	D	SL	DSL	IR	Q			N	Road	Road and timber harvest
	52	38	1703-7	Covington Mill	Disturbed			A	P			N	Mining	Powerline easement; All access roads gated, viewed from Hwy 3. This is a large area of bare ground caused by historic mining. Abundant surface erosion and localized nested small slides likely generating significant sediment. Keep this slide on the map (special circumstance sediment source)
214	53	38	1703-7	Covington Mill	D	SL	DSL	ID	P	Y	67-100%	N	Road	
215	54	38	1703-6	Covington Mill	D	SL + FL	DSL + FL	ID	D	Y	67-100%	Y	Roads and timber harvest	Steep and deep inner gorge. Few existing slides within mapped imits contributing to sediment supply are small and shallow (est. 2 ft deep, only 10 % of mapped area). Some old roads in slide limits.
216	55	38	1703-6	Covington Mill	D	SL + FL	DSL + FL	IR	P			Y	Road	
217	56	38	1703-5	Covington Mill	D	SL	DSL	ID	P	Y	0-33%	N	Road	
218	57	38	1703-5	Covington Mill	D	SL	DSL	IR	Q			N	Road	
219	58	38	1003-233	Covington Mill	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
220	59	38	1003-234	Covington Mill	D	SL	DSL	ID	P	N		N	Natural	
221	60	38	1003-234	Covington Mill	D	SL	DSL	ID	Q	N		N	Natural	
222	61	38	1003-235	Covington Mill	D	FL	DFL	ID	P	Y	67-100%	N	Natural	
223	62	39	1603-233	Covington Mill	D	SL	DSL	A	P	Y	67-100%	N	Natural	Streambank erosion (Cement Creek)
224	63	39	1603-233	Covington Mill	D	SL	DSL	IR	P			N	Roads and timber harvest	
225	64	39	1603-233	Covington Mill	D	FL	DFL	A	D	N		N	Roads and timber harvest	Timber harvest, Fantastic example of fresh slide!
226	65	38	1003-235	Covington Mill	D	SL	DSL	ID	Q	N		N	Natural	
227	1	37	1703-35	Trinity Dam	D	SL	DSL	IR	Q			N	Road	Adjacent to Hwy 3, possibly road runoff related (?)
228	2	37	1703-36	Trinity Dam	D	SL + FL	DSL + FL	IR	D			Y	Roads and timber harvest	Very steep slopes, large slide. Bedrock at slide head is DG.
229	3	38	1703-8	Trinity Dam	D	FL	DFL	IR	Q			N	Road	Power line easement at crown scarp
	4	38	1703-8	Trinity Dam										Field verification determined this is not a slide (it's a rilling and gullying Hwy 3 road cut)
230	5	38	1703-14	Trinity Dam	D	SL	DSL	ID	D	N		N	Road	Slide in road cut, also abundant surface erosion (rills and gullies).
231	6	38	1703-14	Trinity Dam	D	FL	DFL	ID	P	Y	67-100%	N	Road	Outboard edge of dirt road, timber harvest area
232	7	38	1703-14	Trinity Dam	D	SL	DSL	ID	P	Y	0-33%	N	Road	Outboard edge of dirt road, timber harvest area
233	8	39	1603-219	Trinity Dam	D	SL	DSL	IR	P			Y	Road	Road traverses slide body. Land use looks like historic timber harvest and access roads
234	9	39	1603-219	Trinity Dam	D	SL	DSL	IR	P			Y	Road	Road traverses slide body. Land use looks like historic timber harvest and access roads
235	10	39	1603-220	Trinity Dam	D	SL	DSL	IR	Q			N	Natural?	Tough call - could just be a natural drainage.
236	11	39	1603-223	Trinity Dam	D	SL	DSL	IR	P			N	Road	Road at crown scarp
237	12	39	1603-225	Trinity Dam	D	SL	DSL	IR	Q			N	Road + Timber harvest	Road and slide crown
238	1	43	1603-64	Carrville	D	SL + FL	DSL + FL	ID	D	N		N	Road	Spectacular runout
239	2	43	1603-64	Carrville	D	SL + FL	DSL + FL	ID	D	Y	67-100%	Y	Road	Spectacular runout
240	3	43	1603-64	Carrville	D	FL	DFL	ID	D	Y	67-100%	Y	Road	Spectacular runout
241	4	43	1603-64	Carrville	D	SL	DSL	ID	D	Y	34-66%	N	Road + Timber harvest	
242	5	43	1603-64	Carrville	D	SL	DSL	ID	D	N		N	Road + Timber harvest	Awesome double crown scarp
243	6	43	1603-63	Carrville	D	FL	DFL	ID	D	Y	67-100%	Y	Road + Timber harvest	
244	7	43	503-183	Carrville	D	SL	DSL	IR	Q			Y	Road	Contemporary+ Roads + Timber harvest
245	8	43	503-183	Carrville	D	SL	DSL	ID	P	N		N	Road + Timber harvest	
246	9	43	503-182	Carrville	D	SL	DSL	ID	D	N		N	Road + Timber harvest	
247	10	43	503-182	Carrville	D	FL	DFL	ID	P	Y	67-100%	Y	Road + Timber harvest	
248	11	43	503-182	Carrville	D	FL	DFL	ID	P	Y	67-100%	N	Road + Timber harvest	
	12	43	503-181	Carrville										Field verification determined this is not a slide
249	13	42	503-129	Carrville	D	SL + FL	DSL + FL	ID	Q	N		N	Quarry	This is either an active quarry or quarry related slide
	14	42	503-129	Carrville										Field verification determined this is not a slide
	15	42	503-129	Carrville										Field verification determined this is not a slide
250	16	42	503-131	Carrville	D	SL	DSL	ID	Q	Y	34-66%	N	Road + Timber harvest	

Total Landslide Count	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Material Type (R, D, E)	Movement type (FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No if activity state = A or ID, blank if IR.	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with slide and adjacent area	Additional notes
251	17	42	503-134	Carrville	R	FA	RFA	ID	P	Y (lake)	0-33%	N	Road	Hwy 3
252	18	41	503-111	Carrville	D	SL	DSL	IR	P			N	Quarry / mining	
253	19	41	503-114	Carrville	D	FL	DFL	A	D	Y	67-100%	N	Road + Timber harvest	Clearcut. Slide observed from Scorpion Creek (across valley).
254	20	40	1603-171	Carrville	D	SL + FL	DSL + FL	ID	D	N		N	Road + Timber harvest	
255	1	40	1603-177	Trinity Center	D	SL	DSL	ID	D	N		N	Road	Road cut, translational debris slide exacerbated by quarrying.
256	2	40	1603-182	Trinity Center	D	SL	DSL	IR	P			N	Road + Timber harvest	
257	3	40	1603-187	Trinity Center	D	SL	DSL	IR	P			N		Stream erosion of toe (Sawmill Creek)
258	4	41	503-104	Trinity Center	D	SL	DSL	IR	Q			Y		Crown scarp at head of small tributary
259	5	41	503-107	Trinity Center	D	SL	DSL	ID	P	Y	67-100%	N		Stream erosion at toe (unnamed trib. to lake)
260	6	41	503-109	Trinity Center	D	SL	DSL	ID	D	N		N	Mining	Mining (According to map)
261	7	42	503-141	Trinity Center	D	SL	DSL	ID	P	Y (lake)	67-100%	Y	Timber harvest	
262	8	42	503-141	Trinity Center	D	SL	DSL	ID	D	Y (lake)	67-100%	N	Timber harvest	
263	9	42	503-142	Trinity Center	R	SL	RSL	ID	Q	Y	67-100%	N	Timber harvest	
264	10	42	503-144	Trinity Center	D	SL	DSL	ID	Q	Y (lake)	34-66%	N	Natural	
265	11	43	503-171	Trinity Center	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
266	12	43	503-171	Trinity Center	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
267	13	43	503-171	Trinity Center	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
268	14	43	503-172	Trinity Center	D	SL	DSL	ID	P	Y	34-66%	N	Road + Timber harvest	
269	15	43	503-172	Trinity Center	D	SL	DSL	ID	P	N		N	Road + Timber harvest	
270	16	43	503-172	Trinity Center	D	SL	DSL	ID	D	Y	67-100%	N	Road + Timber harvest	
271	17	43	503-173	Trinity Center	D	FL	DFL	IR	P			Y	Road + Timber harvest	
272	18	43	503-173	Trinity Center	D	SL	DSL	ID	P	Y	67-100%	N	Road + Timber harvest	
273	19	43	503-174	Trinity Center	D	SL	DSL	ID	D	N		N	Road	
274	20	43	503-174	Trinity Center	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
275	21	43	503-177	Trinity Center	D	SL + FL	DSL + FL	IR	Q			Y		Questionable semi vegetated to bare ground, strong inner gorge morphology
276	22	43	503-177	Trinity Center	D	SL + FL	DSL + FL	IR	Q			Y		
277	23	43	503-177	Trinity Center	D	SL + FL	DSL + FL	IR	Q			Y		
278	24	43	503-177	Trinity Center	D	SL	DSL	ID	P	N		N	Natural	
279	1	40	1603-188	Papoose Creek	D	SL	DSL	ID	P	Y	67-100%	N	Natural	
280	2	40	1603-193	Papoose Creek	D	SL	DSL	ID	P	Y	67-100%	N	Timber harvest	?
281	3	40	1603-193	Papoose Creek	D	SL	DSL	ID	P	Y	67-100%	N	Timber harvest	?
282	4	41	1603-206	Papoose Creek	D	SL	DSL	ID	P	N		N	Road + Timber harvest	On outboard toe at switchback
283	5	41	503-98	Papoose Creek	D	SL	DSL	IR	Q			N	Road + Timber harvest	
284	6	42	503-146	Papoose Creek	D	SL	DSL	IR	D			Y	Road + Timber harvest	Post slide?
285	7	42	503-146	Papoose Creek	D	SL	DSL	IR	D			Y	Road + Timber harvest	Post slide?
286	8	42	503-147	Papoose Creek	D	SL	DSL	ID	D	Y	67-100%	N	Road	
287	9	42	503-147	Papoose Creek	D	SL	DSL	ID	D	Y	67-100%	N	Road	
288	10	42	503-149	Papoose Creek	D	SL	DSL	A	D	N		N	Road + Timber harvest	
289	11	43	503-164	Papoose Creek	D	SL	DSL	IR	P			N	Road + Timber harvest	Currently road and timber harvest-post slide
290	A			Papoose Creek	D	SL	DSL	A	D	Y	67-100%	N	Natural	New slide identified in field (not inventoried during air photo analysis).
291	1	45	1603-18	South China Mountain	R	FA	RFA	ID	D	N		N	Natural	
292	2	45	1603-18	South China Mountain	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
293	3	46	1503-238	South China Mountain	R	FA	RFA	ID	D	N		N	Natural	
294	4	46	1503-239	South China Mountain	D	FL	DFL	ID	D	Y	34-66%	N	Road + Timber harvest	Road failure
295	5	46	1503-245	South China Mountain	D	SL	DSL	A	D	N		N	Road + Timber harvest	
296	6	48	1503-209	South China Mountain	D	FL	DFL	IR	Q			Y	Road + Timber harvest	? (Relict) current land use=roads and timber harvest
297	7	49	1503-152	South China Mountain	D	SL + FL	DSL + FL	A	D	Y	0-33%	Y	Natural	
298	8	49	1503-154	South China Mountain	D	SL	DSL	A	D	Y (lake)	34-66%	N	Natural	
299	9	49	1503-154	South China Mountain	D	SL	DSL	ID	Q	N		N	Natural	
300	1	46	1503-248	Mumbo Basin	D	SL	DSL	ID	P	N		N	Natural	
301	2	46	1503-248	Mumbo Basin	D	SL	DSL	ID	P	N		N	Natural	
302	3	46	1503-248	Mumbo Basin	D	SL	DSL	ID	P	N		N	Natural	
303	4	46	1503-251	Mumbo Basin	R	SL	RSL	ID	D	N		N	Natural	
304	5	46	603-205	Mumbo Basin	R	SL	RSL	ID	D	N		N	Natural + Road	
305	6	46	603-208	Mumbo Basin	D	FL	DFL	ID	D	Y	67-100%	N	Road	
	7	48	1503-195	Mumbo Basin										Field verification determined this is not a slide
306	8	48	1503-201	Mumbo Basin	D	SL	DSL	ID	D	N		N	Natural	
307	9	48	1503-201	Mumbo Basin	D	SL	DSL	ID	D	N		N	Natural	
308	10	48	1503-201	Mumbo Basin	D	SL	DSL	ID	D	N		N	Natural	
309	1	44	1603-57	Whisky Bill Peak	R	FA + SL	RFA + SL	A	D	N		N	Natural	Wilderness
310	2	44	1603-58	Whisky Bill Peak	R	SL	RSL	ID	D	Y	34-66%	Y	Natural	
311	3	44	1603-58	Whisky Bill Peak	R	SL	RSL	ID	D	Y	34-66%	Y	Natural	
312	4	45	603-192	Whisky Bill Peak	D	SL	DSL	IR	Q			N	Road	? At present road traverses slide

Total Landslide Count	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Material Type (R, D, E)	Movement type (FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No if activity state = A or ID, blank if IR.	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with slide and adjacent area	Additional notes
313	5	45	603-193	Whisky Bill Peak	D	SL	DSL	ID	P	Y	34-66%	N	Road + Timber harvest	Not all slide runout reached Trinity River
314	6	45	603-194	Whisky Bill Peak	D	SL	DSL	ID	P	Y	34-66%	N	Road + Timber harvest	
315	7	45	603-194	Whisky Bill Peak	R	FA	RFA	A	D	N		N	Natural	
316	8	45	603-195	Whisky Bill Peak	D	SL	DSL	ID	P	N		N	Road + Timber harvest	
317	9	45	603-195	Whisky Bill Peak	D	SL	DSL	ID	Q	Y	67-100%	N	Road + Timber harvest	
318	10	45	603-195	Whisky Bill Peak	R	SL	RSL	ID	Q	Y	34-66%	N	Natural	This could be a slide or it could be a deeply wxd outcrop…tough call
319	11	46,46	603-195, 603-214	Whisky Bill Peak	R	FA + SL	RFA + SL	A	D	Y	34-66%	Y	Natural	
320	12	45	603-196	Whisky Bill Peak	D	SL	DSL	IR	P			N	Road + Timber harvest	Possible former meander bend eroding cutbank.
321	13	45	603-197	Whisky Bill Peak	R	SL	RSL	A	D	Y	0-33%	N	Road	This is a nested group of narrow chutes
322	14	46	603-208	Whisky Bill Peak	D	SL	DSL	ID	D	N		N	Road	
323	15	46	603-213	Whisky Bill Peak	R	FA	RFA	ID	D	Y (lake)	0-33%	N	Natural	
324	16	46	603-214	Whisky Bill Peak	R	FA + SL	RFA + SL	ID	D	Y	34-66%	Y	Natural	
325	17	46	603-214	Whisky Bill Peak	R	SL	RSL	ID	D	Y	34-66%	N	Natural	
326	18	46	603-214	Whisky Bill Peak	R	SL	RSL	A	D	Y	0-33%	N	Natural	Same outcrop as slide #10 but this one's definite
327	19	46	603-218	Whisky Bill Peak	D	SL	DSL	A	P	N		N	Road	This could be road-related earthquake, but there appears to be a prominent headscarp
328	20	48	503-241	Whisky Bill Peak	D	SL	DSL	A	P	N		N	Road	Additional earthwork appears to have occurred at this location
329	21	48	503-241	Whisky Bill Peak	D	SL	DSL	A	P	N		N	Road	Appears to be an outboard edge failure
330	22	48	503-189	Whisky Bill Peak	D	SL	DSL	A	P	N		N	Natural	
331	23	48	503-191	Whisky Bill Peak	R	SL	RSL	A	D	N		N	Road + Timber harvest	
332	A				D	SL	DSL	ID	D	N			Road + Timber harvest	New slide identified in field (not inventoried during air photo analysis). Slide likely caused by road failure.
333	1	44	503-198	Damnation Peak	D	SL	DSL	IR	Q			N	Road + Timber harvest	
334	2	44	503-199	Damnation Peak	D	SL	DSL	ID	P	Y	0-33%	N	Road + Timber harvest	
335	1	49	1503-154	Mt. Eddy	R	SL	RSL	ID	D	N		N	Natural	
336	2	49	1503-154	Mt. Eddy	D	FL	DFL	ID	D	N		Y	Natural	
337	3	49	1503-154	Mt. Eddy	R	FA + SL	RFA + SL	A	D	N		N	Natural	
338	4	49	1503-154	Mt. Eddy	D	SL	DSL	A	D	N		Y	Natural	Few inner gorges in large area from stream incision (runoff/gullying) in what appears to be highly erodible material
339	5	49	1503-154	Mt. Eddy	R	FA	RFA	ID	D	N		N	Natural	
340	6	49	1503-154	Mt. Eddy	D	SL	DSL	IR	P			N	Natural	
341	1	51	1503-96	Seven Lakes Basin	R	FA + SL	RFA + SL	ID	D	Y	67-100%	N	Natural	
	2	50	1503-114	Seven Lakes Basin										Field verification determined this is not a slide
342	3	49	1503-166	Seven Lakes Basin	R	FA + SL	RFA + SL	ID	D	N		N	Natural	
343	4	49	1503-172	Seven Lakes Basin	D	SL	DSL	ID	P	Y	67-100%	N	Road + Timber harvest	
344	1	49	1503-173	Chicken Hawk Hill	R	SL	RSL	A	D	N		N	Road + Timber harvest	
345	2	49	1503-175	Chicken Hawk Hill	R	SL	RSL	ID	D	N		N	Natural	
						TOTAL:	345							

APPENDIX B. Comparison showing differences between initial aerial photo interpretation and subsequent field verification.

Landslides identified on 2003 aerial photographs 9/2005 and field verified 10/2005. Red text denotes a change from initial aerial photograph interpretation following fie

Identification method	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Material Type (R, D, E)	Movement type FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with the slide	Summary of changes
					Criteria by Crudden and Varnes (1996)									
Air photo interpretation	18	34	1003-131	Caribou Lake	D	SL	DSL	ID	Q	Y	67-100%	N	Natural	
Field verification	18a				D	FL	DFL	ID	P	Y	67-100%	N	Natural	Originally mapped as a single landside; field verification determined two separate landslides.
Field verification	18b				D	SL	DSL	A	D	Y	67-100%	N	Natural	
Air photo interpretation	11	37	1003-210	Ycatapom Peak	D	SL	DSL	A	D	Y	67-100%	N	Natural	
Field verification					D	SL	DSL	A	D	Y	67-100%	N	Natural	No change.
Air photo interpretation	42	36	1003-190	Ycatapom Peak	D	SL	DSL	A	P	Y	67-100%	N	Natural	
Field verification					D	SL	DSL	A	P	Y	67-100%	N	Natural	No change.
Air photo interpretation	43	36	1003-190	Ycatapom Peak	D	SL	DSL	A	P	Y	67-100%	N	Natural	
Field verification					D	SL	DSL	A	D	Y	67-100%	N	Natural	Identification certainty upgraded from Probable to Definite.
Air photo interpretation	44	36	1003-190	Ycatapom Peak+ Caribou Lake	D	SL	DSL	IR	P	N/A	N/A	N	Natural	
Field verification					R	SL	RSL	IR	P	N/A	N/A	N	Natural	Material type changed from Debris to Rock.
Air photo interpretation	52	38	1703-7	Covington Mill	D	SL	DSL	IR	P	N/A	N/A	N	Road	
Field verification					Disturbed area			A	P	N/A	N/A	N	Mining	Not a slide (bare ground caused by historic mining). Abundant surface erosion and localized nested small slides likely generating significant sediment (decided to keep this in the inventory as a special circumstance sediment source)
Air photo interpretation	54	38	1703-6	Covington Mill	D	SL + FL	DSL + FL	ID	D	Y	67-100%	Y	Road	
Field verification					D	SL + FL	DSL + FL	ID	D	Y	67-100%	Y	Roads and timber harvest	Included timber harvest with land use activity.
Air photo interpretation	63	39	1603-233	Covington Mill	D	SL	DSL	IR	Q	N/A	N/A	N	Natural	
Field verification					D	SL	DSL	IR	P	N/A	N/A	N	Roads and timber harvest	Identification certainty upgraded from Questionable to Probable, added timber harvest to land use activity..
Air photo interpretation	2	37	1703-36	Trinity Dam	D	FL	DFL	IR	P	N/A	N/A	Y	Road	
Field verification					D	SL + FL	DSL + FL	IR	D	N/A	N/A	Y	Roads and timber harvest	Movement type changed from Flow to Slide + Flow, Identification certainty upgraded from Probable to Definite, added timber harvest to land use activity.
Air photo interpretation	3	38	1703-8	Trinity Dam	D	FL	DFL	IR	Q	N/A	N/A	N	Road	
Field verification					D	FL	DFL	IR	Q	N/A	N/A	N	Road	No change.
Air photo interpretation	4	38	1703-8	Trinity Dam	R	SL	RSL	ID	P	N	N/A	N	Road	
Field verification					NOT A SLIDE									Field verification determined this is not a slide.
Air photo interpretation	5	38	1703-14	Trinity Dam	R	SL	RSL	ID	P	N	N/A	N	Road	
Field verification					D	SL	DSL	ID	D	N	N/A	N	Road	Material type changed from Rock to Debris.
Air photo interpretation	8	39	1603-219	Trinity Dam	D	SL	DSL	ID	P	Y (lake)	67-100%	Y	Road	
Field verification					D	SL	DSL	IR	P	N/A	N/A	Y	Road	Activity state changed from Inactive Dormant to Inactive Relict
Air photo interpretation	9	39	1603-219	Trinity Dam	D	SL	DSL	ID	P	Y (lake)	67-100%	Y	Road	
Field verification					D	SL	DSL	IR	P	N/A	N/A	Y	Road	Activity state changed from Inactive Dormant to Inactive Relict
Air photo interpretation	10	39	1603-220	Trinity Dam	D	SL	DSL	IR	Q	N/A	N/A	Y	Road	
Field verification					D	SL	DSL	IR	Q	N/A	N/A	N	Natural?	Field verification determined no inner gorge morphology.
Air photo interpretation	1	43	1603-64	Carrville	D	FL	DFL	ID	D	N	N/A	N	Road	
Field verification					D	SL + FL	DSL + FL	ID	D	N	N/A	N	Road	Movement type changed from Flow to Slide + Flow
Air photo interpretation	2	43	1603-64	Carrville	D	FL	DFL	ID	D	Y	67-100%	Y	Road	
Field verification					D	SL + FL	DSL + FL	ID	D	Y	67-100%	Y	Road	Movement type changed from Flow to Slide + Flow
Air photo interpretation	5	43	1603-64	Carrville	D	SL	DSL	ID	D	N	N/A	N	Road + Timber harvest	
Field verification					D	SL	DSL	ID	D	N	N/A	N	Road + Timber harvest	No change.
Air photo interpretation	6	43	1603-63	Carrville	D	FL	DFL	ID	P	Y	67-100%	Y	Road + Timber harvest	
Field verification					D	FL	DFL	ID	D	Y	67-100%	Y	Road + Timber harvest	Identification certainty upgraded from Probable to Definite
Air photo interpretation	12	43	503-181	Carrville	D	SL	DSL	ID	Q	Y	67-100%	N	Road + Timber harvest	
Field verification					NOT A SLIDE									Field verification determined this is not a slide.
Air photo interpretation	14	42	503-129	Carrville	D	SL	DSL	ID	P	Y	67-100%	N	Road + Timber harvest	
Field verification					NOT A SLIDE									Field verification determined this is not a slide.
Air photo interpretation	15	42	503-129	Carrville	D	SL	DSL	ID	P	Y	67-100%	N	Road + Timber harvest	
Field verification					NOT A SLIDE									Field verification determined this is not a slide.

Identification method	Landslide number	Air photo flight line	Air photo number	USGS 7.5-minute quad sheet	Material Type (R, D, E)	Movement type FA, T, SL, SP, FL)	Combined Material and movement	Activity state (A, ID, IR)	Certainty of identification (D, P, Q)	Sediment delivery to a watercourse? Yes or No	Percentage of sediment delivered to watercourse: 0-33%, 34-66%, 67-100%)	Inner gorge morphology? Yes or No	Land use activity associated with the slide	Summary of changes
Air photo interpretation	17	42	503-134	Carrville	R	FA	RFA	ID	P	Y (lake)	0-33%	N	Road	
Field verification					R	FA	RFA	ID	P	Y (lake)	0-33%	N	Road	No change.
Air photo interpretation	18	41	503-111	Carrville	D	SL	DSL	IR	P	N/A	N/A	N	?	
Field verification					D	SL	DSL	IR	P	N/A	N/A	N	**Quarry / mining**	Unidentifiable land use activity verified as quarry / mining.
Air photo interpretation	19	41	503-114	Carrville	D	FL	DFL	A	P	Y	67-100%	N	Road + Timber harvest	
Field verification					D	FL	DFL	A	**D**	Y	67-100%	N	Road + Timber harvest	Identification certainty upgraded from Probable to Definite
Air photo interpretation	1	40	1603-177	Trinity Center	D	SL	DSL	ID	P	Y	0-33%	N	Road	
Field verification					D	SL	DSL	ID	**D**	**N**	**N/A**	N	Road	Identification certainty upgraded from Probable to Definite, field verification determined no sediment delivery to a watercourse.
Air photo interpretation	2	40	1603-182	Trinity Center	D	SL	DSL	IR	P	N/A	N/A	N	?	
Field verification					D	SL	DSL	IR	P	N/A	N/A	N	**Road + Timber harvest**	Unidentifiable land use activity verified as roads + timber harvest.
Air photo interpretation	4	46	1503-239	South China Mountain	D	FL	DFL	ID	Q	Y	34-66%	N	Road + Timber harvest	
Field verification					D	FL	DFL	ID	**D**	Y	34-66%	N	Road + Timber harvest	Identification certainty upgraded from Questionable to Definite.
Air photo interpretation	5	46	1503-245	South China Mountain	D	SL	DSL	A	D	N	N/A	N	Road + Timber harvest	
Field verification					D	SL	DSL	A	D	N	N/A	N	Road + Timber harvest	No change.
Air photo interpretation	6	48	1503-209	South China Mountain	D	FL	DFL	IR	Q	N/A	N/A	Y	Road + Timber harvest	
Field verification					D	FL	DFL	IR	Q	N/A	N/A	Y	Road + Timber harvest	No change.
Air photo interpretation	4	46	1503-251	Mumbo Basin	R	SL	RSL	ID	D	N	N/A	N	Natural	
Field verification					R	SL	RSL	ID	D	N	N/A	N	Natural	No change.
Air photo interpretation	6	46	603-208	Mumbo Basin	D	FL	DFL	ID	D	Y	67-100%	N	Road	
Field verification					D	FL	DFL	ID	D	Y	67-100%	N	Road	No change.
Air photo interpretation	7	48	1503-195	Mumbo Basin	D	FL	DFL	ID	P	Y	67-100%	N	Road	
Field verification										**NOT A SLIDE**				Field verification determined this is not a slide.
Air photo interpretation	8	48	1503-201	Mumbo Basin	D	SL	DSL	ID	D	N	N/A	N	Natural	
Field verification					D	SL	DSL	ID	D	N	N/A	N	Natural	No change.
Air photo interpretation	9	48	1503-201	Mumbo Basin	D	SL	DSL	ID	D	N	N/A	N	Natural	
Field verification					D	SL	DSL	ID	D	N	N/A	N	Natural	No change.
Air photo interpretation	10	48	1503-201	Mumbo Basin	D	SL	DSL	ID	D	N	N/A	N	Natural	
Field verification					D	SL	DSL	ID	D	N	N/A	N	Natural	No change.
Air photo interpretation	8	45	603-195	Whisky Bill Peak	D	SL	DSL	ID	P	Y	0-33%	N	Road + Timber harvest	
Field verification					D	SL	DSL	ID	P	**N**	N/A	N	Road + Timber harvest	Field verification determined no sediment delivery to a watercourse.
Air photo interpretation	11	46,46	603-195, 603-214	Whisky Bill Peak	R	SL	RSL	A	D	Y	34-66%	Y	Natural	
Field verification					R	**FA + SL**	**RFA + SL**	A	D	Y	34-66%	Y	Natural	Movement type changed from Fall to Fall + Slide
Air photo interpretation	12	45	603-196	Whisky Bill Peak	D	SL	DSL	IR	P	N/A	N/A	N		
Field verification					D	SL	DSL	IR	P	N/A	N/A	N	Road + Timber harvest	No change.
Air photo interpretation	14	46	603-208	Whisky Bill Peak	D	SL	DSL	ID	D	N	N/A	N	Road	
Field verification					D	SL	DSL	ID	D	N	N/A	N	Road	No change.
Air photo interpretation	1	44	503-198	Damnation Peak	D	SL	DSL	ID	Q	Y	34-66%	N	Road + Timber harvest	
Field verification					D	SL	DSL	**IR**	Q	**N/A**	**N/A**	N	Road + Timber harvest	Activity state changed from Inactive Dormant to Inactive Relict.
Air photo interpretation	2	50	1503-114	Seven Lakes Basin	D	FL	DFL	ID	D	Y	67-100%	N	Road + Timber harvest	
Field verification										**NOT A SLIDE**				Field verification determined this is not a slide.
Air photo interpretation	3	49	1503-166	Seven Lakes Basin	R	FA + SL	RFA + SL	ID	D	N	N/A	N	Natural	
Field verification					R	FA + SL	RFA + SL	ID	D	N	N/A	N	Natural	No change.