

**EROSION AND TURBIDITY MONITORING
IN LOST MAN CREEK,
REDWOOD NATIONAL AND STATE PARKS
ANNUAL REPORT FOR 2003-2004: YEAR 2**

By:

Randy Klein, Hydrologist
Terry Spreiter, Supervisory Geologist
Gregory Gibbs, Geologist

With Contributions by:
Mike Sanders, Geologist
Neal Youngblood, Geologist

Redwood National and State Parks
February, 2005

TABLE OF CONTENTS

Background and Project Objectives.....	1
Study Area	2
Methods	6
Onsite Turbidity Sampling.....	6
Onsite Qualitative Monitoring	7
Offsite Water Quality Sampling and Discharge Measurement	8
Results	11
Onsite Sampling	11
Offsite Water Quality: Recording Sites.....	16
Discussion.....	34
Future Monitoring	36
Literature Cited.....	37

FIGURES

Figure 1. Location map of study area in Lost Man Creek watershed	3
Figure 2. Physiography of Lost Man Creek with monitoring sites	4
Figure 3. Comparison of WY2003 and WY2004 discharges in South Fork Lost Man Creek	10
Figure 4. Onsite turbidities from 7 December, 2003	11
Figure 5. Onsite turbidities from 13 December, 2003	11
Figure 6. Onsite turbidities from 29 December, 2003	12
Figure 7. Onsite turbidities from 17 February, 2004	12
Figure 8. Onsite turbidities from 26 February, 2004	13
Figure 9. Turbidity at recording sites, Nov., 2003	16
Figure 10. Turbidity at recording sites, Dec., 2003	16
Figure 11. Turbidity at recording sites, Jan., 2004	17
Figure 12. Turbidity at recording sites, Feb., 2004	17
Figure 13. Turbidity at recording sites, Mar., 2004	18
Figure 14. Onsite and recorded turbidities, 7-9 Dec., 2003	19
Figure 15. Onsite and recorded turbidities, 12-14 Dec., 2003	19
Figure 16. Onsite and recorded turbidities, 28-30 Dec., 2003	20
Figure 17. Onsite and recorded turbidities, 16-18 Feb., 2004	20
Figure 18. Onsite and recorded turbidities, 26-27 Feb., 2004	21
Figure 19. Longitudinal distribution of turbidities along the main stem	22
Figure 20. Comparison of peak turbidities at LMC and SFL	23
Figure 21. Ratio of peak turbidities at recording stations	24

TABLES

Table 1. Characteristics of Lost Man Creek watershed and sub-basins	2
Table 2. Restoration progress in Lost Man Creek as of winter, 2004	5
Table 3. Onsite turbidity locations in WY2004	6
Table 4. Summary of onsite turbidity results	15
Table 5. Erosion types and volumes at onsite turbidity monitoring locations, WY2003-04	27

BACKGROUND AND PROJECT OBJECTIVES

Redwood National and State Parks (RNSP) has undertaken an erosion control and prevention program to reduce long-term sediment yield from lands in the Redwood Creek basin, northern California. The extensive network of abandoned and failing logging roads in the basin poses risks to water quality of streams and dependent, federally listed threatened species. RNSP initiated a watershed restoration program in 1978, following expansion of the park (PL 95-250). The goal of the program is to reduce erosion and sedimentation of streams, and to restore the natural ecosystems to conditions similar to what would have existed without the logging disturbance. The program addresses roads both within the park as well as those on private lands within the basin through cooperative agreements with landowners.

The primary focus of watershed restoration work within the park is to remove unneeded roads that pose sedimentation risks to downstream resources. The goal of this work is to reduce erosion and sedimentation risks from abandoned logging roads to accelerate the recovery of stream channels and dependent aquatic ecosystems. Typically, road removal in RNSP consists of excavating stream crossing fill material, restoring channels close to their original configuration, and placing excavated fill in stable locations to best mimic pre-disturbance topography and drainage patterns. Although completely preventing erosion following road removal is physically impossible, minimizing erosion and the resultant effects on downstream turbidity and suspended sediment concentrations (SSC) is an important goal of the program, particularly in light of studies documenting the detrimental effects of excessive and chronic turbidity on federally listed threatened salmonid species (Newcombe and Jensen, 1996; Nicholas and Hankin, 1989).

Studies of erosional responses to road removal work (Klein, 1984; Weaver and Sonnevill, 1984; Weaver et al, 1987; Madej, 2001), and over 25 years of observations of road removal work indicate that: 1) most sites will likely experience modest erosion and a few may experience relatively large volumes of erosion, 2) that most channel erosional responses occur within the first several years following road removal and greatly diminish as vegetation grows on excavation sideslopes and channels find stable grades and armor themselves with rock and woody debris, and 3) that causative factors cannot always be anticipated or mitigated. Since the inception of the program in 1978, the parks have employed adaptive management to modify restoration treatments to best meet National Park Service management policies.

With the recent listing of several salmonid species, REDW developed a Biological Assessment (BA) in consultation with NOAA Fisheries to evaluate the possible effects of road removal on listed salmonids in Lost Man Creek. The BA included a proposal to undertake a post-restoration monitoring program. Because measuring direct effects on fish is very difficult and expensive, the BA proposed to monitor the assumed primary stressors on fish arising from road removal, specifically erosion and sedimentation processes. The objectives of the monitoring program are: 1) to assess the effects of the road removal program on downstream turbidity and suspended sediment concentrations; and 2) to provide adaptive management feedback for refining erosion control methods and application criteria aimed at minimizing downstream effects and maximizing cost-effectiveness. In response, NOAA Fisheries issued a Biological Opinion (BO) supporting the restoration work with terms and conditions requiring (among other things) the proposed monitoring program.

A monitoring plan was developed for the 2002-03 winter runoff season that included winter storm sampling for turbidity and suspended sediment concentration (SSC) at stream crossings and several other downstream locations in the watershed. Monitoring was continued in 2003-04, with several improvements in the monitoring strategy. Data were collected through a services contract by a private consulting firm and were provided to RNSP for analysis and reporting. Results are presented herein.

Study Area

Lost Man Creek is a major tributary to Prairie Creek, composing about one-third of total basin area (see Fig. 1), and has been the main focus of recent restoration efforts by RNSP. Table 1 gives physical characteristics of sub-basins in Lost Man Creek. Similar to much of the former old-growth redwood areas in north coastal California, Lost Man Creek was heavily logged and roaded during the 1950s to early 1970's, prior to implementation of the state's forest practice rules in 1975. Forest land use during this period consisted of largely unregulated road and landing construction, and many large areas were clearcut. Lost Man Creek, experienced widespread erosion and sedimentation during the 1955, 1964 and later floods in response to this unregulated logging. The Middle and South Forks and the remaining old growth along the lower main stem were acquired by the National Park Service in 1968; the area north of Geneva Road, including most of the North Fork and Larry Damm Creek, was not acquired until 1978, and experienced particularly severe ground disturbance during the final phase of logging, just prior to the park expansion. Figure 2 shows the geography and physiography of the watershed.

Table 1. Characteristics of Lost Man Creek watershed and sub-basins.

<i>Sub-basin</i>	<i>Drainage Area (mi²)</i>	<i>Drainage Area (acres)</i>	<i>Mean Basin Slope (%)</i>	<i>Elevation Range (ft)</i>	<i>Area in Prairie Creek Fm.(PPpc) (acres [%])</i>	<i>Area in Old Growth (acres)</i>
Larry Damm Creek (LDC)	1.9	1181	27.6	1600	853 [72%]	245
North Fork Lost Man Creek (NFL)	2.4	1422	35.6	1440	742 [52%]	135
Middle Fork Lost Man Creek (MFL)	2.4	1444	37.0	1600	583 [40%]	35
South Fork Lost Man Creek (SFL)	4.3	2522	39.3	1920	177 [7%]	304
Other Areas (Interfluves)	1.1	1160	---	---	106 [9%]	1116
Lost Man Creek at Hatchery (LMC): Basin Mouth Totals	12.1	7729	34.9	2180	2461 [32%]	1835

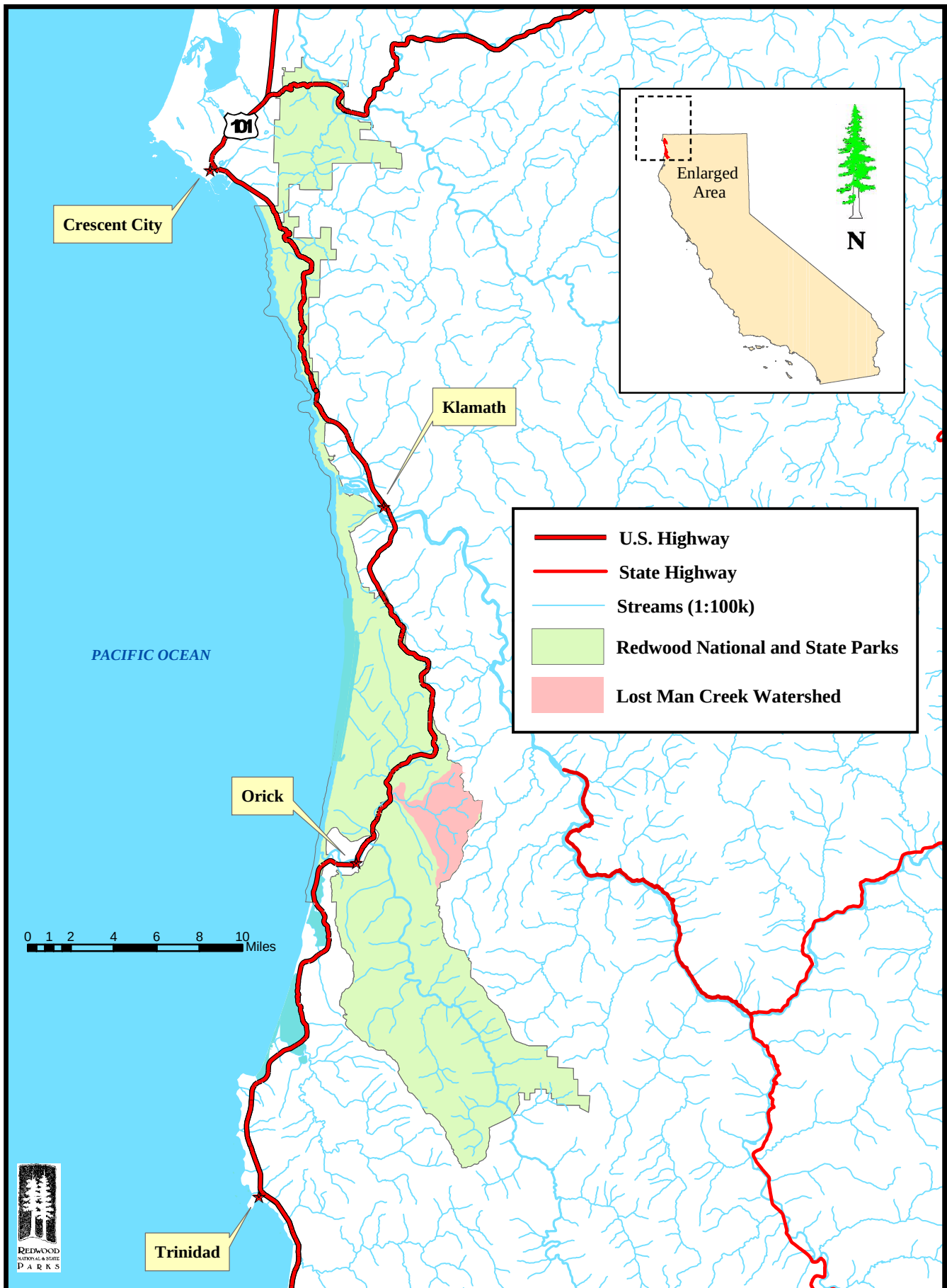
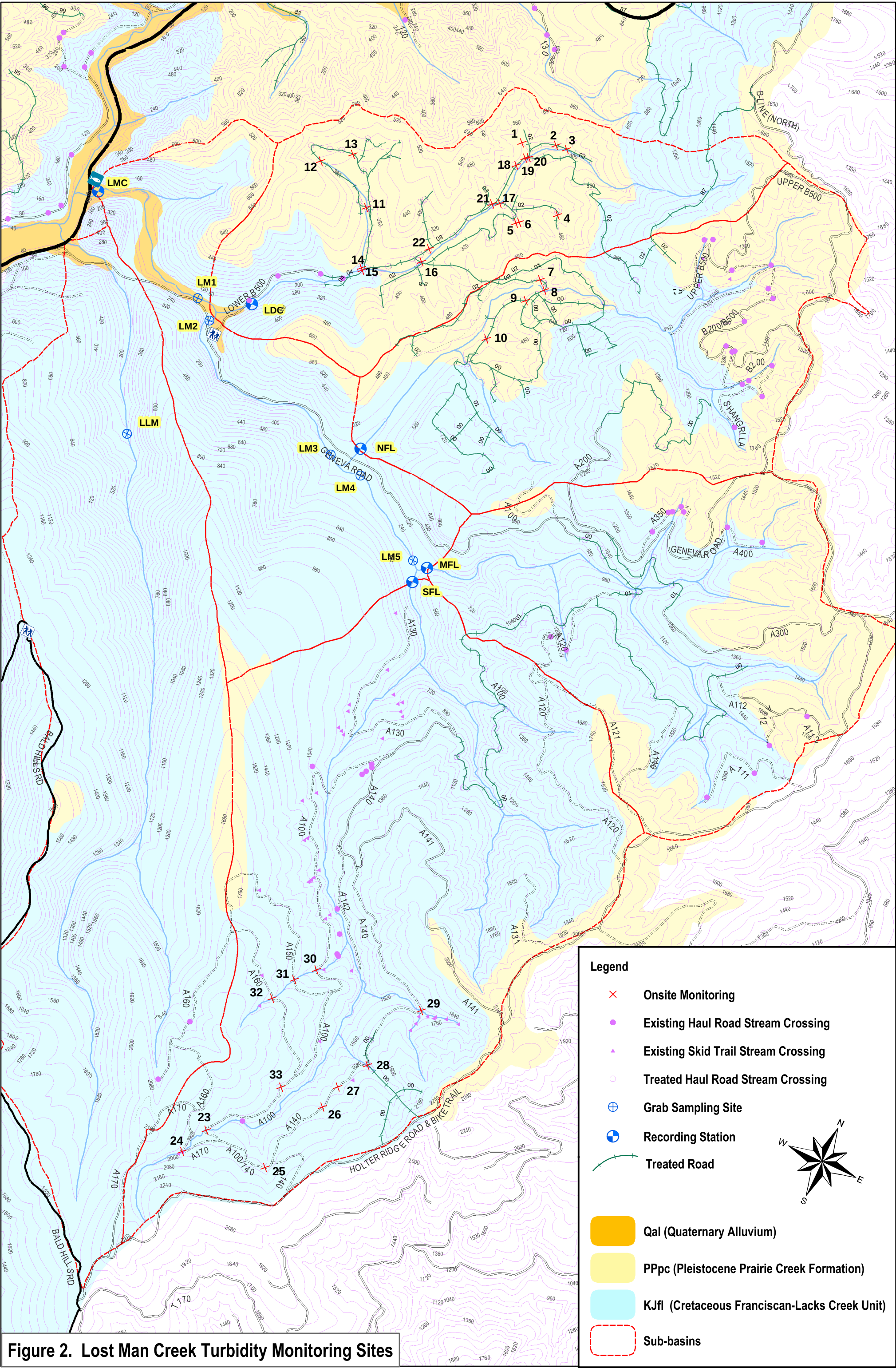


**Figure 1: Lost Man Creek - Redwood National and State Parks
General Location Map**



As shown in Table 1, a significant portion (32%) of this watershed is underlain by the Prairie Creek Formation (PPpc, Fig. 2), with virtually all of the rest of the watershed (75%) underlain by the somewhat more stable Coherent Unit of Lacks Creek (Franciscan Assemblage) (Kjfl, Fig. 2). Observations indicate that hillslopes within the Prairie Creek Fm. are particularly susceptible to erosion following disturbance (prior logging, recent road removal), thus restoration work in this formation requires additional efforts to avoid or minimize post-excavation erosion.

Table 2 lists data on recent road removal work in the watershed. Approximately 44 miles of haul roads have been identified for removal as part of the restoration of the Lost Man Creek watershed (note that these numbers may change as more of the watershed is field mapped). Between the beginning of restoration work in Lost Man Creek in 2000 and 2003, nearly half of these roads have been treated, with the remainder to be treated within the next 5-10 years.

Table 2. Restoration progress in Lost Man Creek as of winter, 2004.

<i>Sub-basin or Interfluve Area</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>	<i>Cum. to date</i>
Miles of Haul Roads					
Larry Damm Creek (LDC)	0	0.0	2.9	4.2	7.1
N. Fork Lost Man Creek (NFL)	6.9	1.6	2.4	0	10.9
M. Fork Lost Man Creek (MFL)	2.1	1.5	0	0	3.5
S. Fork Lost Man Creek (SFL)	2.0	0.7	0	0	2.7
Interfluves	0	0	0	0	0
Total Miles:	11.0	3.8	5.2	4.2	24.2
Number of Stream Crossing Excavations (haul roads, skid trails, and swales)					
Larry Damm Creek (LDC)	0	0	36	39	75
N. Fork Lost Man Creek (NFL)	32	11	16	0	59
M. Fork Lost Man Creek (MFL)	7	5	0	0	12
S. Fork Lost Man Creek (SFL)	19	1	0	0	20
Interfluves	0	0	0	0	0
Total Number:	58	17	52	39	166
Volume of Stream Crossing Excavations (cubic yards)¹					
Larry Damm Creek (LDC)	0	0	160,565	146,060	306,625
N. Fork Lost Man Creek (NFL)	127,877	54,595	26,896	0	209,368
M. Fork Lost Man Creek (MFL)	30,560	14,488	0	0	45,048
S. Fork Lost Man Creek (SFL)	62,969	20,755	0	0	83,724
Interfluves	0	0	0	0	0
Total Volumes:	221,406	89,838	187,461	146,060	644,765
Volume Not Within Stream Crossings ('export outslope', cubic yards)¹					
Larry Damm Creek (LDC)	0	0	106,375	80,100	186,475
N. Fork Lost Man Creek (NFL)	52,271	33,481	59,806	0	145,558
M. Fork Lost Man Creek (MFL)	10,870	6,209	0	0	17,079
S. Fork Lost Man Creek (SFL)	17,520	13,963	0	0	15,683
Interfluves	0	0	0	0	0
Total Volumes:	80,661	53,653	166,181	80,100	380,595

METHODS

The main focus of this project was to document the effects of road removal on erosion and sedimentation or water quality, specifically turbidity and suspended sediment concentration. A suite of both onsite and offsite water sampling stations was established in the first year of this project (see monitoring report of July, 2003). Most of these stations, along with a suite of new ones, made up the sampling network for the 2003-2004 study period (see Fig. 2).

Onsite Turbidity Sampling

Because of its ease of measurement and strong correlation with erosion and sedimentation, turbidity was selected as the primary water quality monitoring parameter for onsite samples. Samples were not tested for suspended sediment concentration (SSC) because turbidity alone was sufficient for evaluating the relative magnitude of onsite water quality effects and far less expensive.

Onsite water sampling for turbidity consisted of taking nested (upstream-downstream) sample pairs at a subset of both treated and untreated stream crossings in Lost Man Creek. Of the 58 stream crossings excavated in 2002, 12 (21% of the total) were selected for water quality sampling during winter storms in WY2003, and monitoring was continued at 9 of these same sites in WY2004 to evaluate second-year water quality. In 2003, 39 stream crossings were excavated, and 9 of them (23%) were chosen as water quality monitoring sites. In addition, eleven (11) untreated stream crossings were also monitored to compare with the excavated crossings, bringing the total number of onsite sampling locations to 29 for WY2004. The locations of these sampling sites are shown in Figure 2. Table 3 shows their distribution within the watershed.

The selected sites include a range of excavation sizes and settings, with consideration to relative ease and safety of winter access. Due to the layout of the roads within Larry Damm Creek, and the scheduling of the work in the basin over 2 years, the majority (8 out of 12) of the 2002 excavation sites were on tributaries to Larry Damm Creek with no other restoration work upstream. All but one of the 2003 excavation sites had extensive restoration work upstream, and 4 of the 9 sites were main stem excavations, where incoming turbidity was influenced by activities throughout the basin.

Table 3. Onsite turbidity grab sampling locations in Lost Man Creek, WY2004.

Sub-basin	2002 Excavations	2003 Excavations	Untreated Crossings
Larry Damm Cr.	5 (No. 1-3, 5, 6)	9 (No. 14-22)	0
N. Fork Lost Man	4 (No. 7-10)	0	0
S. Fork Lost Man	0	0	11 (No. 23-33)
Total Number	9	9	11

Two grab samples were taken at each sampled crossing to compare water entering the site with water leaving the site. The downstream sample was taken first to avoid contamination from sediment that might be generated by walking within the crossing, although this was avoided to the extent possible. Wide mouth sample bottles were used for sampling as these allow rapid water entry without submerging the bottle's mouth, a condition that could cause contamination by re-

circulation of stream water within the bottle. Care was taken not to contaminate the sample with streambed sediment by selecting locations with sufficient water depth.

Grab samples of water were taken during five storm events in the 2003-2004 winter runoff season (WY2004). Attempts were made to obtain grab samples from all onsite stations during significant rainstorms as these are the times when erosional activity and turbidity generation within the stream crossing excavations would be most likely to occur. However, delays in site selection as well as practical difficulties in getting to all site during a single sampling round caused the sampling to be incomplete for four of the five storm events (all **except** the Dec. 29, 2003, event).

Turbidity of most samples (those with <1000 NTU) was determined using a Hach 2100P portable turbidimeter by the contractor. Samples exceeding 1000 NTU were diluted to allow the meter to provide a reading within the range, and the turbidity of the original sample was estimated by multiplying the diluted turbidity by the dilution factor (usually 2).

Onsite Qualitative Monitoring

Onsite monitoring also included qualitative observations of erosional activity and photo-documentation (photopoints) during periodic visits to the project sites by the responsible project geologists (RNSP staff). Pertinent observations of erosion processes and conditions were made at the 21 stream crossing excavations monitored in 2003-2004. Photos were taken and observations of erosion and sedimentation (processes, quantities, and possible causes) were recorded on field forms. Though mostly qualitative, such observations are important for documenting the timing and magnitude of erosion processes and for understanding why some sites performed well and others did not.

Photopoints: Photopoints are monumented locations where repeated photographs are taken of the same location over time to document changes (e.g., erosion, and vegetation growth). Photopoint locations are monumented, either by use of permanent features (e.g., a stump) or by establishing a monument using a PVC stake. Depending on the stream crossing and the ability to capture the entire excavated area, the number of photopoints may differ from site to site. A typical site would have a likely minimum of 2 or 3 photopoints. One photopoint was typically established proximal to the channel at the upstream end of the excavation with a view looking downstream. Others were established on the excavation side slopes at the downstream end of the excavation. Where the length of the excavated channel was exceptionally long, additional photopoints were established to adequately document original conditions and the subsequent changes.

The first set of photos taken in fall, 2003 (following excavation) document the initial conditions for qualitative comparison with follow-up spring photos taken from the same locations and with the same framing. Additional photos were occasionally taken during mid-winter site reconnaissance visits, depending on whether or not there were any noticeable changes. A complete set of post-winter photos were taken by summer, 2004.

Erosion Assessment Forms: Erosion was also tracked during the winter by use of simple assessment forms. The forms require separate information on three types of erosion: surface erosion, mass wasting erosion (referred to as “bulk erosion” on the forms), and channel erosion.

Visual estimates were made of volumes displaced from hillslope positions and the proportion of those volumes that was ‘delivered’ (entered a stream channel), along with possible causes and mechanisms of failure.

Surface erosion, generally in the form of rilling, was categorized as high, medium, or low, with the surface area estimated. Channel erosion dimensions (length, width and depth) were visually estimated and recorded to estimate volume. Mass wasting features were categorized as bank slumps (referred to as “channel scallop” on the forms), shallow debris slides and earth flows. The dimensions (length, width, and depth) were visually estimated to quantify volume. The delivery volume (as a percentage of the entire mass) was also estimated. Features such as seeps or springs that could give rise to future failure were documented.

The assessment form also included a sketch of both new and enlarged erosion features that were noted on each site visit. Initially, a site-specific template sketch was prepared that included permanent features useful as reference markers (stumps and large woody debris). On each visit, the template was updated to show new erosion features and changes to existing features as they evolved through the wet season. Erosion volumes from these assessments are presented in the results section of this report.

At the end of the wet season, each geologist summarized the post-excavation erosional activity observed on his or her respective projects. These were included in the individual project reports and in this report. The project reports and erosion assessment forms are archived at RNSP’s South Operations Center (SOC) in Orick, CA.

Offsite Water Quality Sampling and Discharge Measurement

In addition to onsite monitoring, hydrologic monitoring was done ‘offsite’ at ten locations on larger streams in the watershed. The spatial distribution of offsite sampling locations (Fig. 2) was selected to provide treatment and control subbasins to evaluate effects of road removal on downstream water quality. Two of the sites (‘LMC’, or Lost Man Creek at the former Prairie Creek Fish Hatchery, and ‘SFL’, or South Fork Lost Man Creek) were set up as recording stations for WY2003, where stage and turbidity was electronically recorded at 10-minute intervals. LMC is near the basin outflow to Prairie Creek, while SFC is a tributary basin farthest from the confluence with Prairie Creek (Fig. 2).

Three tributaries located between SFL and LMC (Larry Damm Creek (LDC), North Fork Lost Man Creek (NFL), and Middle Fork Lost Man Creek (MFL); see Fig. 2) were manual sampling sites in WY2003. To obtain a more complete picture of offsite tributary responses to restoration work, the three tributary stations (LDC, NFL, and MFL) were retrofitted with automated equipment (data logger, stage sensor, and turbidity sensor) to record hydrologic information on 10-minute intervals in WY2004. Combined with the two recording stations installed the previous year (South Fork Lost Man and Main Channel Lost Man at the Hatchery), a total of five recording stations were employed in WY2004.

Water samples were taken during stormflows at the five recording sites. Almost all offsite samples were depth-integrated samples (DIS), but a few grab samples similar to onsite sampling were also

taken. Samples were transported to a laboratory soon after collection and tested for turbidity using a Hach 2100P portable turbidity meter. Offsite samples were also analyzed for suspended sediment concentration (SSC) using filtration methods. To complement the water quality data, stage readings and discharge measurements were also taken manually, and discharge rating curves were constructed to convert recorded stage data to discharge.

Five other offsite sampling locations along the main channel of Lost Man Creek were also sampled in WY2003 and continued in WY2004. These are labeled LM1-5 in Figure 2, and they bracket the mouths of the main tributaries. They were included to provide redundancy with the tributary sites and to characterize variation in turbidity along the main channel of Lost Man Creek.

Hydrologic monitoring began in October, 2003, at the beginning of the federal water year, although several of the new recording stations were not operational until later in the season. Some gaps in data recording occurred due to equipment failure and vandalism (see Results section).

Selection of offsite sampling locations was guided by a ‘treatment/control’ sampling strategy. Larry Damm Creek and North Fork Lost Man Creek provided treatment cases (road removal occurred in 2002), while the Middle Fork Lost Man Creek and the South Fork Lost Man Creek served as controls. It should be noted that the South and Middle Forks both had a moderate amount of road removal in 2000-2001, but none in 2002 or 2003, and thus they should be considered quasi-controls. In addition, a long term gaging station on Little Lost Man Creek (LLM, drainage area = 3.46 sq. mi.) is adjacent to Lost Man Creek and is virtually pristine, thus it serves as an additional control. As described earlier, watershed geology and slope varied among the tributary basins, thus some of the differences in turbidity and SSC may be due to these independent variables.

Following are descriptions of offsite recording stations (also see Table 1):

Lost Man Creek at Fish Hatchery Site (LMC): This site drains nearly the entire basin area of Lost Man Creek, about 12.1 mi². The area above LMC consists of a combination of residual and old growth redwood stands and areas disturbed by extremely destructive logging practices of the 1950s-70s. Road removal work has been underway since 2000. Geology consists primarily (about 66% of basin area) of Franciscan sedimentary rocks (Coherent Unit of Lacks Creek, or KJfl, Fig. 2), with virtually all of the rest (32% of basin area) underlain by Prairie Creek Fm rocks derived from fluvial and marine sediments (PPpc, Fig. 2).

Larry Damm Creek (LDC): This is the first named tributary entering Lost Man Creek upstream from LMC, entering the main channel from the north. Drainage area upstream from the sampling site is about 1.9 mi². Extensive road removal work occurred in 2002 and 2003. Clearcut logging and tractor yarding in the 1960’s and 70’s caused extensive ground disturbance in all but the lowest portion, where substantial old growth was left behind and remains today. The geology is primarily Prairie Creek Fm. (72% of basin area) with the remainder underlain by Franciscan Fm. The most intense logging occurred in the area underlain by the Prairie Creek Formation.

North Fork Lost Man Creek (NFL): This is the second named tributary entering Lost Man Creek upstream from LMC, entering the main channel from the north. This site drains about 2.4 mi² of

watershed area. Road removal work has occurred each year in 2000-02, but none occurred there in 2003. While land use and remnant old growth is similar to Larry Damm Creek in the middle and lower portions of the sub-basin, the upper watershed was selectively logged in the 1950's and 1960's, and ground disturbance was moderate. The geology consists of both the Franciscan and Prairie Creek Formations in approximately equal proportion.

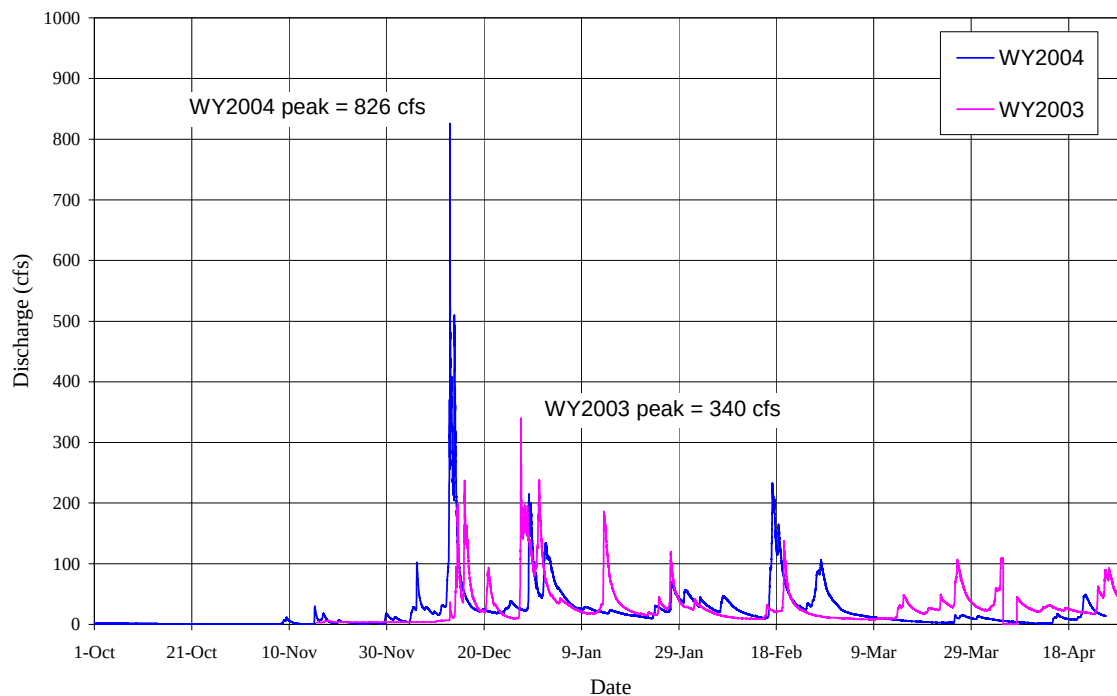
Middle Fork Lost Man Creek (MFL): Drainage area upstream from this site is about 2.4 mi². This sub-basin was selectively logged in the 1950's and 1960's, and ground disturbance is moderate. Road removal work occurred in 2000 and 2001, with none occurring in 2002-03. The geology consists of both the Franciscan (60%) and Prairie Creek (40%) formations.

South Fork Lost Man Creek (SFL): This was the site of a former USGS synoptic stream gaging station (No. 11482450, "Lost Man Creek near Orick", 1974-75). Drainage area above the site is 4.3 mi². This sub-basin was selectively logged in the 1950's and 1960's, and ground disturbance was moderate. Road removal work occurred in 2000 and 2001, with none in 2002-03. The geology consists of primarily the Franciscan Fm (93%), with only a very minor proportion underlain by Prairie Creek Fm. (7%). A substantial tract of old growth remains in the lower western part of the basin.

RESULTS

Following are results from both the onsite and offsite data collection from WY2004, consisting of both automatically recorded data from the five gaging stations and manual samples of stream water taken from both the gaging sites and onsite locations. An important preface to discussing sampling results is to put the study period into hydrologic perspective. Figure 3 shows streamflow for South Fork Lost Man Creek (SFL) for WY2003-04. As shown, the peak discharge in WY2004 was much higher than in WY2003. From this it is assumed that hydrologic stresses should have caused much more erosion and suspended sediment transport in WY2004 than in WY2003, all other factors being equal. However, because the restoration work done in 2002 had a full year to season, those site would have generally been more stable than the more recent (2003) worksites.

Figure 3. South Fork Lost Man Creek (SFL) discharge, Oct-Apr, WY2003-04



Onsite Sampling

For several reasons (lateness of site selection, large number of onsite locations, and access challenges), sampling was inconsistent among the onsite sampling locations employed in WY2004. Nonetheless, 210 samples were taken covering the five major storm periods of the 2003-2004 winter runoff period. Figures 4-8 show the onsite sampling results for the five storms sampled.

Figure 4. Onsite water sampling results from 7 December, 2003 (first round),
for treatment sites in Lost Man Creek, WY2004

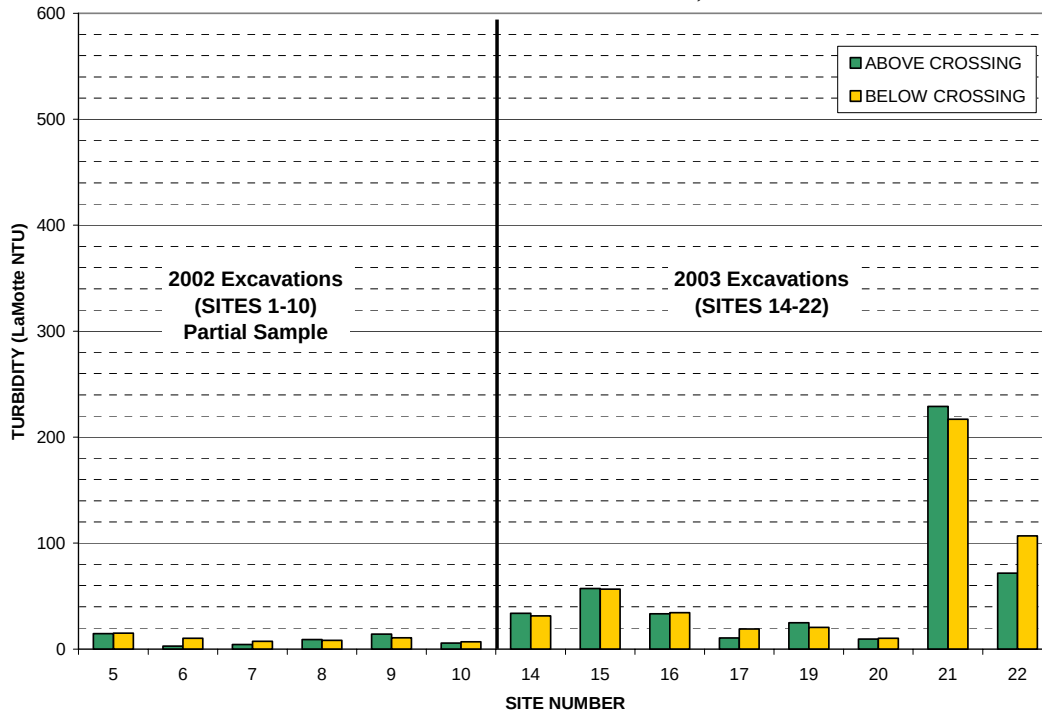


Figure 5. Onsite water sampling results from 13 December, 2003, for treatment sites
in Lost Man Creek, WY2004

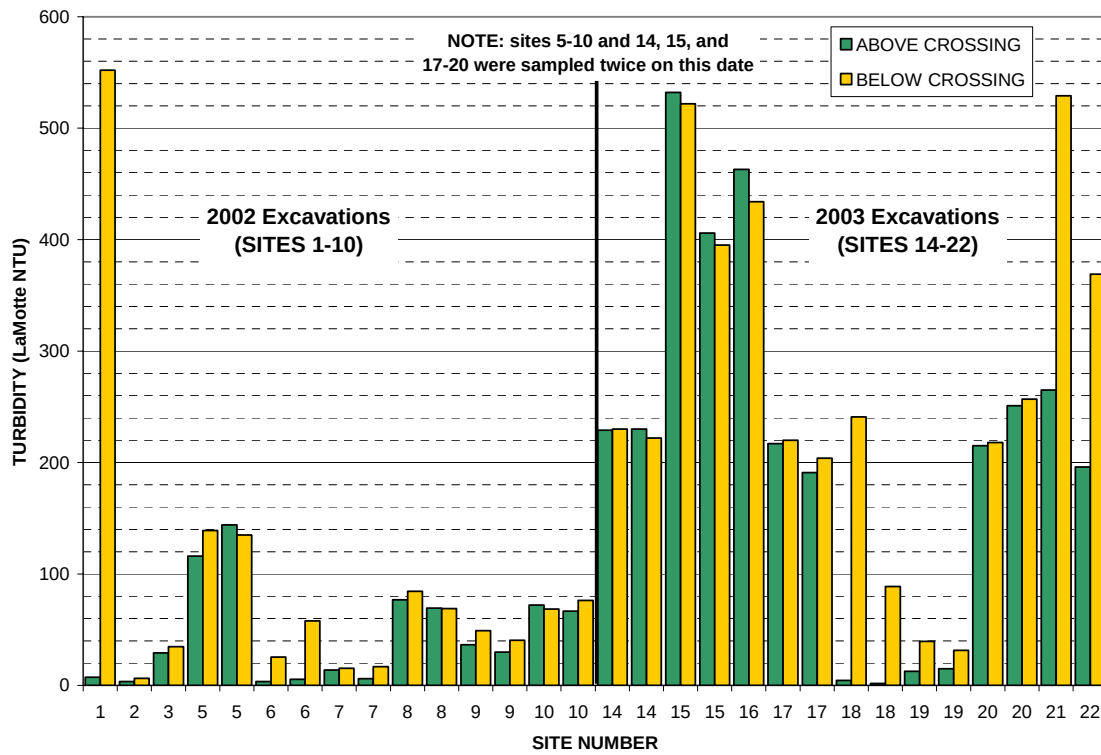


Figure 6. Onsite water sampling results from 29 December, 2003,
for treatment and pre-treatment control sites in Lost Man Creek, WY2004

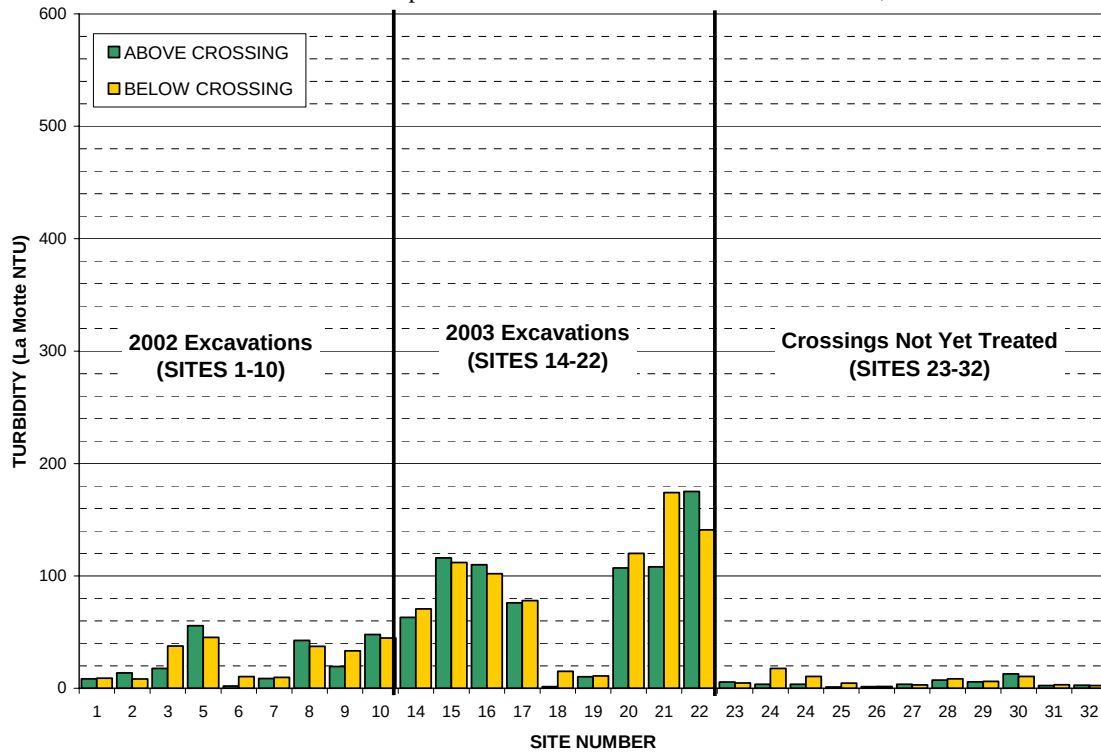


Figure 7. Onsite water sampling results from 17 February, 2004,
for treatment sites in Lost Man Creek, WY2004

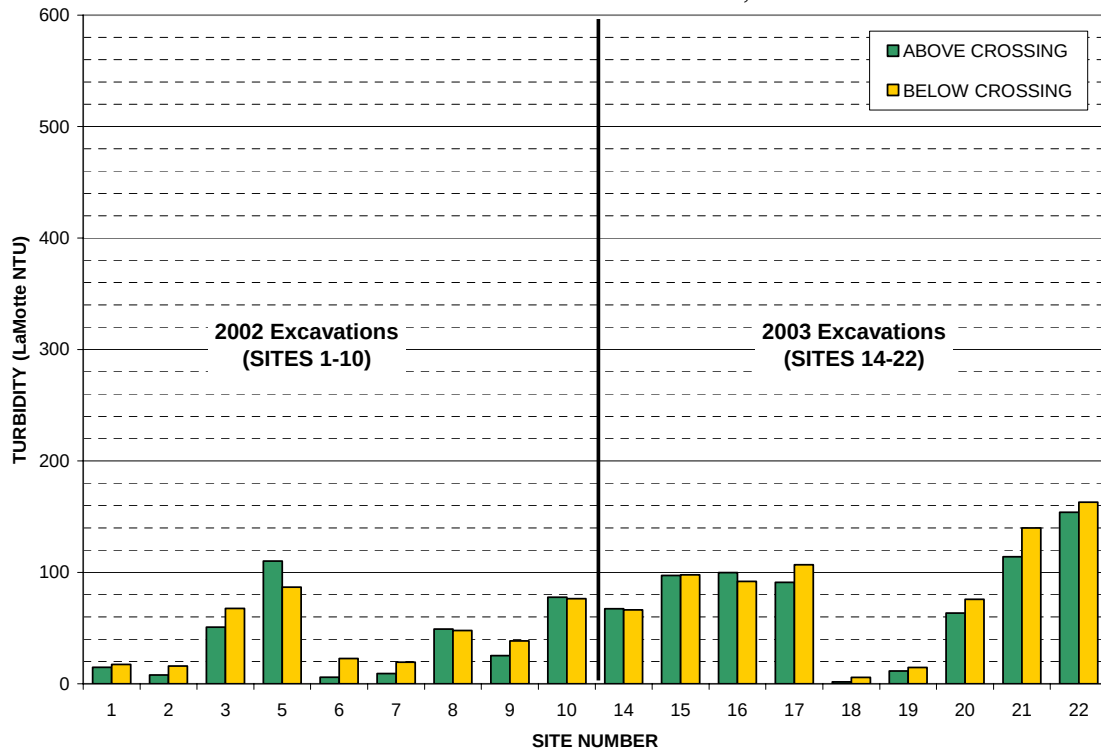


Figure 8. Onsite water sampling results from 26 February, 2004,
for pre-treatment control sites in Lost Man Creek, WY2004

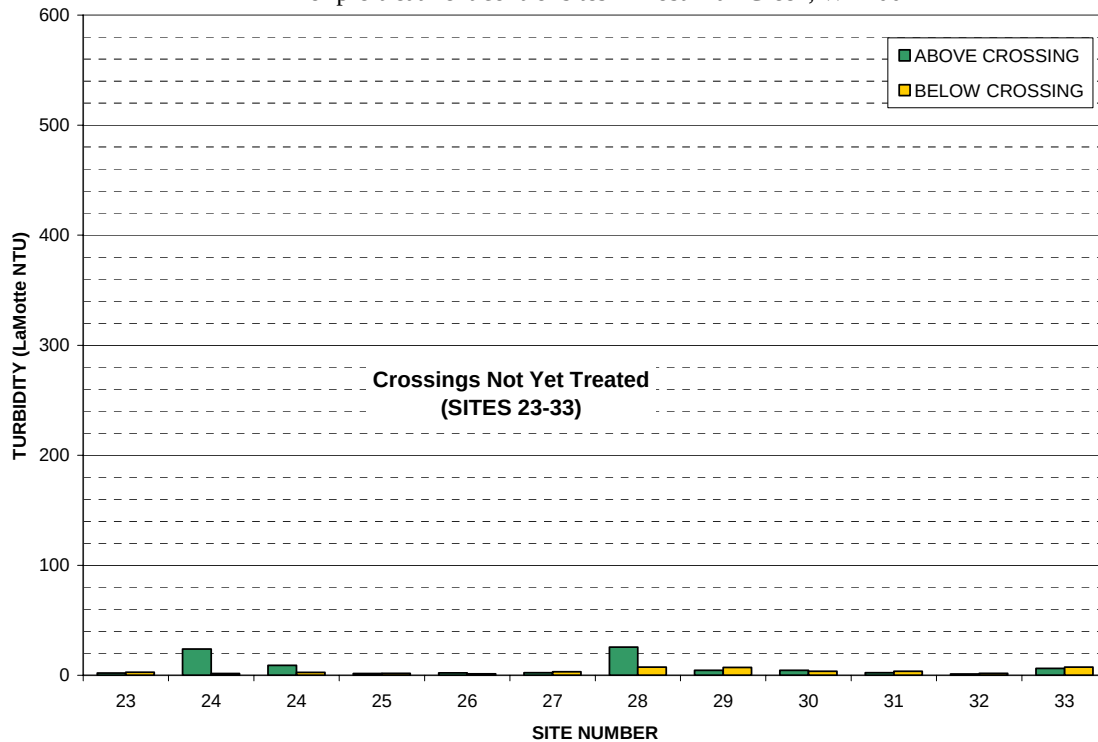


Table 4 summarizes onsite turbidity increases measured during WY2004 grouped in several different ways. Note that the summaries for ‘all data’ should be viewed with caution as many low turbidity sample pairs were included in this group. The group including only those sample pairs where the downstream (treatment) sample exceeded 25 NTU provides a more valid summary. Equally important is to note that the sampling on any particular day spanned about 4-6 hours, enough time for significant changes in runoff in these relatively small drainages. Thus, these data should only be considered rough approximations of differences among sites and storms.

Table 4. Summary of onsite turbidity increases (percent increase through the site; negative values (red font) indicate turbidity decrease through site) for Lost Man Creek, WY2004. ('N/A' indicates no turbidities >25 NTU; 'N/S' indicates no sampling).

		Percent turbidity increase through xing						
		All Data			Only pairs where downstream sample was >25 NTU			
Grouped by:		Ave %	Min %	Max %	Ave %	Min %	Max %	Comments (n = number of sites)
Storm Date	12/7/2003 (treatment)	31	-25	262	8	-7	49	incomplete sampling; WY03 sites (n=6); WY04 sites (n=8)
	12/7/2003 (control)	N/S	N/S	N/S	N/S	N/S	N/S	no sampling
	12/13/2003 (treatment)	671	-6	7441	735	-6	7441	all treatment sites sampled (n=18)
	12/13/2003 (control)	N/S	N/S	N/S	N/S	N/S	N/S	no sampling
	12/29/2003 (treatment)	88	-40	979	19	-19	114	all treatment sites sampled (n=18)
	12/29/2003 (control)	82	-19	390	N/A	N/A	N/A	all untreated xings sampled (n=11)
	2/17/2004 (treatment)	49	-21	288	10	-21	53	all treatment sites sampled (n=18)
	2/17/2004 (control)	N/S	N/S	N/S	N/S	N/S	N/S	no sampling
	2/26/2004 (treatment)	N/S	N/S	N/S	N/S	N/S	N/S	no sampling
	2/26/2004 (control)	-2	-93	71	N/A	N/A	N/A	all untreated xings sampled (n=11)
Sub-basin	LDC	374	-40	7441	455	-21	7441	2002 and 2003 excavations (n=17)
	NFL	28	-25	172	16	-13	72	2002 excavations (n=4)
	SFL	38	-93	390	N/A	N/A	N/A	untreated xings (n=10)
Sub-basin and Year of Treatment	LDC 2002	540	-40	7441	913	-21	7441	2002 excavations (n=9)
	LDC 2003	298	-19	5139	320	-19	5139	2003 excavations (n=9)
	NFL 2002	28	-25	172	16	-13	72	2002 excavations (n=4)
	SFL (control)	38	-93	390	N/A	N/A	N/A	untreated xings (n=10)

As shown in Table 4, percent turbidity increases within excavated crossings were sometimes quite high, although this does not necessarily indicate large impacts to water quality. For example, if upstream turbidity was 2 NTU and downstream turbidity was 27 NTU, the percent increase would be 1000%, an alarming figure except when placed in the context of the actual turbidity (streamflow at 27 NTU appears fairly clear). Additionally, comparisons of upstream and downstream pairs is subject to influences not related to erosion and sediment delivery from the treatment site, such as issues such as timing of the samples during unsteady flow conditions (i.e., storms), variable local hydraulic conditions affecting the sampling locations, inherent meter error, and variability due to how the representative sub-sample is extracted from the whole sample for measurement in the turbidimeter. Considering that these sources of variability are unrelated to road decommissioning, small turbidity differences between nested sample pairs should not necessarily be taken true differences. While data do not exist for constructing error bars around the turbidity data, we believe that differences on the order of 10% or less cannot be confidently concluded to be indicative of true differences.

Several negative values are shown in Table 4, indicating a decrease in turbidity from upstream to downstream through a site. Although it is possible that turbidity may decrease slightly as streamflow passes through a treatment site, the apparent decreases are likely due to the sources of variability mentioned above.

Although several different groupings of onsite data are provided in Table 4, perhaps the best summary exists in the grouping by sub-basin and year of treatment (near the bottom of the table). Larry Damm exhibited by far the largest turbidity increases through stream crossing excavations, while the North Fork and South Fork exhibited similarly low turbidity increases.

Surprisingly, the older excavations in Larry Damm Creek (those treated in 2002) generally exhibited higher turbidity increases than the newer excavations (treated in 2003). This is contrary to expectations of decreasing erosional activity with the passage of time and the occurrence of storms that erode the readily available material from fresh excavations. However, looking at Figures 4-8, it is apparent that the 2003 excavations were almost always higher in turbidity than the 2002 excavations, with one exception: Site 1 on Dec. 13, 2003, exhibited a large turbidity increase due to additional excavation done within the crossing in 2003. Average turbidities shown in Table 4 are significantly influenced by this unusual condition. In addition, 'percent increases' can be misleading when used as a measure of causal relationships: when the initial value is low, a small absolute increase can result in a large percent increase.

Offsite Water Quality: Recording Sites

Figures 9-13 show monthly graphs of turbidity for the high flow months (Nov-Mar) for the five recording offsite sampling stations in Lost Man Creek. Although plotting at these scales make detailed evaluation of turbidity differences among the sites difficult, gross differences are apparent. For example, Larry Damm Creek (LDC) is obviously far more turbid during the earliest and largest storms than the others (e.g., storms of Nov. 27 and 29 in Fig. 9, Dec. 13 in Fig. 10, Jan. 23 in Fig. 11, Feb. 2 and 16 in Fig. 12, and Mar. 25 in Fig. 13).

Figure 9. Turbidity at recording sites in Lost Man Creek, Nov., 2003

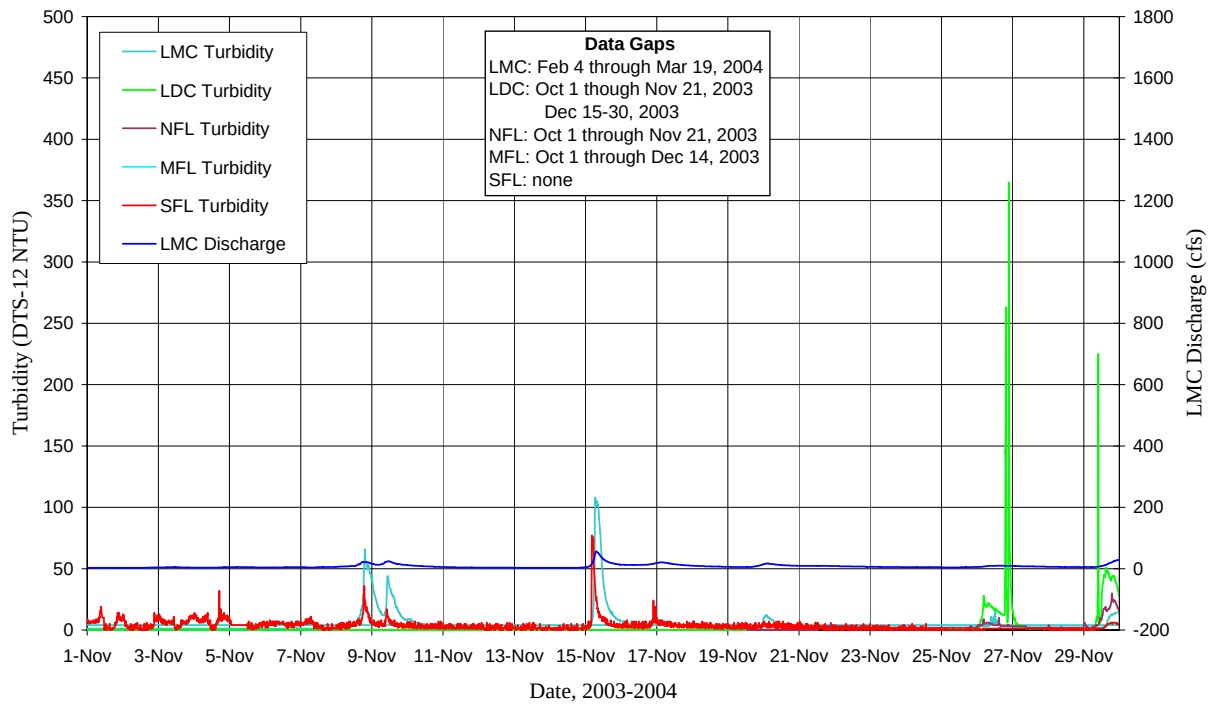


Figure 10. Turbidity at recording sites in Lost Man Creek, Dec., 2003

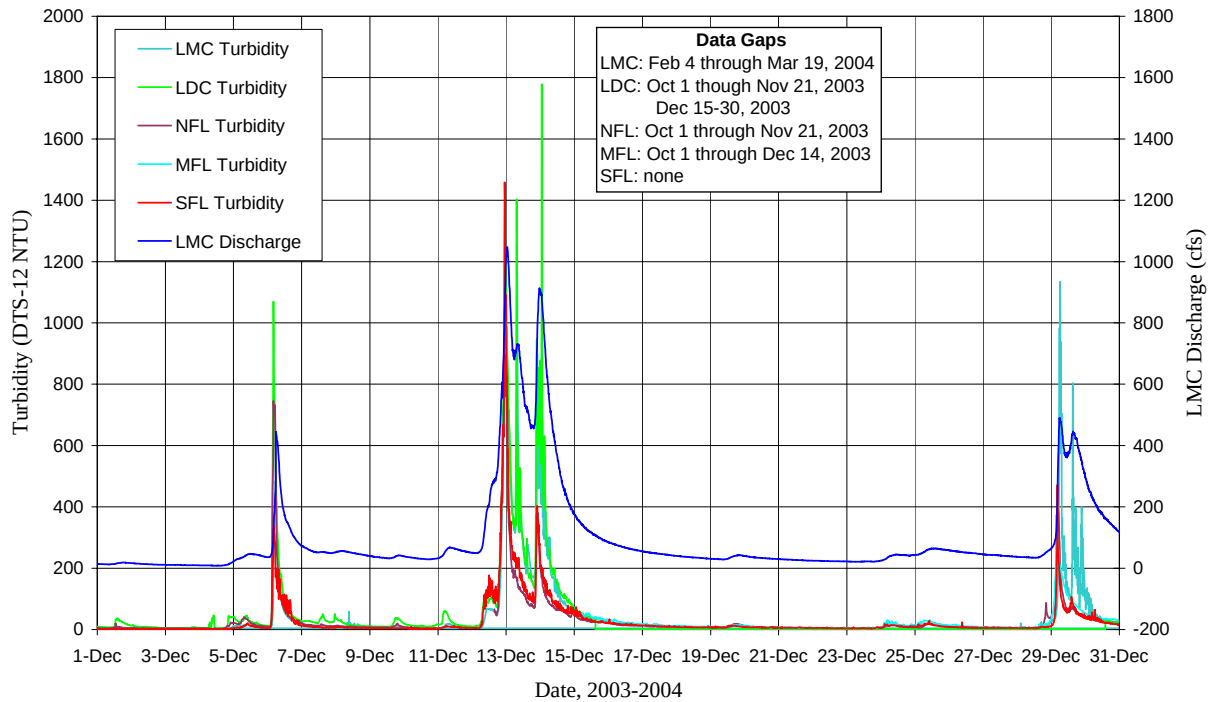


Figure 11. Turbidity at recording sites in Lost Man Creek, Jan., 2004

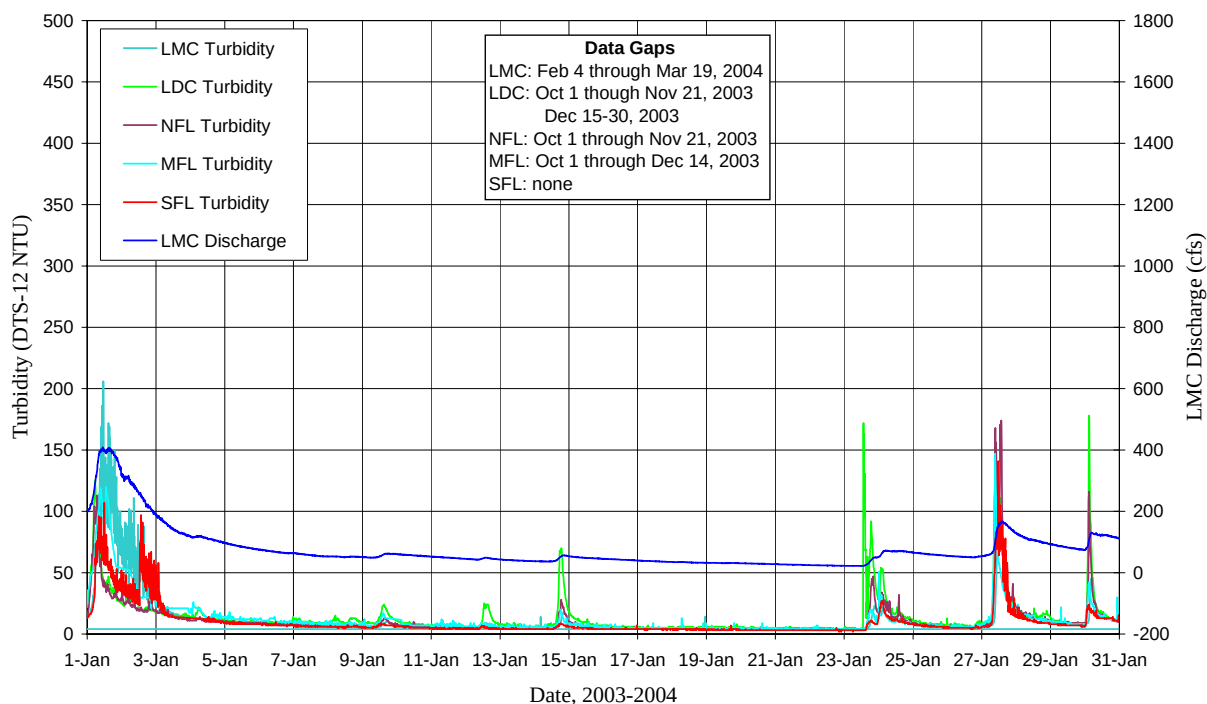


Figure 12. Turbidity at recording sites in Lost Man Creek, Feb., 2004

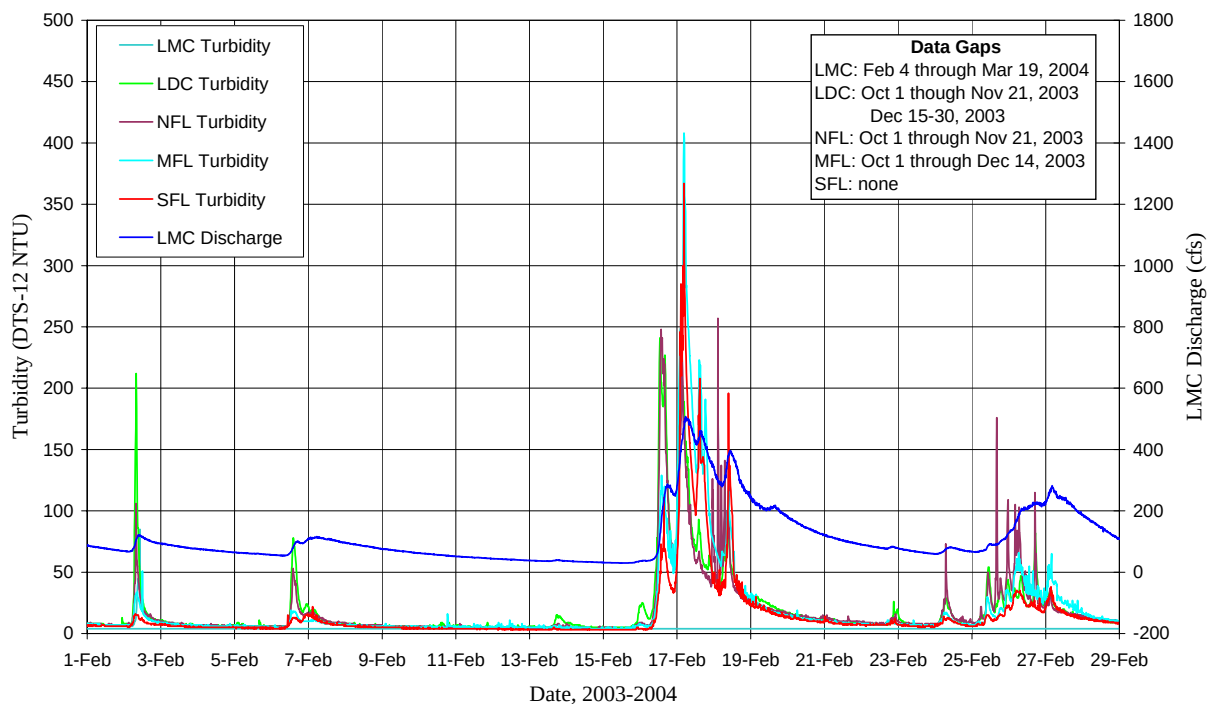
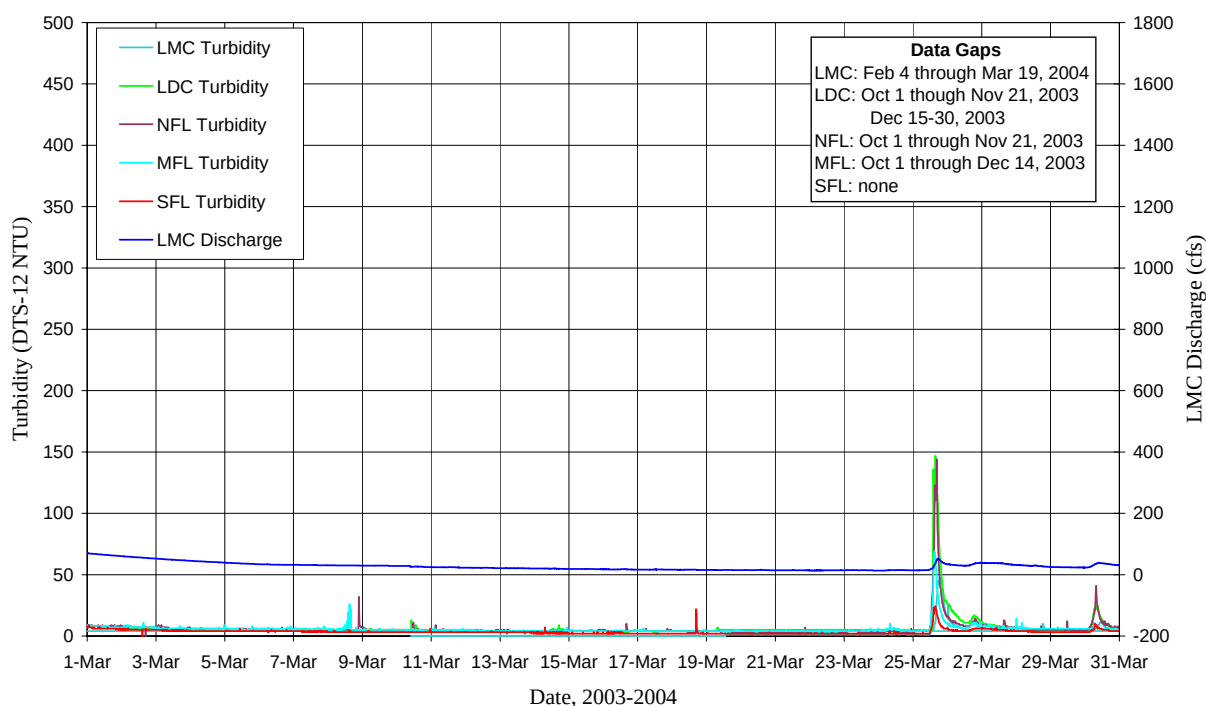


Figure 13. Turbidity at recording sites in Lost Man Creek, Mar., 2004



For a more detailed look at several storms, Figures 14-18 show turbidities from the five recording stations for the five storm periods when onsite sampling was performed (NOTE the vertical scale changes when comparing these plots). Onsite results are included in Figures 14-18 to put the onsite data into the perspective of the downstream (offsite) conditions and to help understand the practical limitations associated with manual sampling during unsteady flow and turbidity conditions typical of most storm periods. Specifically, the efficacy of manual sampling to provide a valid assessment of onsite conditions and to compare turbidity differences among sites is limited by:

- Uncertainty in deciding which storms to sample, a decision that must be made in the early hours of a rainfall event,
- The considerable time needed to mobilize field crews once the decision to sample has been made,
- The considerable time needed to make a complete sampling round, and
- The often brief times when sample sites are erosionally active.

These unavoidable practical limitations caused sampling to occur at different positions on the storm hydrograph (as shown in Figs. 14-15) and some storm peaks to be missed altogether (as in Figs. 16-18).

We specified six onsite sampling rounds in the contract for services for WY04 with a goal of sampling the largest storms of the season. The decision to manual sampling was triggered by evaluating storm magnitude in the beginning hours of the storm

Figure 14. Lost Man Creek onsite grab sample and offsite continuous turbidities, Dec. 7-9, 2003.

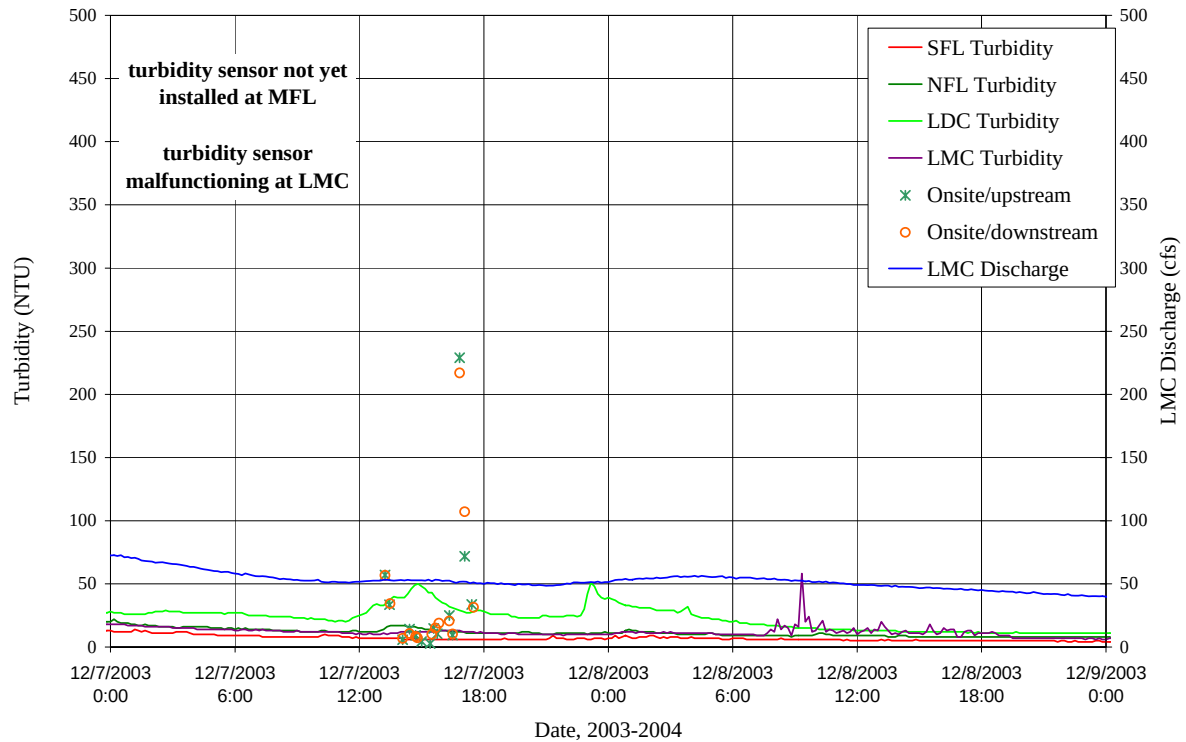


Figure 15. Lost Man Creek onsite grab sample and offsite continuous turbidities, Dec. 12-14, 2003.

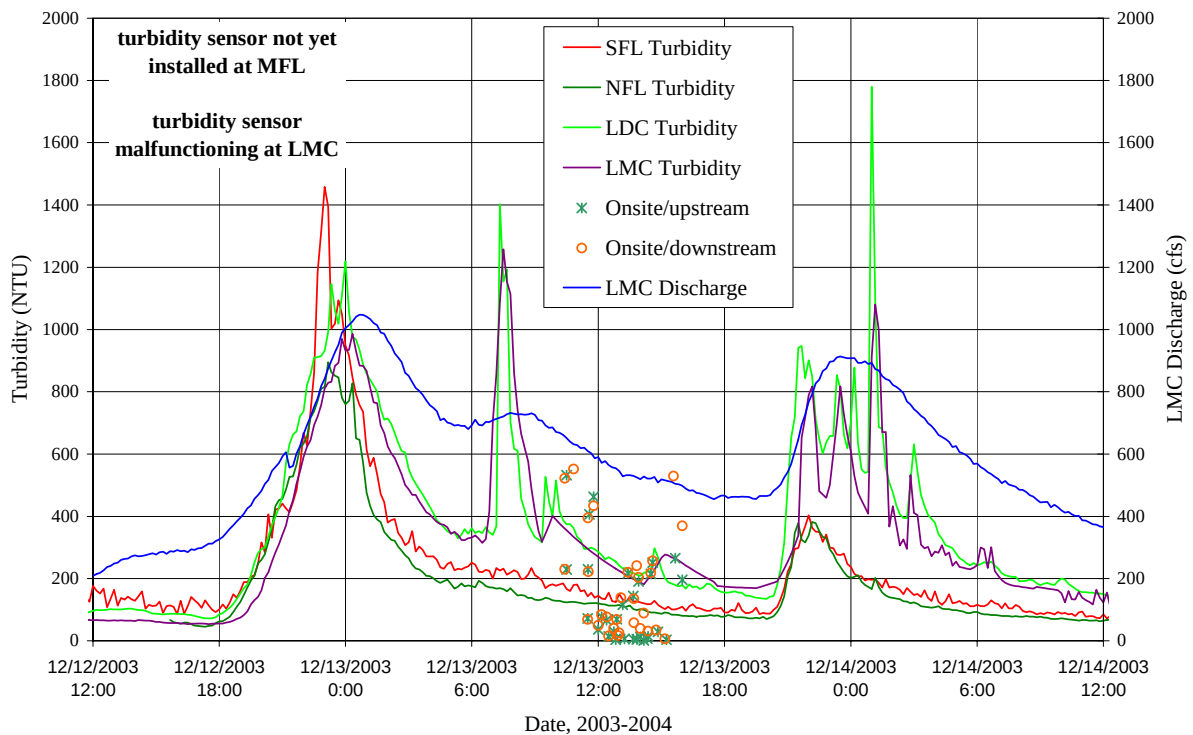


Figure 16. Lost Man Creek onsite grab sample and offsite continuous turbidities, Dec. 28-30, 2003.

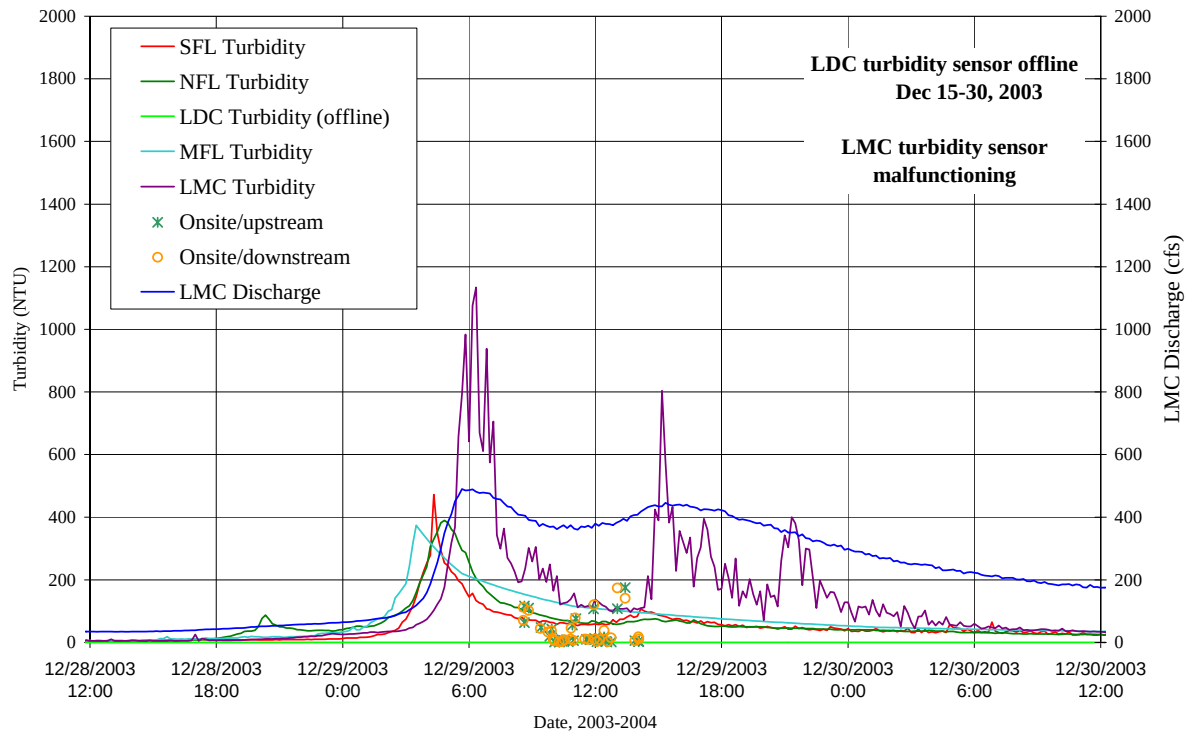


Figure 17. Lost Man Creek onsite grab sample and offsite continuous turbidities, Feb. 16-18, 2004.

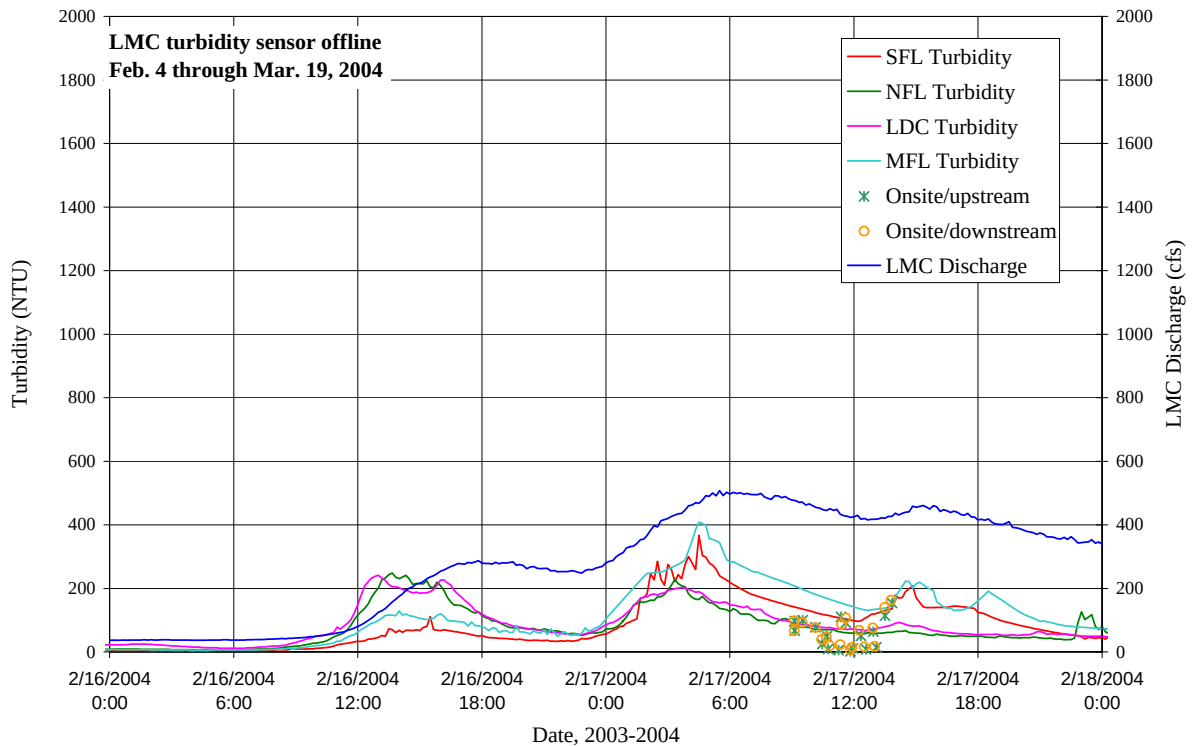
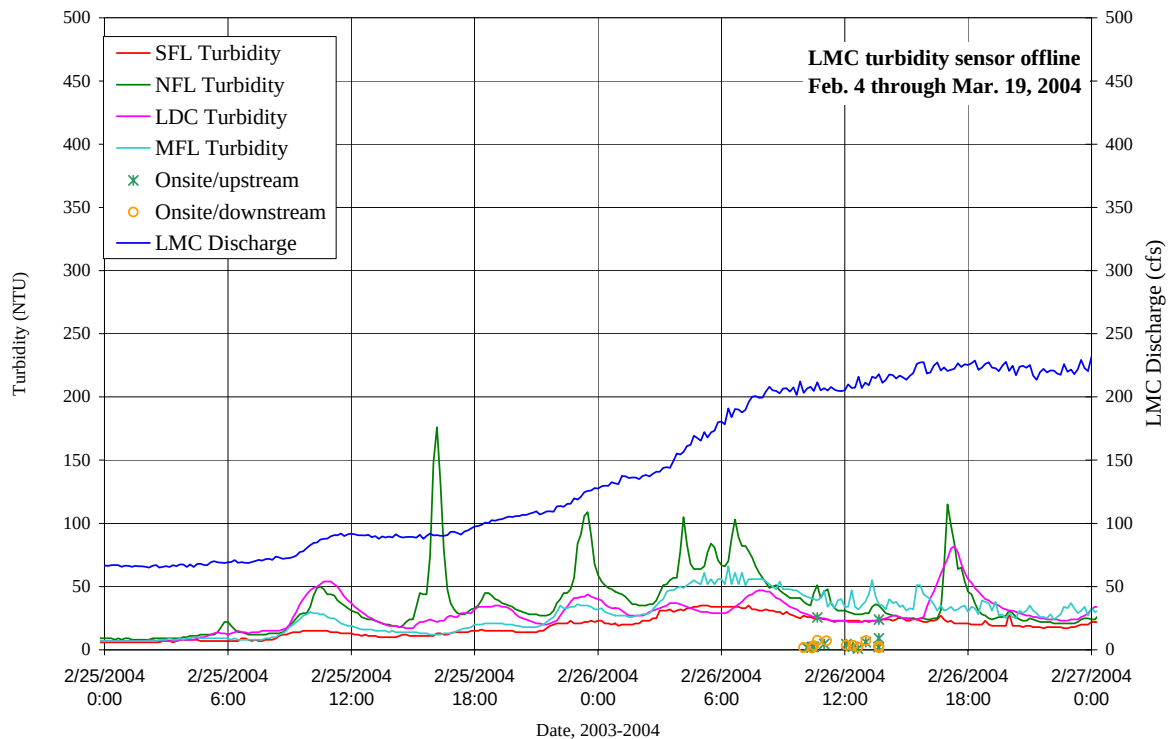


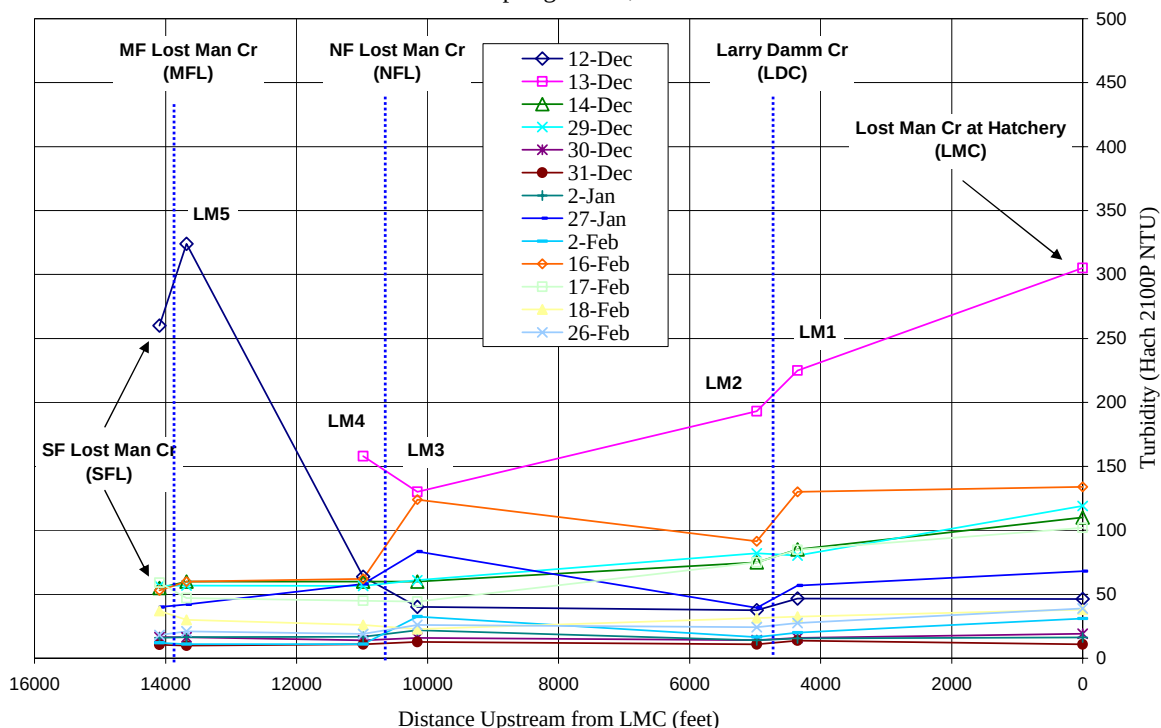
Figure 18. Lost Man Creek onsite grab sample and offsite continuous turbidities, Feb. 26-27, 2004.



The longitudinal distribution of turbidity along the mainstem of Lost Man Creek was evaluated using the five mainstem grab sampling sites (LM1-5) and the uppermost and lowermost recording stations (SFL and LMC, respectively). Figure 19 shows variations in turbidity along the mainstem for 13 sampling events in WY2004, along with the locations of the three intervening tributaries (LDC, NFL, and MFL). Most of these sampling events did not occur during times of significant storm runoff, and the turbidities for these events were generally below 50 NTU at the lowermost site (LMC). Several notable storms were those of Dec. 12 and 13, 2003, and Feb. 16, 2004.

During the first of these (Dec. 12), the South Fork and Middle Fork appeared to have contributed a great amount of turbidity in the uppermost part of the study reach, as indicated by high turbidities at SFL and LM5. Following the turbidity downstream, there appeared to be a precipitous drop in turbidity from LM5 to LM4. Considering there are no significant tributaries between these two locations that could have diluted the turbid water to this extent, we conclude that this was due instead to the non-simultaneous timing of samples. Sampling over a period of almost two hours during this event as follows: 1) 18:35 at LM4 (64 NTU), 2) 19:40 at MFL (246 NTU), 3) 19:47 at SFL (260 NTU), and 4) 20:12 at LM5 (324 NTU). This was a period of extremely rapid changes in flow and turbidity, with the largest peak flow of the season occurring at SFL at 23:30. Thus, it is highly likely that the longitudinal distribution of turbidities shown in Figure 19 for the Dec. 12, 2003, grab sampling distorts the true geographical relationships along Lost Man Creek. This was an unavoidable consequence of grab sampling.

Figure 19. Longitudinal distribution of turbidities along the mainstem Lost Man Creek for 13 sampling events, WY2004

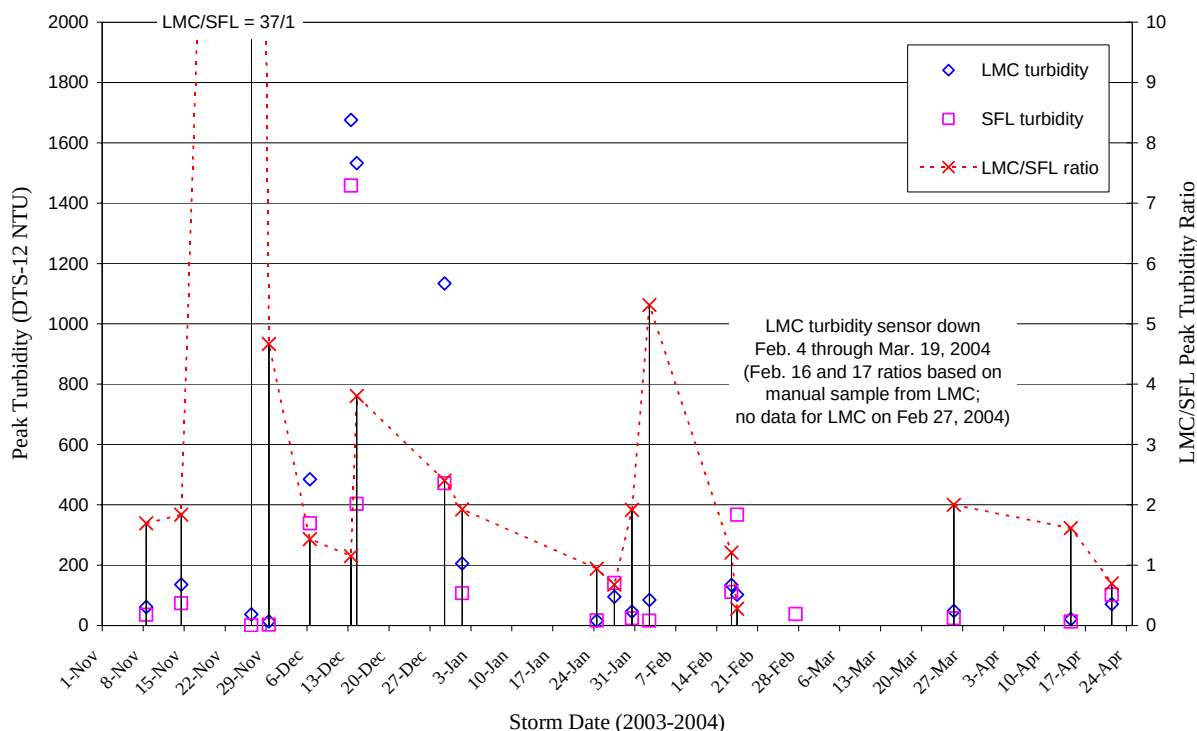


The large storm of Dec 13, 2003, exhibited a more logical longitudinal trend, but unfortunately the uppermost sites (SFL, MFL, and LM5) were not sampled. The decrease in turbidity from LM4 to LM3 suggests that mainstem turbidity was diluted by less turbid water flowing in from NFL, however, this is also likely due to non-simultaneous sampling during unsteady flows. The best example of longitudinal turbidity variation is perhaps the storm of Feb. 16, 2004. All mainstem sites were sampled, and sampling occurred during a slowly rising storm. Although the Middle Fork (MFL, control tributary) changed mainstem turbidity by only a small amount, both of the two treatment tributaries (NFL and LDC) caused the mainstem turbidity to jump significantly (from 62 to 124 NTU due to NFL inflows, and 92 to 130 NTU from LDC). However, most other sampling events showed little change in mainstem turbidity due to tributary inflows.

Figure 20 shows peak turbidities recorded at the lowest and highest gaging stations in the watershed (LMC and SFL, respectively) for the eighteen largest storm events of WY2004 (many of these were relatively small events). In addition to peak turbidities, the ratio of peak turbidities at LMC (affected by road removal in 2003) and SFL (not affected by road removal in 2003) are shown. On three relatively turbid occasions in December 2003 (Dec. 13, 14, and 29) turbidity at LMC was abnormally high relative to SFL (ratio greater than 2 during a period of relatively high turbidity; note that for some storms, there was a high ratio, but the storm turbidities were quite low so they are not considered significant). This indicates that on these occasions, mid-basin (between SFL and LMC) erosion and sedimentation processes were exceptionally active. Later in the winter runoff season (January through March), mid-basin erosional activity appears to have subsided, as

indicated by the turbidity ratio for LMC and SFL dropping to about two or less for the last several storms.

Figure 20. Comparison of peak turbidities at LMC and SFL in Lost Man Creek, WY04.

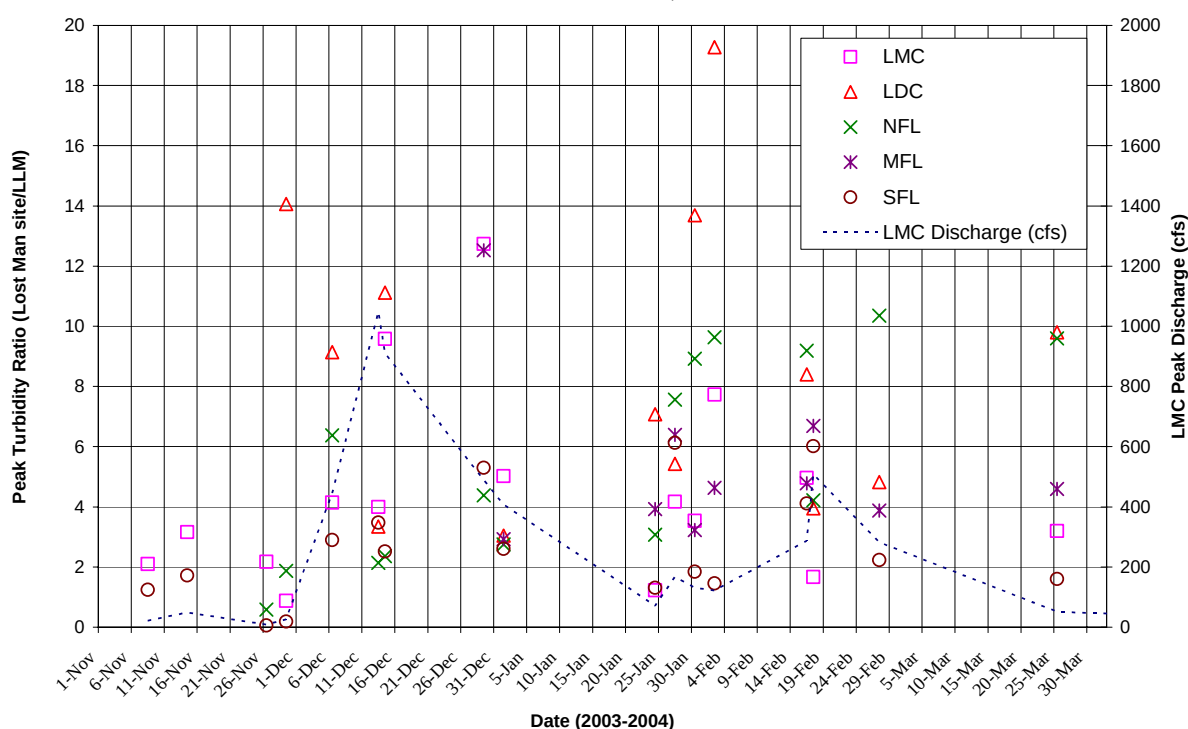


Peak turbidities for the recording stations in Lost Man Creek can also be compared with a nearby site in Little Lost Man Creek, a nearly pristine watershed ($DA = 3.46 \text{ mi}^2$) adjacent to Lost Man Creek. Little Lost Man Creek (code: LLM) is underlain predominantly by Franciscan rocks (Coherent Unit of Lacks Creek), the same geology as most of Lost Man Creek. The main channel is relatively steep and bounded by many landslides, following a fault lineament for most of its length. Thus, it is a relatively erodable basin compared to other areas in the Prairie Creek watershed. Nonetheless, it is a good control site for comparing with sites in Lost Man Creek, particularly the areas with similar geology (MFL, SFL). Figure 21 shows ratios of peak turbidities for the Lost Man sites along with corresponding peaks from the LLM record (note that the LLM site uses an OBS-3 turbidity sensor, while the Lost Man sites use DTS-12 sensors; some differences may be expected due to the use of different sensors). Corresponding peak discharges for the downstream-most station (LMC) are also shown for comparing storm magnitudes. (Note that periods of missing turbidity data occurred at LMC, LDC, and MFL, thus ratios could not be calculated for all sites for all times).

As indicated in Figure 21, the three sites in Lost Man Creek that were downstream of recent restoration work (LMC, LDC, and NFL) had consistently higher peak turbidities relative to LLM. The highest ratios occurred at the LDC site and were occasionally in the range of 10 to 20, averaging 9.5. NFL, also a tributary with recent restoration work, was next highest with several ratios in the 6-10 range (averaging 5.2). The downstream-most site (LMC), reflecting the complex

combination of processes in the entire Lost Man Creek watershed, had ratios similar to NFL and MFL (tributary with no recent restoration), averaging about 5. Both LMC and MFL had ratios of about 12.5 for the Dec. 29, 2003, storm (second largest of the season), while NFL had a ratio of only 4.4 for this storm. SFL, a tributary with no recent restoration, but still reflecting legacy effects from past timber harvest and geologically most similar to LLM, had ratios averaging about 2.5. Overall, the ratios of peak turbidities between Little Lost Man Creek and the Lost Man Creek sites indicate that turbidities were greater where recent restoration work was done, although geologic differences may also explain some of the high ratios for LMC, LDC, and NFL. Occasionally high ratios spanned the entire season, but were most pronounced in the earlier, larger storms.

Figure 21. Ratio of peak turbidities at recording stations in Lost Man Creek with Little Lost Man Creek, WY04.



Erosion Observations at Excavated Stream Crossings Monitored in WY2004

As mentioned earlier, restoration geologists made occasional site visits to the monitored stream crossing excavations during the winter seasons of 2002-2003 (excavations done in summer, 2002) and 2003-2004 (excavations done in both summer 2002 and 2003). For the 2002 excavations, the two years of observations provided the opportunity to evaluate more than just the first-year erosion responses. Erosion was categorized by process (surface erosion, channel erosion, bulk erosion (slumping)) and volumes were estimated with the delivery amount specified. Table 5 summarizes these observations. As shown, erosion varied substantially among the monitored excavations, with some experiencing little or no observable erosion, most experiencing a modest amount, and a few experiencing large volumes. The average volume of material eroded among all monitored excavations for both years was about 24 cubic yards (cy), ranging from zero to 140 cy.

Erosion was generally greatest at the excavations in Larry Damm Creek, averaging about 42 cy for the eight crossings monitored in WY03, while erosion at the four North Fork crossings averaged only about 7 cy during the same period. While this is probably a reasonable generalization, it must be recognized that the small sample size may not be representative of the North Fork as a whole.

In WY04, 12 additional excavations treated in summer, 2003, were included in the on-site monitoring network. All these sites were in Larry Damm Creek, the main focus of road removal activities that year. Considerably greater erosion occurred in WY03, with the two most likely reasons being: 1) peak discharge was higher in WY03, and 2) over half the monitored stream crossing excavations (the ones excavated in 2002) had already experienced their first winter period, thus much of the erosion and some re-vegetation had already occurred before WY04.

The untreated stream crossings monitored in WY04 were not surveyed for erosion, however, little or none likely occurred due to the episodic nature of crossing failure and the relatively minor erosional stresses in WY04. As anticipated, the turbidity sampling showed results consistent with this assumption, i.e., very little additional if any turbidity was added as streamflow moved through these crossings.

Following are short synopsis for each of the monitoring sites, at treated stream crossings, that were visited for observational analysis. These summaries are intended to give brief accounts of the site setting, and the nature and possible cause of any erosion incurred. For more extensive narratives of each of the sites refer to the separate documents listed in Appendix D.

2002 Excavations:

Monitoring Site 1: RX16, AA2 Road, Larry Damm Creek (project 02-04; Ingrid Corson)

Setting: Tributary to Larry Damm Creek; No restoration upstream of this site on this tributary; Settling pond at bottom of excavation.

Note: Additional excavation near the bottom of this site in summer 2003 may have influenced water year 2004 turbidity data.

There were two notable adjustments in RX-16 (monitoring site 1), both occurring during the December 14, 2002 storm. The shallow adjustment in the push road below the fillsite occurred in fill placed by the excavator as it was working out of a site. This steep fill was not compacted by a bulldozer. The other notable adjustment also occurred in excavator-placed fill at the bottom of a through-cut.

Table 5. Characteristics of Sediment Erosion and Delivery at Grab Sample Turbidity Monitoring Sites, Lost Man Creek.

	Site #	Sub-basin ¹	Total Volume Excav (yd ³)	Erosion Volumes (yd ³)							Delivery / Excav (%)	Delivery /Erosion (%)	Mulching		BMP Factors? (y/n) ⁴
				2003 ²		2004		Total Cumulative					Guide-lines Met? (y/n)	Effective? (y/n)	
				Eroded	Delivered	Eroded	Delivered	Eroded		Delivered					
								Type ³	Vol						
2002 Excavations	1	LDC	19500	45.9	21.3	0	0	B	45.9	21.3	0.11	46.4	Y	Y	N
	2	LDC	7864	26.9	0	0	0	B	26.9	0	0.00	0.0	Y	Y	N
	3	LDC	8694	29.2	8.5	0	0	B	29.2	8.5	0.10	29.1	Y	Y	N
	5	LDC	25671 ⁵	123.5	58.2	15.0	1.7	B	138.5	59.9	0.28 ⁵	43.2	N	Y	Y
	6	LDC	----- ⁵	83.4	9.7	44.4	3.1	B	127.8	12.8	0.05 ⁵	10.0	Y	Y	Y
	7	NFL	5908	23.3	23.3	0	0	B	23.3	23.3	0.39	100.0	Y	Y	N
	8	NFL	2264	0	0	0	0	-----	0	0	0.00	0.0	Y	Y	N
	9	NFL	1083	5.7	4.5	0	0	B	5.7	4.5	0.42	78.9	Y	N	N
	10	NFL	8521	0.7	0.7	0	0	C	0.7	0.7	0.01	100.0	Y	Y	N
	11	LDC	5632	0.1	0.1	0	0	S	0.1	0.1	0.00	100.0	N	N	N
	12	LDC	5834	0	0	0.9	0.1	B	0.9	0.1	0.00	11.1	Y	Y	N
	13	LDC	3475	55.6	27.8	14.9	1.5	B	70.5	29.3	0.84	41.6	Y	Y	N
	TOTALS		94446	394.3	154.1	75.2	6.4		469.5	160.5	0.18	46.69			
2003 Excavations	14	LDC	400	-----	-----	0	0	-----	0	0	0.00	0.0	Y	Y	N
	15	LDC	4065	-----	-----	1.7	1.7	C	1.7	1.7	0.04	100.0	Y	Y	N
	16	LDC	2460	-----	-----	0.7	0.7	C	0.7	0.7	0.03	100.0	Y	Y	N
	17	LDC	3803	-----	-----	8.9	8.9	C	8.9	8.9	0.23	100.0	Y	Y	N
	18	LDC	1055	-----	-----	5.0	3.9	C/B	5.0	3.9	0.37	78.0	Y	Y	N
	19	LDC	1049	-----	-----	1.5	1.5	C	1.5	1.5	0.14	100.0	Y	Y	N
	20	LDC	745	-----	-----	3.3	3.3	C	3.3	3.3	0.44	100.0	Y	Y	N
	21	LDC	3453	-----	-----	14.8	7.4	B	14.8	7.4	0.21	50.0	N	N	Y
	22	LDC	1413	-----	-----	0	0	-----	0	0	0.00	0.0	Y	Y	N
	23-32 ²	SFL	N/A			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	TOTALS		18443			35.9	27.4		35.9	27.4	0.16	69.78			
TOTALS		112889	394.3	154.1	111.1	33.8		505.4	187.8	0.17	37.2				

¹ LDC = Larry Damm Creek; NFL = North Fork Lost Man Creek.

² Sites 23 to 32 are untreated sites, and have no statistics for this table. Likewise, sites 14 to 22 have no statistics for 2003 because they were untreated at that time.

³ "Type" refers to the process that is dominantly responsible for the erosion volume: B=bulk; C=channel; S=surface.

⁴ "BMP Factors" refers to site specific post-excavation conditions that may have promoted sediment erosion and/or delivery that can be addressed at future stream crossing excavations. A "Y" in this column should encourage a reading of the site narrative (appendix A) for more detailed information.

⁵ Sites 5 and 6 were reported together as one, single, excavation volume.

There was no new erosion observed when the site was revisited in April of 2004. Moreover, the two small debris slides observed at the earlier visits both appeared to have stabilized by the spring of 2004.

Monitoring Site 2: RX3, AA1 Road, Larry Damm Creek (project 02-04; Ingrid Corson)

Setting: Tributary to Larry Damm Creek; No restoration upstream of this site on this tributary. Bottom of excavation is at Larry Damm Creek floodplain. Settling pond near bottom of excavation.

A shallow adjustment originating mid-slope on the left bank of RX-3 (monitoring site 2) occurred during the first big December (2002) storm. The upper slope is a fillsite and the slide is in the same location as a steep push road used to access the fillsite. The push road was removed and the hillslope shaped by the excavator. The finishing fill was not compacted by the bulldozer. The scarp was 1.5 feet tall on March 27, 2003, and there was no delivery to Larry Damm Creek as of April 2004.

Monitoring Site 3: RX-1, AA1 Road, Larry Damm Creek (project 02-04; Ingrid Corson)

Setting: Tributary to Larry Damm Creek; No restoration upstream of this site on this tributary. Bottom of excavation is at Larry Damm Creek floodplain.

On December 14, 2002, during the first site visit (during the first big storm of the winter) Ingrid noticed that the RX-1 excavation (monitoring site 3) was carrying fines and in a few places was quite cloudy. This cloudiness was most likely due to a few small (1-3 cubic foot blocks) settling in to the channel as the banks adjusted in the heavy rains. On March 27, 2003 Ingrid noticed that this tributary creek was running clear while Larry Damm Creek was visibly cloudy. By April 24, 2003 there seemed to be no new adjustments at this site. The two shallow adjustments on the right bank of the crossing delivered an approximate total of 8 yd³, and occurred in steep uncompacted soil placed by the excavator as it was working away from the site. In April 2004, the site looked great, with no new erosion and lots of new vegetation coming in between the large wood mulch.

Monitoring Sites 5 and 6: RX3/RX4 (Sites 6 and 5 respectively), 530 Road, Larry Damm Creek (project 02-02; Mike Sanders)

Setting: Two tributaries to Larry Damm Creek that join upstream of their confluence with Larry Damm Creek; No restoration upstream of these sites on either tributary. Bottom of excavation is shared by both sites. Mulching of fillsites was very difficult with this worksite.

Monitoring Site 6 (RX3) had minimal rilling but experienced 3 areas of bulk erosion during the first winter. Two were associated with fill material and the third was an over-steepened side bank to the main channel. For the two fillsites, both were due to excessive moisture, one being likely due to springs, the other in part due to the nature of the fill material. The initial high moisture content of the fill coupled with the addition of the winter rains, quite likely caused these fill failures. Fortunately, the majority of material from both of these failures was contained by LWD placed proximal to the stream channel. It was estimated both of these failures contributed 3.1 yd³ of material to the channel. The third failure was immediately adjacent to the channel but it too had

most of the mobilized material contained by LWD. Still it contributed approximately 6.5 yd³ to the channel.

Additional adjustments occurred during the first winter on the left bank of RX4 (monitoring site 5). As with previous sites, the likely mechanism for this was poorly compacted fill placed by an excavator. Approximately 58 yd³ of material were mobilized and transported to the channel, however, the majority of this material was arrested by the large woody debris placed in the channel during the excavation. It is likely that this material will eventually be metered into the system. In addition to the bulk erosion, approximately 2300 ft² of area experienced moderate rilling and this contributed an additional 0.3 yd³.

Observations during the winter of 2003-2004, indicated no major adjustments occurred on either of the crossings. However, both sites did have some continued failure of pre-existing features. On RX3, the two failures associated with fillsites increased in size but had low delivery due to LWD. Both features contributed 3.1 yd³ of material. The failure along the stream bank showed no signs of any erosion. Rilling was essentially non-existent mainly due to hardening and armoring of the surface but also due to the presence of new vegetation.

RX4 also had one preexisting feature increase in size but the bulk of the material was contained on the slope by LWD. This feature contributed 1.5 yd³ of material. Rilling continued with 600 ft² of moderate rilling and 600 ft² of area suffering high degree of rilling. This rilling is estimated to have contributed less than 0.2 yd³ of material.

Monitoring Site 7: Work Item 11, 550 Road, North Fork Lost Man Creek (project 02-01; Gilbert Craven)

Setting: Tributary to North Fork Lost Man Creek; Some minor restoration (outslope treatment) upslope of this site that probably has no sediment contribution. Bottom of excavation is at North Fork Lost Man Creek floodplain.

Work Item 11 exhibited sediment mobilization and channel adjustments along the length of the excavated tributary to the North Fork. A two-foot knickpoint formed at the confluence of the tributary and the North Fork, apparently caused by the destruction of the riparian root mat. Numerous small slides with sediment delivery to the channel have occurred along the upper reaches (approximately 23 yd³ delivered). Some have been caused by undercutting of the steep upper slopes during removal of fill in the channel; at least one, also with sediment delivery to the tributary, occurred in an outsloped skid road prism.

Monitoring Site 8: Work Item 10, 550 Road, North Fork Lost Man Creek (project 02-01; Gilbert Craven)

Setting: Log stringer bridge crossing the mainstem of North Fork Lost Man Creek; restoration upstream of this site includes another crossing on the mainstem (B554 rd.; exc. 2000), a large landing on the south bank (approximately 200 feet upstream of the B550 crossing – excavated in 2000), as well as a few crossings on small tributaries that may contribute turbidity to the North Fork

Work Item 10 exhibited no evidence of sediment mobilization or delivery. The excavated channel was laterally stable, with a new riffle forming. The bed changes may be a result of a mobilized slug of sediment formerly impounded upstream from the crossing. No new erosion was evident in the second season following excavation.

Monitoring Site 9: Work Item 7, 550 Road, North Fork Lost Man Creek
(Project 02-01; Neal Youngblood)

Setting: Tributary to North Fork Lost Man Creek; a large landing was excavated at the headwater portion of this channel in 2000.

During monitoring visits, the excavation experienced some bank adjustments along the steeper right bank portion of the excavation. The two locations that contributed sediment to the channel were a shallow debris slide (4' x 4' x 3") and a small slope toe failure (15' x 5' x 2'), totaling about 4.5 yd³. Causal mechanisms for the erosion features were not discernable, and are attributed to bank adjustment as the woody debris settled into place. Most of the coarse grain sediment appeared to be retained by the copious amount of large wood debris placed as channel bedding elements.

No new erosion was noted during the 2003 – 2004 winter, although small bare areas may likely have contributed to some turbidity during heavy rains

Monitoring Site 10: Work Item 4, 550 Road, North Fork Lost Man Creek
(Project 02-01; Neal Youngblood)

Setting: Tributary to North Fork Lost Man Creek; significant restoration upstream of this site (2000) on 2 tributaries that confluence in a naturally dynamic zone above here.

The post excavation erosion that occurred was limited to sapping process below (vertically) the wind-throw (see appendix A narrative). Approximately one cubic yard of channel sediment evacuated the deposit as intercepted subsurface flow exited.

The site was revisited in the spring of 2004 and no evidence of new erosion was observed.

Monitoring Site 11: RX W5, 560 Road, Larry Damm Creek (project 02-02; Mike Sanders)

Setting: Tributary to Larry Damm Creek; Two crossing restoration excavations (2002) upstream of this site: one on this tributary (monitor site 12); one on a tributary to this stream (monitor site 13).

RX W5 (monitoring site 11) had naturally steep sidebanks; most substantial was the right bank in the upper portion of the channel. This bank was nearly vertical when finally unearthed. Almost all the fill was pushed away on both sides of the crossing. Original "bedrock" was a more compacted sandstone/sand and was more resistant to post-excavation erosion. Portions of the left bank showed signs where the veneer of material that was not completely removed from the original surface was

more readily transported by surface runoff. This material was subject to rilling, but the amount of material was minimal and rills were typically very moderate and not extensive along the surface. Rilling of the left bank is estimated to have generated several cubic yards of material, but less than 1 yd³ was delivered.

Monitoring Sites 11, 12, and 13 were not sampled in the 2003-2004 winter season due to unreasonable access. The sites were visited for observation and photos, and Site 11 showed no new erosion and a negligible amount of sediment input.

Monitoring Site 12: RX W2, 560 Road, Larry Damm Creek (project 02-02; Mike Sanders)

Setting: Tributary to Larry Damm Creek; No restoration upstream of this site on this tributary.

This site handled the winter very well. Minimal rilling occurred on the left bank that was modestly mulched with locally derived material. The limited amount of mulching material encouraged maximum placement proximal to the channel and the upper most portions of the left bank excavation were minimally covered. Fortunately, the side slopes of this excavation had a relatively low gradient and the development of rills was minimal. Estimates made during winter observations placed the mobilized volume at less than 5 yd³ and the delivered volume at much less than 1 yd³.

Monitoring Sites 11, 12, and 13 were not sampled in the 2003-2004 winter season due to unreasonable access. The sites were visited for observation and photos, and Site 12 showed no new erosion.

Monitoring Site 13: RX E3/SX E3, 560 Road, Larry Damm Creek (project 02-02; Mike Sanders)

Setting: Tributary to Larry Damm Creek; No restoration upstream of this site on this tributary.

Most of this excavation was accomplished by dishing out the draw with a bulldozer. Fillsites for this excavation were located out of the immediate draw and only a minimal amount of fill was placed proximal to the excavation. This last amount of fill was excavated and placed using an excavator and some of it slumped during the winter. However, the final channel configuration and large woody debris prevented much of this material from being introduced into the channel itself. The estimated volume of the slumps was about 55 yd³ and approximately 50% was introduced to the channel.

Monitoring Sites 11, 12, and 13 were not sampled in the 2003-2004 winter season due to unreasonable access. The sites were visited for observation and photos, and Site 13 showed minor new erosion with approximately 1.5 yd³ of new sediment input.

2003 Excavations:

Monitoring Site 14: 560 Road, Larry Damm Creek (project 03-02; Mike Sanders)

Setting: skid road crossing of Tributary to Larry Damm Creek; Restoration upstream of this site on this tributary consists of monitoring sites 11, 12, and 13. Bottom of excavation is at confluence with Larry Damm Creek.

Most of the crossing had previously failed leaving a steeply perched lobe of fill on the left bank of 560 creek, near the confluence with Larry Damm Creek. No excavation or bank restoration work was done on the right bank of this crossing. No erosion was evident on the January 22 visit.

Monitoring Site 15: Lower B500 Road, Larry Damm Creek (project 03-02; Mike Sanders)

Setting: Downstream-most crossing of mainstem Larry Damm Creek; Restoration upstream of this site includes all stream crossing excavations that contribute to Larry Damm Creek.

No erosion was evident on the January 22 visit. Some deposition had occurred onsite, with an interesting deposit of sand approximately 100 feet upstream of the excavation site (no direct connection). On the May visit, almost 2 yd³ of bank erosion was documented.

Monitoring Site 16: B550 Road, Larry Damm Creek (project 03-02; Mike Sanders)

Setting: Log stringer bridge crossing of mainstem Larry Damm Creek; Restoration upstream of this site includes extensive stream crossing excavations throughout the Larry Damm Creek watershed.

A minimum of channel adjustment (<1 yd³) occurred at the site in the form of bank erosion during the 2003 – 2004 winter. Due to the gentle slopes of the channel banks, there is little likelihood that the excavation site contributed much to the turbidity levels of the winter flows.

Monitoring Site 17: B530 Road, Larry Damm Creek (project 03-02; Mike Sanders)

Setting: Log stringer bridge crossing of mainstem Larry Damm Creek; Restoration upstream of this site includes numerous stream crossing excavations throughout the Larry Damm Creek watershed.

Once again the bank configuration of the excavation allowed for gentle grades along the flood plain of Larry Damm Creek. No sediment sources were identified from surface erosion. By the March visit approximately 4.5 cubic yards of sediment had been mobilized as channel banks adjusted at the upstream end of the excavation. A fair amount of gravel was also deposited throughout the restored length of channel. By late May, the channel erosion had enlarged to a cumulative volume of 9 yd³.

Monitoring Site 18: RX4, Lower B500 Road, Larry Damm Creek (project 03-01; Ingrid Corson)

Setting: Tributary to Larry Damm Creek; No restoration upstream of this site on this tributary.

A portion of the upper right bank calved off, possibly due to bank erosion at the toe of the slope, contributing approximately 0.5 yd³ to the stream. And an additional 3.0 yd³ was delivered due to channel erosion, including a headcut. Most of the coarse sediment was trapped in the woody debris left in the exhumed channel.

Monitoring Site 19: RX3, Lower B500 Road, Larry Damm Creek (project 03-01; Ingrid Corson)

Setting: Tributary to Larry Damm Creek; Restoration excavations upstream of this site on this tributary consist of the very large monitoring site 1(2002) and a smaller tributary to monitoring site 1, excavated in 2003.

The finished surface was severely heavily mulched with vegetation. The only sign of post-excavation erosion was a 1 foot channel incision near the bottom of the site totaling about 1.5 yd³ of material mobilized.

Monitoring Site 20: RX2, Lower B500 Road, Larry Damm Creek (project 03-01; Ingrid Corson)

Setting: Upstream-most crossing of mainstem Larry Damm Creek; Restoration excavations upstream of this site include four tributary stream crossing excavations; 2 excavated in 2002 (including monitoring sites 2 and 3) and 2 excavated in 2003.

The finished excavation left a 5 foot channel width with a small pool in the middle of the excavation, along the left bank. After the first big winter rain, the channel changed as the pool filled with a large rootwad and pebble sized gravel. Additionally, the right bank suffered minor erosion (approximately 1.75 yd³) as the channel thalweg shifted to the right. Another 1.5 yd³ had eroded from the right bank as of April 28th, and the feature has yet to stabilize.

Monitoring Site 21: RX5, Lower B500 Road, Larry Damm Creek (project 03-01; Ingrid Corson)

Setting: Tributary to Larry Damm Creek; Restoration excavations upstream of this site on this tributary are extensive and consist of the very large "PT" complex of crossings (2003).

On site, an estimated 15 yd³ block slide occurred on the left bank near what would be the inboard ditch of the former road. Half of this material (7.4 yd³) delivered to the stream, exposing the bedrock beneath. The rest of this volume, and possibly more, will probably deliver in future heavy rains.

Monitoring Site 22: Work Item 23, Lower B500 Road, Larry Damm Creek (Project 03-03; Neal Youngblood)

Setting: Tributary to Larry Damm Creek; Restoration excavations upstream of this site on this tributary are extensive and consist of the "Bratwurst" complex of crossings (2003).

No erosion from channel configuration was evident during the following winter. Surface erosion associated with a foot path that was left for administrative access was observed, but likely contributed to elevated turbidity only. Surface erosion features accounted for less than 0.002 yd³ of delivered sediment.

DISCUSSION

WY2004, the second year of monitoring the effects of restoration work in Lost Man Creek, was somewhat drier than WY2003. At Little Lost Man Creek (the nearest rain gage to Lost Man Creek), rainfall totaled 51.3 inches from October, 2003, through May, 2004, whereas the total for WY2003 for the same period was 61.1 (about 20% greater than WY2004). Peak discharge was also lower in WY2004 (1048 cfs at LMC on Dec. 13, 2003) than in WY2003 (1311 cfs at LMC on Dec. 27, 2002) by about 20%. In addition, rainfall during the month of April, 2003, was record-setting at many northcoast gages, causing numerous small storms, while rainfall virtually ceased after early March, 2004. From this, it is clear that erosional stresses were substantially lower in WY2004 than in WY2003, and the results of this monitoring period must be viewed in this context.

In general, results from WY2004 were similar in form to those from WY2003, and led to similar conclusions: 1) onsite samples showed that turbidity often (but not always) increased as water flowed through stream crossing excavations, 2) peak storm turbidities were often higher in tributaries draining areas with recent road removal than in tributaries with little or no recent disturbance, and 3) erosional responses at restoration sites generally diminished as the winter runoff season progressed. However, modifications in the monitoring program for WY2004 allowed some additional questions to be investigated and insights to be gained. Specifically: 1) conversion of three tributary sites from manual to automated stations allowed more confidence in comparing restoration effects among treated and untreated tributaries, 2) continuation of onsite monitoring of the 2002 excavations through WY2004 allowed us to evaluate longer-term erosion and sediment delivery from road removal, and 3) onsite monitoring of yet-to-be treated stream crossings confirmed the episodic nature of sediment delivery from such sites (i.e., they generally do not contribute sediment during small to medium magnitude storms, but pose substantial risk of sediment delivery only during larger storms than occurred in WY2004).

One of the more notable phenomena from the past winter's monitoring data is the occurrence of large turbidity spikes during recessional stormflows at Larry Damm Creek (LDC) on the storms of Dec. 13 and 14, 2003 (see Fig. 10). The other recording stations did not exhibit these spikes (note that the turbidity sensor at the Middle Fork had not yet been installed, thus no data are available for this site for this storm). As described earlier, Larry Damm Creek (LDC) has the highest proportion of Prairie Creek Fm. of any of the main tributaries within Lost Man Creek. Accordingly, it is fair to say that this sub-basin is most prone to surface erosion and shallow landsliding from ground disturbance. The spikes occurred during the largest rainstorm of the season and during the period of elevated erosion from recent road removal sites (see Table 4).

The recessional turbidity spikes were of large magnitude and short duration, indicating they were produced by brief, episodic (as opposed to chronic) erosion and sediment delivery somewhere

upstream from the gage. Based on their shape and magnitude, they are best explained by one or more of several possible events occurring upstream: 1) channel erosion due to bank slumping, debris jam failure, etc. not associated with road removal activities, 2) streamside landsliding and/or debris torrents not associated with road removal activities, or 3) channel scour (either within or upstream of stream crossing excavations), bank slumping or debris sliding within restoration sites. Of these, debris sliding/slumping is the most likely process for generating the types of spikes observed. However, at present, we cannot ascertain either the process(-es) at work or the cause(-s) (whether or not the erosion was associated with restoration work), even though erosion yields from the monitored sites has been estimated. Nor can we determine whether the spikes resulted from a single erosion feature or from several. Only by performing a basin-wide inventory of recent erosion and sediment delivery immediately following each storm can the source(-s) for the spikes be determined with confidence.

Another notable aspect of the monitoring data collected this past winter were the similar turbidities between nested (upstream-downstream) pairs for most storms (see Figs. 4-8). This is most obvious among the 2003 excavations during the largest storm (Dec. 13, 2003), when both the upstream (control) and downstream (treatment) turbidities were relatively high (>200 NTU) and nearly equal at most of the sites. This indicates that the greatest source of turbidity was upstream (either at another excavation somewhere farther up the stream or at an unrelated erosion feature) and that little if any additional turbidity was picked up within the monitored crossing. This was the case at sites 14-17 and 20-22: site 14 had restoration work upstream in 2002; sites 15-17 and 20 were on the lower mainstem of Larry Damm Creek, and sites 21 and 22 had extensive work upstream in 2003.

The ordering of peak turbidities that occurred during WY04 follows the level of restoration work performed in 2002-03, i.e., Larry Damm Creek had the highest turbidities, followed by the North with the Middle and South forks being the least turbid of the four tributaries (see Table 2 and Fig. 15). The Middle Fork was somewhat more turbid than the South Fork, in spite of more extensive restoration work in the South Fork in 2000-2001, in terms of volume and number of stream crossings. This may be due to the presence of the easily eroded Prairie Creek Formation in the upper portion of the Middle Fork. However, the geology issue remains uncertain, i.e., how much do geologic differences affect the turbidities observed in WY03-04? Over the next several years, assuming continued operation of the five gaging stations in Lost Man Creek, we should be able to address this issue with increased confidence as the effects of already completed road removal wane. And, with the eventual resumption of road removal in the tributaries, we will have a considerable amount of pre-project data with which to evaluate the effects of restoration on water quality as the remaining portions of the basin are treated.

In paired basins studies such as this, the ideal experimental design includes several ‘calibration’ years of data collection prior to conducting any treatments. If the basins are well-paired, they should vary together in the parameters of interest (turbidity, in this case) prior to treatment, which is not to say they must be the same. Because this monitoring plan began three years into the Lost Man Creek restoration project, treatment effects were already occurring when monitoring began in fall, 2002. Relying solely on post-treatment data, as we must do at present, leaves more uncertainty in data interpretation than if we had begun monitoring for several years before restoration work began. However, should this monitoring continue sufficiently into the future, the treatment/control

differences may be detected with more confidence in a retrospective analysis, i.e., treatment effects we are measuring today may be more readily discernable in the future as treatment effects subside. Moreover, the restoration work being performed today should help reduce sediment delivery, and hence turbidity, in Lost Man Creek relative to the pre-treatment period over the long term.

Future Monitoring

Other than a very minor amount of work in Larry Damm Creek in the fall of 2004, no further restoration work is scheduled in Lost Man Creek until the fall of 2006. However, the restoration work is slightly less than half completed in the basin. It is our intention to maintain a continuous record of turbidity data from Lost Man Creek throughout the entire period of restoration activities in the basin, and beyond. Continued monitoring is considered essential for tracking water quality in the watershed throughout the recovery trajectory, a period of unknown length, but expected to be relatively short. Moreover, as the longer term benefits of road removal are realized, the treated tributaries (Larry Damm Creek and North Fork Lost Man) will become important as control sites for future restoration work in the Middle and South Forks. Consequently, some level of continued monitoring will continue in Lost Man Creek.

At a minimum, the five recording streamflow and turbidity stations will be operated, along with maintenance of discharge rating curves, and manual stormflow sampling for turbidity and suspended sediment concentration will be done at these sites. However, onsite monitoring will be discontinued along with sampling at non-recording main channel sites (LM1-LM5).

LITERATURE CITED

- Klein, R.D. 1984. Channel adjustments following logging road removal in small steep-land drainages. In Symposium on Effects of Forest Land Use on Erosion and Slope Stability. C.L. O'Loughlin and A.J. Pearce, eds. Honolulu, HI. 7-11 May, 1984. Pp. 187-195.
- Klein, R.D. 2003. Erosion and turbidity monitoring report, Sanctuary Forest, Inc., stream crossing excavations in the Upper Mattole River Basin, 2002-2003. 35 p.
- Madej, M.A. 2001. Erosion and sediment delivery following removal of forest roads. *Earth Surface Processes and Landforms*. V. 26, pp. 175-190.
- Weaver, W.E. and Sonnevil, R.A. 1984. Relative Cost-effectiveness of Erosion Control for Forest Land Rehabilitation, Redwood National Park. In: C. Forrest, ed. *Erosion Control...Man and Nature*. Proceedings of Conference XV, International Erosion Control Association.
- Weaver, W.E. et al., 1987. An Evaluation of Experimental Rehabilitation Work, Redwood National Park. Redwood National Park Technical Report 19.

Appendix A: Onsite turbidity data by treatment year

2002 EXCAVATIONS IN LARRY DAMM CREEK (LDC)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
12/13/03 15:15	2	2002	LDC	3.62	above	12/13/03 15:10	2	LDC	6.35	below	75%
12/29/03 12:13	2	2002	LDC	13.7	above	12/29/03 12:13	2	LDC	8.19	below	-40%
12/29/03 11:45	1	2002	LDC	8.45	above	12/29/03 11:40	1	LDC	8.98	below	6%
12/7/03 15:25	6	2002	LDC	2.82	above	12/7/03 15:30	6	LDC	10.2	below	262%
12/29/03 10:43	6	2002	LDC	2.01	above	12/29/03 10:50	6	LDC	10.4	below	417%
12/7/03 15:35	5	2002	LDC	14.7	above	12/7/03 15:40	5	LDC	15	below	2%
2/17/04 12:35	2	2002	LDC	8	above	2/17/04 12:30	2	LDC	16.1	below	101%
2/17/04 13:05	1	2002	LDC	14.9	above	2/17/04 13:00	1	LDC	17.3	below	16%
2/17/04 11:15	6	2002	LDC	5.88	above	2/17/04 11:20	6	LDC	22.8	below	288%
12/13/03 12:50	6	2002	LDC	3.55	above	12/13/03 13:00	6	LDC	25.4	below	615%
12/13/03 14:50	3	2002	LDC	29.2	above	12/13/03 14:45	3	LDC	34.8	below	19%
12/29/03 12:25	3	2002	LDC	17.6	above	12/29/03 12:25	3	LDC	37.7	below	114%
12/29/03 10:55	5	2002	LDC	55.7	above	12/29/03 10:51	5	LDC	45.2	below	-19%
12/13/03 13:40	6	2002	LDC	5.59	above	12/13/03 13:42	6	LDC	58	below	938%
2/17/04 12:20	3	2002	LDC	50.7	above	2/17/04 12:15	3	LDC	67.6	below	33%
2/17/04 11:22	5	2002	LDC	110	above	2/17/04 11:24	5	LDC	86.8	below	-21%
12/13/03 13:40	5	2002	LDC	144	above	12/13/03 13:42	5	LDC	135	below	-6%
12/13/03 13:10	5	2002	LDC	116	above	12/13/03 13:05	5	LDC	139	below	20%
12/13/03 14:20	1	2002	LDC	7.32	above	12/13/03 10:50	1	LDC	552	below	7441%
All samples:											AVE: 540%
											MIN: -40%
											MAX: 7441%
Subset of samples with >25 NTU for downstream sample:											AVE: 913%
											MIN: -21%
											MAX: 7441%

2002 EXCAVATIONS IN NORTH FORK LOST MAN CREEK (NFL)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
12/7/03 14:05	10	2002	NFL	5.73	above	12/7/03 14:05	10	NFL	6.85	below	20%
12/7/03 15:00	7	2002	NFL	4.35	above	12/7/03 14:48	7	NFL	7.37	below	69%
12/7/03 14:43	8	2002	NFL	9.16	above	12/7/03 14:43	8	NFL	8.33	below	-9%
12/29/03 10:12	7	2002	NFL	8.54	above	12/29/03 10:00	7	NFL	9.55	below	12%
12/7/03 14:25	9	2002	NFL	14.2	above	12/7/03 14:25	9	NFL	10.7	below	-25%
12/13/03 12:30	7	2002	NFL	13.8	above	12/13/03 12:30	7	NFL	15.4	below	12%
12/13/03 13:15	7	2002	NFL	6.18	above	12/13/03 12:57	7	NFL	16.8	below	172%
2/17/04 10:45	7	2002	NFL	9.24	above	2/17/04 10:50	7	NFL	19.3	below	109%
12/29/03 9:50	9	2002	NFL	19.4	above	12/29/03 9:45	9	NFL	33.4	below	72%
12/29/03 9:56	8	2002	NFL	42.6	above	12/29/03 9:55	8	NFL	37.2	below	-13%
2/17/04 10:28	9	2002	NFL	25.2	above	2/17/04 10:26	9	NFL	38.6	below	53%
12/13/03 12:45	9	2002	NFL	29.8	above	12/13/03 12:44	9	NFL	40.5	below	36%
12/29/03 9:25	10	2002	NFL	47.9	above	12/29/03 9:23	10	NFL	44.6	below	-7%
2/17/04 10:41	8	2002	NFL	49.2	above	2/17/04 10:40	8	NFL	47.9	below	-3%
12/13/03 12:00	9	2002	NFL	36.5	above	12/13/03 12:00	9	NFL	49.2	below	35%
12/13/03 11:30	10	2002	NFL	72.2	above	12/13/03 11:30	10	NFL	68.6	below	-5%
12/13/03 12:53	8	2002	NFL	69.3	above	12/13/03 12:53	8	NFL	68.9	below	-1%
12/13/03 12:24	10	2002	NFL	66.6	above	12/13/03 12:25	10	NFL	76.3	below	15%
2/17/04 10:08	10	2002	NFL	77.7	above	2/17/04 10:08	10	NFL	76.5	below	-2%
12/13/03 12:10	8	2002	NFL	76.8	above	12/13/03 12:10	8	NFL	84.3	below	10%
All samples:											AVE: 28%
											MIN: -25%
											MAX: 172%
Subset of samples with >25 NTU for downstream sample:											AVE: 16%
											MIN: -13%
											MAX: 72%

Appendix A: Onsite turbidity data by treatment year (cont.)

2003 EXCAVATIONS IN LARRY DAMM CREEK (LDC)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
2/17/04 11:50	18	2003	LDC	1.78	above	2/17/04 11:49	18	LDC	5.65	below	217%
12/7/03 16:30	20	2003	LDC	9.4	above	12/7/03 16:30	20	LDC	10.3	below	10%
12/29/03 11:35	19	2003	LDC	10.2	above	12/29/03 11:30	19	LDC	10.9	below	7%
2/17/04 11:57	19	2003	LDC	11.4	above	2/17/04 11:55	19	LDC	14.7	below	29%
12/29/03 12:46	18	2003	LDC	1.4	above	12/29/03 12:45	18	LDC	15.1	below	979%
12/7/03 15:45	17	2003	LDC	10.4	above	12/7/03 15:50	17	LDC	18.9	below	82%
12/7/03 16:20	19	2003	LDC	25	above	12/7/03 16:20	19	LDC	20.6	below	-18%
12/13/03 14:22	19	2003	LDC	15	above	12/13/03 14:22	19	LDC	31.4	below	109%
12/7/03 17:25	14	2003	LDC	33.7	above	12/7/03 17:30	14	LDC	31.4	below	-7%
12/7/03 13:27	16	2003	LDC	33.4	above	12/7/03 13:29	16	LDC	34.4	below	3%
12/13/03 14:00	19	2003	LDC	12.6	above	12/13/03 14:00	19	LDC	39.6	below	214%
12/7/03 13:14	15	2003	LDC	57.1	above	12/7/03 13:14	15	LDC	56.6	below	-1%
2/17/04 9:08	14	2003	LDC	67.4	above	2/17/04 9:07	14	LDC	66.4	below	-1%
12/29/03 8:38	14	2003	LDC	63.2	above	12/29/03 8:35	14	LDC	70.5	below	12%
2/17/04 12:56	20	2003	LDC	63.5	above	2/17/04 12:55	20	LDC	75.8	below	19%
12/29/03 11:05	17	2003	LDC	76.1	above	12/29/03 11:03	17	LDC	78	below	2%
12/13/03 14:10	18	2003	LDC	1.71	above	12/13/03 14:10	18	LDC	88.8	below	5093%
2/17/04 9:31	16	2003	LDC	99.8	above	2/17/04 9:30	16	LDC	91.9	below	-8%
2/17/04 9:08	15	2003	LDC	97.2	above	2/17/04 9:07	15	LDC	97.8	below	1%
12/29/03 8:50	16	2003	LDC	110	above	12/29/03 8:50	16	LDC	102	below	-7%
12/7/03 17:05	22	2003	LDC	71.8	above	12/7/03 17:05	22	LDC	107	below	49%
2/17/04 11:36	17	2003	LDC	91.2	above	2/17/04 11:36	17	LDC	107	below	17%
12/29/03 8:38	15	2003	LDC	116	above	12/29/03 8:35	15	LDC	112	below	-3%
12/29/03 11:55	20	2003	LDC	107	above	12/29/03 11:56	20	LDC	120	below	12%
2/17/04 13:30	21	2003	LDC	114	above	2/17/04 13:29	21	LDC	140	below	23%
12/29/03 13:25	22	2003	LDC	175	above	12/29/03 13:25	22	LDC	141	below	-19%
2/17/04 13:50	22	2003	LDC	154	above	2/17/04 13:48	22	LDC	163	below	6%
12/29/03 13:03	21	2003	LDC	108	above	12/29/03 13:03	21	LDC	174	below	61%
12/13/03 13:55	17	2003	LDC	191	above	12/13/03 13:55	17	LDC	204	below	7%
12/7/03 16:50	21	2003	LDC	229	above	12/7/03 16:50	21	LDC	217	below	-5%
12/13/03 14:30	20	2003	LDC	215	above	12/13/03 14:30	20	LDC	218	below	1%
12/13/03 13:25	17	2003	LDC	217	above	12/13/03 13:25	17	LDC	220	below	1%
12/13/03 11:31	14	2003	LDC	230	above	12/13/03 11:32	14	LDC	222	below	-3%
12/13/03 10:30	14	2003	LDC	229	above	12/13/03 10:25	14	LDC	230	below	0%
12/13/03 13:50	18	2003	LDC	4.6	above	12/13/03 13:50	18	LDC	241	below	5139%
12/13/03 14:35	20	2003	LDC	251	above	12/13/03 14:35	20	LDC	257	below	2%
12/13/03 16:00	22	2003	LDC	196	above	12/13/03 16:00	22	LDC	369	below	88%
12/13/03 11:35	15	2003	LDC	406	above	12/13/03 11:31	15	LDC	395	below	-3%
12/13/03 11:47	16	2003	LDC	463	above	12/13/03 11:47	16	LDC	434	below	-6%
12/13/03 10:30	15	2003	LDC	532	above	12/13/03 10:25	15	LDC	522	below	-2%
12/13/03 15:40	21	2003	LDC	265	above	12/13/03 15:35	21	LDC	529	below	100%
All samples:										AVE:	298%
										MIN:	-19%
										MAX:	5139%
Subset of samples with >25 NTU for downstream sample:										AVE:	320%
										MIN:	-19%
										MAX:	5139%

Appendix A: Onsite turbidity data by treatment year (cont.)

UNTREATED CROSSINGS IN SOUTH FORK LOST MAN CREEK (SFL)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
2/26/04 10:25	26	N/A	SFL	2.28	above	2/26/04 10:25	26	SFL	1.4	below	-39%
2/26/04 13:40	24	N/A	SFL	23.9	above	2/26/04 13:40	24	SFL	1.58	below	-93%
12/29/03 10:18	26	N/A	SFL	1.33	above	12/29/03 10:17	26	SFL	1.63	below	23%
2/26/04 10:10	25	N/A	SFL	1.69	above	2/26/04 10:00	25	SFL	1.8	below	7%
2/26/04 12:38	32	N/A	SFL	1.11	above	2/26/04 12:39	32	SFL	1.9	below	71%
12/29/03 12:30	32	N/A	SFL	2.74	above	12/29/03 12:35	32	SFL	2.27	below	-17%
2/26/04 13:40	24	N/A	SFL	9.03	above	2/26/04 13:40	24	SFL	2.53	below	-72%
2/26/04 13:39	23	N/A	SFL	2.05	above	2/26/04 13:39	23	SFL	2.85	below	39%
12/29/03 10:25	27	N/A	SFL	3.54	above	12/29/03 10:26	27	SFL	2.85	below	-19%
12/29/03 12:05	31	N/A	SFL	2.37	above	12/29/03 12:05	31	SFL	3.16	below	33%
2/26/04 10:30	27	N/A	SFL	2.5	above	2/26/04 10:30	27	SFL	3.29	below	32%
2/26/04 12:24	31	N/A	SFL	2.42	above	2/26/04 12:24	31	SFL	3.53	below	46%
2/26/04 12:05	30	N/A	SFL	4.61	above	2/26/04 12:05	30	SFL	3.69	below	-20%
12/29/03 10:04	25	N/A	SFL	1.16	above	12/29/03 10:03	25	SFL	4.58	below	295%
12/29/03 13:53	23	N/A	SFL	5.46	above	12/29/03 13:53	23	SFL	4.75	below	-13%
12/29/03 10:58	29	N/A	SFL	5.61	above	12/29/03 10:58	29	SFL	6.02	below	7%
2/26/04 11:00	29	N/A	SFL	4.64	above	2/26/04 11:07	29	SFL	7.17	below	55%
2/26/04 13:01	33	N/A	SFL	6.18	above	2/26/04 13:02	33	SFL	7.32	below	18%
2/26/04 10:40	28	N/A	SFL	25.7	above	2/26/04 10:40	28	SFL	7.47	below	-71%
12/29/03 10:30	28	N/A	SFL	7.18	above	12/29/03 10:32	28	SFL	8.47	below	18%
12/29/03 14:04	24	N/A	SFL	3.56	above	12/29/03 14:04	24	SFL	10.6	below	198%
12/29/03 11:58	30	N/A	SFL	12.7	above	12/29/03 11:58	30	SFL	10.6	below	-17%
12/29/03 14:03	24	N/A	SFL	3.61	above	12/29/03 14:03	24	SFL	17.7	below	390%
All samples:										AVE:	38%
										MIN:	-93%
										MAX:	390%
Subset of samples with >25 NTU for downstream sample:										AVE:	N/A
										MIN:	N/A
										MAX:	N/A

Unpaired Samples:

Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca
12/7/03 16:10	18		LDC	---	above	12/7/03 16:10	18	LDC	81.9	below
12/13/03 10:50	16		LDC	529	above	12/13/03 14:15	1	LDC	18.4	below

Appendix B: Onsite turbidity data by sub-basin

LARRY DAMM CREEK (LDC)											Turb Incr
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	(%)
2/17/04 11:50	18	2003	LDC	1.78	above	2/17/04 11:49	18	LDC	5.65	below	217%
12/13/03 15:15	2	2002	LDC	3.62	above	12/13/03 15:10	2	LDC	6.35	below	75%
12/29/03 12:13	2	2002	LDC	13.7	above	12/29/03 12:13	2	LDC	8.19	below	-40%
12/29/03 11:45	1	2002	LDC	8.45	above	12/29/03 11:40	1	LDC	8.98	below	6%
12/7/03 15:25	6	2002	LDC	2.82	above	12/7/03 15:30	6	LDC	10.2	below	262%
12/7/03 16:30	20	2003	LDC	9.4	above	12/7/03 16:30	20	LDC	10.3	below	10%
12/29/03 10:43	6	2002	LDC	2.01	above	12/29/03 10:50	6	LDC	10.4	below	417%
12/29/03 11:35	19	2003	LDC	10.2	above	12/29/03 11:30	19	LDC	10.9	below	7%
2/17/04 11:57	19	2003	LDC	11.4	above	2/17/04 11:55	19	LDC	14.7	below	29%
12/7/03 15:35	5	2002	LDC	14.7	above	12/7/03 15:40	5	LDC	15	below	2%
12/29/03 12:46	18	2003	LDC	1.4	above	12/29/03 12:45	18	LDC	15.1	below	979%
2/17/04 12:35	2	2002	LDC	8	above	2/17/04 12:30	2	LDC	16.1	below	101%
2/17/04 13:05	1	2002	LDC	14.9	above	2/17/04 13:00	1	LDC	17.3	below	16%
12/7/03 15:45	17	2003	LDC	10.4	above	12/7/03 15:50	17	LDC	18.9	below	82%
12/7/03 16:20	19	2003	LDC	25	above	12/7/03 16:20	19	LDC	20.6	below	-18%
2/17/04 11:15	6	2002	LDC	5.88	above	2/17/04 11:20	6	LDC	22.8	below	288%
12/13/03 12:50	6	2002	LDC	3.55	above	12/13/03 13:00	6	LDC	25.4	below	615%
12/13/03 14:22	19	2003	LDC	15	above	12/13/03 14:22	19	LDC	31.4	below	109%
12/7/03 17:25	14	2003	LDC	33.7	above	12/7/03 17:30	14	LDC	31.4	below	-7%
12/7/03 13:27	16	2003	LDC	33.4	above	12/7/03 13:29	16	LDC	34.4	below	3%
12/13/03 14:50	3	2002	LDC	29.2	above	12/13/03 14:45	3	LDC	34.8	below	19%
12/29/03 12:25	3	2002	LDC	17.6	above	12/29/03 12:25	3	LDC	37.7	below	114%
12/13/03 14:00	19	2003	LDC	12.6	above	12/13/03 14:00	19	LDC	39.6	below	214%
12/29/03 10:55	5	2002	LDC	55.7	above	12/29/03 10:51	5	LDC	45.2	below	-19%
12/7/03 13:14	15	2003	LDC	57.1	above	12/7/03 13:14	15	LDC	56.6	below	-1%
12/13/03 13:40	6	2002	LDC	5.59	above	12/13/03 13:42	6	LDC	58	below	938%
2/17/04 9:08	14	2003	LDC	67.4	above	2/17/04 9:07	14	LDC	66.4	below	-1%
2/17/04 12:20	3	2002	LDC	50.7	above	2/17/04 12:15	3	LDC	67.6	below	33%
12/29/03 8:38	14	2003	LDC	63.2	above	12/29/03 8:35	14	LDC	70.5	below	12%
2/17/04 12:56	20	2003	LDC	63.5	above	2/17/04 12:55	20	LDC	75.8	below	19%
12/29/03 11:05	17	2003	LDC	76.1	above	12/29/03 11:03	17	LDC	78	below	2%
2/17/04 11:22	5	2002	LDC	110	above	2/17/04 11:24	5	LDC	86.8	below	-21%
12/13/03 14:10	18	2003	LDC	1.71	above	12/13/03 14:10	18	LDC	88.8	below	5093%
2/17/04 9:31	16	2003	LDC	99.8	above	2/17/04 9:30	16	LDC	91.9	below	-8%
2/17/04 9:08	15	2003	LDC	97.2	above	2/17/04 9:07	15	LDC	97.8	below	1%
12/29/03 8:50	16	2003	LDC	110	above	12/29/03 8:50	16	LDC	102	below	-7%
12/7/03 17:05	22	2003	LDC	71.8	above	12/7/03 17:05	22	LDC	107	below	49%
2/17/04 11:36	17	2003	LDC	91.2	above	2/17/04 11:36	17	LDC	107	below	17%
12/29/03 8:38	15	2003	LDC	116	above	12/29/03 8:35	15	LDC	112	below	-3%
12/29/03 11:55	20	2003	LDC	107	above	12/29/03 11:56	20	LDC	120	below	12%
12/13/03 13:40	5	2002	LDC	144	above	12/13/03 13:42	5	LDC	135	below	-6%
12/13/03 13:10	5	2002	LDC	116	above	12/13/03 13:05	5	LDC	139	below	20%
2/17/04 13:30	21	2003	LDC	114	above	2/17/04 13:29	21	LDC	140	below	23%
12/29/03 13:25	22	2003	LDC	175	above	12/29/03 13:25	22	LDC	141	below	-19%
2/17/04 13:50	22	2003	LDC	154	above	2/17/04 13:48	22	LDC	163	below	6%
12/29/03 13:03	21	2003	LDC	108	above	12/29/03 13:03	21	LDC	174	below	61%
12/13/03 13:55	17	2003	LDC	191	above	12/13/03 13:55	17	LDC	204	below	7%
12/7/03 16:50	21	2003	LDC	229	above	12/7/03 16:50	21	LDC	217	below	-5%
12/13/03 14:30	20	2003	LDC	215	above	12/13/03 14:30	20	LDC	218	below	1%
12/13/03 13:25	17	2003	LDC	217	above	12/13/03 13:25	17	LDC	220	below	1%
12/13/03 11:31	14	2003	LDC	230	above	12/13/03 11:32	14	LDC	222	below	-3%
12/13/03 10:30	14	2003	LDC	229	above	12/13/03 10:25	14	LDC	230	below	0%

Appendix B: Onsite turbidity data by sub-basin (cont.)

LARRY DAMM CREEK (LDC) (cont.)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
12/13/03 13:50	18	2003	LDC	4.6	above	12/13/03 13:50	18	LDC	241	below	5139%
12/13/03 14:35	20	2003	LDC	251	above	12/13/03 14:35	20	LDC	257	below	2%
12/13/03 16:00	22	2003	LDC	196	above	12/13/03 16:00	22	LDC	369	below	88%
12/13/03 11:35	15	2003	LDC	406	above	12/13/03 11:31	15	LDC	395	below	-3%
12/13/03 11:47	16	2003	LDC	463	above	12/13/03 11:47	16	LDC	434	below	-6%
12/13/03 10:30	15	2003	LDC	532	above	12/13/03 10:25	15	LDC	522	below	-2%
12/13/03 15:40	21	2003	LDC	265	above	12/13/03 15:35	21	LDC	529	below	100%
12/13/03 14:20	1	2002	LDC	7.32	above	12/13/03 10:50	1	LDC	552	below	7441%
All samples:										AVE:	374%
										MIN:	-40%
										MAX:	7441%
Subset of samples with >25 NTU for downstream sample:										AVE:	455%
										MIN:	-21%
										MAX:	7441%
NORTH FORK LOST MAN CREEK (NFL)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
12/7/03 14:05	10	2002	NFL	5.73	above	12/7/03 14:05	10	NFL	6.85	below	20%
12/7/03 15:00	7	2002	NFL	4.35	above	12/7/03 14:48	7	NFL	7.37	below	69%
12/7/03 14:43	8	2002	NFL	9.16	above	12/7/03 14:43	8	NFL	8.33	below	-9%
12/29/03 10:12	7	2002	NFL	8.54	above	12/29/03 10:00	7	NFL	9.55	below	12%
12/7/03 14:25	9	2002	NFL	14.2	above	12/7/03 14:25	9	NFL	10.7	below	-25%
12/13/03 12:30	7	2002	NFL	13.8	above	12/13/03 12:30	7	NFL	15.4	below	12%
12/13/03 13:15	7	2002	NFL	6.18	above	12/13/03 12:57	7	NFL	16.8	below	172%
2/17/04 10:45	7	2002	NFL	9.24	above	2/17/04 10:50	7	NFL	19.3	below	109%
12/29/03 9:50	9	2002	NFL	19.4	above	12/29/03 9:45	9	NFL	33.4	below	72%
12/29/03 9:56	8	2002	NFL	42.6	above	12/29/03 9:55	8	NFL	37.2	below	-13%
2/17/04 10:28	9	2002	NFL	25.2	above	2/17/04 10:26	9	NFL	38.6	below	53%
12/13/03 12:45	9	2002	NFL	29.8	above	12/13/03 12:44	9	NFL	40.5	below	36%
12/29/03 9:25	10	2002	NFL	47.9	above	12/29/03 9:23	10	NFL	44.6	below	-7%
2/17/04 10:41	8	2002	NFL	49.2	above	2/17/04 10:40	8	NFL	47.9	below	-3%
12/13/03 12:00	9	2002	NFL	36.5	above	12/13/03 12:00	9	NFL	49.2	below	35%
12/13/03 11:30	10	2002	NFL	72.2	above	12/13/03 11:30	10	NFL	68.6	below	-5%
12/13/03 12:53	8	2002	NFL	69.3	above	12/13/03 12:53	8	NFL	68.9	below	-1%
12/13/03 12:24	10	2002	NFL	66.6	above	12/13/03 12:25	10	NFL	76.3	below	15%
2/17/04 10:08	10	2002	NFL	77.7	above	2/17/04 10:08	10	NFL	76.5	below	-2%
12/13/03 12:10	8	2002	NFL	76.8	above	12/13/03 12:10	8	NFL	84.3	below	10%
All samples:										AVE:	28%
										MIN:	-25%
										MAX:	172%
Subset of samples with >25 NTU for downstream sample:										AVE:	16%
										MIN:	-13%
										MAX:	72%

Appendix B: Onsite turbidity data by sub-basin (cont.)

SOUTH FORK LOST MAN CREEK (SFL)											Turb Incr (%)
Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
2/26/04 10:25	26	2010	SFL	2.28	above	2/26/04 10:25	26	SFL	1.4	below	-39%
2/26/04 13:40	24	2010	SFL	23.9	above	2/26/04 13:40	24	SFL	1.58	below	-93%
12/29/03 10:18	26	2010	SFL	1.33	above	12/29/03 10:17	26	SFL	1.63	below	23%
2/26/04 10:10	25	2010	SFL	1.69	above	2/26/04 10:00	25	SFL	1.8	below	7%
2/26/04 12:38	32	2010	SFL	1.11	above	2/26/04 12:39	32	SFL	1.9	below	71%
12/29/03 12:30	32	2010	SFL	2.74	above	12/29/03 12:35	32	SFL	2.27	below	-17%
2/26/04 13:40	24	2010	SFL	9.03	above	2/26/04 13:40	24	SFL	2.53	below	-72%
2/26/04 13:39	23	2010	SFL	2.05	above	2/26/04 13:39	23	SFL	2.85	below	39%
12/29/03 10:25	27	2010	SFL	3.54	above	12/29/03 10:26	27	SFL	2.85	below	-19%
12/29/03 12:05	31	2010	SFL	2.37	above	12/29/03 12:05	31	SFL	3.16	below	33%
2/26/04 10:30	27	2010	SFL	2.5	above	2/26/04 10:30	27	SFL	3.29	below	32%
2/26/04 12:24	31	2010	SFL	2.42	above	2/26/04 12:24	31	SFL	3.53	below	46%
2/26/04 12:05	30	2010	SFL	4.61	above	2/26/04 12:05	30	SFL	3.69	below	-20%
12/29/03 10:04	25	2010	SFL	1.16	above	12/29/03 10:03	25	SFL	4.58	below	295%
12/29/03 13:53	23	2010	SFL	5.46	above	12/29/03 13:53	23	SFL	4.75	below	-13%
12/29/03 10:58	29	2010	SFL	5.61	above	12/29/03 10:58	29	SFL	6.02	below	7%
2/26/04 11:00	29	2010	SFL	4.64	above	2/26/04 11:07	29	SFL	7.17	below	55%
2/26/04 13:01	33	2010	SFL	6.18	above	2/26/04 13:02	33	SFL	7.32	below	18%
2/26/04 10:40	28	2010	SFL	25.7	above	2/26/04 10:40	28	SFL	7.47	below	-71%
12/29/03 10:30	28	2010	SFL	7.18	above	12/29/03 10:32	28	SFL	8.47	below	18%
12/29/03 14:04	24	2010	SFL	3.56	above	12/29/03 14:04	24	SFL	10.6	below	198%
12/29/03 11:58	30	2010	SFL	12.7	above	12/29/03 11:58	30	SFL	10.6	below	-17%
12/29/03 14:03	24	2010	SFL	3.61	above	12/29/03 14:03	24	SFL	17.7	below	390%
All samples:										AVE:	38%
										MIN:	-93%
										MAX:	390%
Subset of samples with >25 NTU for downstream sample:										AVE:	N/A
										MIN:	N/A
										MAX:	N/A

Unpaired Samples:

Date/Time	Site #	YearExc	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca
12/7/03 16:10	18		LDC	---	above	12/7/03 16:10	18	LDC	81.9	below
12/13/03 10:50	16		LDC	529	above	12/13/03 14:15	1	LDC	18.4	below

Appendix C: Onsite turbidity data by storm date

STORM OF DEC. 7, 2003										Turb Incr
Date/Time	Site #	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	(%)
12/7/03 14:05	10	NFL	5.73	above	12/7/03 14:05	10	NFL	6.85	below	20%
12/7/03 15:00	7	NFL	4.35	above	12/7/03 14:48	7	NFL	7.37	below	69%
12/7/03 14:43	8	NFL	9.16	above	12/7/03 14:43	8	NFL	8.33	below	-9%
12/7/03 15:25	6	LDC	2.82	above	12/7/03 15:30	6	LDC	10.2	below	262%
12/7/03 16:30	20	LDC	9.4	above	12/7/03 16:30	20	LDC	10.3	below	10%
12/7/03 14:25	9	NFL	14.2	above	12/7/03 14:25	9	NFL	10.7	below	-25%
12/7/03 15:35	5	LDC	14.7	above	12/7/03 15:40	5	LDC	15	below	2%
12/7/03 15:45	17	LDC	10.4	above	12/7/03 15:50	17	LDC	18.9	below	82%
12/7/03 16:20	19	LDC	25	above	12/7/03 16:20	19	LDC	20.6	below	-18%
12/7/03 17:25	14	LDC	33.7	above	12/7/03 17:30	14	LDC	31.4	below	-7%
12/7/03 13:27	16	LDC	33.4	above	12/7/03 13:29	16	LDC	34.4	below	3%
12/7/03 13:14	15	LDC	57.1	above	12/7/03 13:14	15	LDC	56.6	below	-1%
12/7/03 17:05	22	LDC	71.8	above	12/7/03 17:05	22	LDC	107	below	49%
12/7/03 16:50	21	LDC	229	above	12/7/03 16:50	21	LDC	217	below	-5%
All samples:										AVE: 31%
										MIN: -25%
										MAX: 262%
Subset of samples with >25 NTU for downstream sample:										AVE: 8%
										MIN: -7%
										MAX: 49%

STORM OF DEC. 13, 2003										Turb Incr
Time	Site #	Subas	NTU	Loca	Time	Site #	Subas	NTU	Loca	(%)
12/13/03 15:15	2	LDC	3.62	above	12/13/03 15:10	2	LDC	6.35	below	75%
12/13/03 12:30	7	NFL	13.8	above	12/13/03 12:30	7	NFL	15.4	below	12%
12/13/03 13:15	7	NFL	6.18	above	12/13/03 12:57	7	NFL	16.8	below	172%
12/13/03 12:50	6	LDC	3.55	above	12/13/03 13:00	6	LDC	25.4	below	615%
12/13/03 14:22	19	LDC	15	above	12/13/03 14:22	19	LDC	31.4	below	109%
12/13/03 14:50	3	LDC	29.2	above	12/13/03 14:45	3	LDC	34.8	below	19%
12/13/03 14:00	19	LDC	12.6	above	12/13/03 14:00	19	LDC	39.6	below	214%
12/13/03 12:45	9	NFL	29.8	above	12/13/03 12:44	9	NFL	40.5	below	36%
12/13/03 12:00	9	NFL	36.5	above	12/13/03 12:00	9	NFL	49.2	below	35%
12/13/03 13:40	6	LDC	5.59	above	12/13/03 13:42	6	LDC	58	below	938%
12/13/03 11:30	10	NFL	72.2	above	12/13/03 11:30	10	NFL	68.6	below	-5%
12/13/03 12:53	8	NFL	69.3	above	12/13/03 12:53	8	NFL	68.9	below	-1%
12/13/03 12:24	10	NFL	66.6	above	12/13/03 12:25	10	NFL	76.3	below	15%
12/13/03 12:10	8	NFL	76.8	above	12/13/03 12:10	8	NFL	84.3	below	10%
12/13/03 14:10	18	LDC	1.71	above	12/13/03 14:10	18	LDC	88.8	below	5093%
12/13/03 13:40	5	LDC	144	above	12/13/03 13:42	5	LDC	135	below	-6%
12/13/03 13:10	5	LDC	116	above	12/13/03 13:05	5	LDC	139	below	20%
12/13/03 13:55	17	LDC	191	above	12/13/03 13:55	17	LDC	204	below	7%
12/13/03 14:30	20	LDC	215	above	12/13/03 14:30	20	LDC	218	below	1%
12/13/03 13:25	17	LDC	217	above	12/13/03 13:25	17	LDC	220	below	1%
12/13/03 11:31	14	LDC	230	above	12/13/03 11:32	14	LDC	222	below	-3%
12/13/03 10:30	14	LDC	229	above	12/13/03 10:25	14	LDC	230	below	0%
12/13/03 13:50	18	LDC	4.6	above	12/13/03 13:50	18	LDC	241	below	5139%
12/13/03 14:35	20	LDC	251	above	12/13/03 14:35	20	LDC	257	below	2%
12/13/03 16:00	22	LDC	196	above	12/13/03 16:00	22	LDC	369	below	88%
12/13/03 11:35	15	LDC	406	above	12/13/03 11:31	15	LDC	395	below	-3%
12/13/03 11:47	16	LDC	463	above	12/13/03 11:47	16	LDC	434	below	-6%
12/13/03 10:30	15	LDC	532	above	12/13/03 10:25	15	LDC	522	below	-2%
12/13/03 15:40	21	LDC	265	above	12/13/03 15:35	21	LDC	529	below	100%
12/13/03 14:20	1	LDC	7.32	above	12/13/03 10:50	1	LDC	552	below	7441%
All samples:										AVE: 671%
										MIN: -6%
										MAX: 7441%
Subset of samples with >25 NTU for downstream sample:										AVE: 735%
										MIN: -6%
										MAX: 7441%

Appendix C: Onsite turbidity data by storm date (cont.)

STORM OF DEC. 29, 2003										Turb Incr
Date/Time	Site #	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	(%)
12/29/03 12:13	2	LDC	13.7	above	12/29/03 12:13	2	LDC	8.19	below	-40%
12/29/03 11:45	1	LDC	8.45	above	12/29/03 11:40	1	LDC	8.98	below	6%
12/29/03 10:12	7	NFL	8.54	above	12/29/03 10:00	7	NFL	9.55	below	12%
12/29/03 10:43	6	LDC	2.01	above	12/29/03 10:50	6	LDC	10.4	below	417%
12/29/03 11:35	19	LDC	10.2	above	12/29/03 11:30	19	LDC	10.9	below	7%
12/29/03 12:46	18	LDC	1.4	above	12/29/03 12:45	18	LDC	15.1	below	979%
12/29/03 9:50	9	NFL	19.4	above	12/29/03 9:45	9	NFL	33.4	below	72%
12/29/03 9:56	8	NFL	42.6	above	12/29/03 9:55	8	NFL	37.2	below	-13%
12/29/03 12:25	3	LDC	17.6	above	12/29/03 12:25	3	LDC	37.7	below	114%
12/29/03 9:25	10	NFL	47.9	above	12/29/03 9:23	10	NFL	44.6	below	-7%
12/29/03 10:55	5	LDC	55.7	above	12/29/03 10:51	5	LDC	45.2	below	-19%
12/29/03 8:38	14	LDC	63.2	above	12/29/03 8:35	14	LDC	70.5	below	12%
12/29/03 11:05	17	LDC	76.1	above	12/29/03 11:03	17	LDC	78	below	2%
12/29/03 8:50	16	LDC	110	above	12/29/03 8:50	16	LDC	102	below	-7%
12/29/03 8:38	15	LDC	116	above	12/29/03 8:35	15	LDC	112	below	-3%
12/29/03 11:55	20	LDC	107	above	12/29/03 11:56	20	LDC	120	below	12%
12/29/03 13:25	22	LDC	175	above	12/29/03 13:25	22	LDC	141	below	-19%
12/29/03 13:03	21	LDC	108	above	12/29/03 13:03	21	LDC	174	below	61%
12/29/03 10:18	26	SFL	1.33	above	12/29/03 10:17	26	SFL	1.63	below	23%
12/29/03 12:30	32	SFL	2.74	above	12/29/03 12:35	32	SFL	2.27	below	-17%
12/29/03 10:25	27	SFL	3.54	above	12/29/03 10:26	27	SFL	2.85	below	-19%
12/29/03 12:05	31	SFL	2.37	above	12/29/03 12:05	31	SFL	3.16	below	33%
12/29/03 10:04	25	SFL	1.16	above	12/29/03 10:03	25	SFL	4.58	below	295%
12/29/03 13:53	23	SFL	5.46	above	12/29/03 13:53	23	SFL	4.75	below	-13%
12/29/03 10:58	29	SFL	5.61	above	12/29/03 10:58	29	SFL	6.02	below	7%
12/29/03 10:30	28	SFL	7.18	above	12/29/03 10:32	28	SFL	8.47	below	18%
12/29/03 14:04	24	SFL	3.56	above	12/29/03 14:04	24	SFL	10.6	below	198%
12/29/03 11:58	30	SFL	12.7	above	12/29/03 11:58	30	SFL	10.6	below	-17%
12/29/03 14:03	24	SFL	3.61	above	12/29/03 14:03	24	SFL	17.7	below	390%
All samples:										AVE: 86%
										MIN: -40%
										MAX: 979%
Subset of samples with >25 NTU for downstream sample:										AVE: 48%
										MIN: -19%
										MAX: 390%

STORM OF FEB. 17, 2004										Turb Incr
Date/Time	Site #	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	(%)
2/17/04 11:50	18	LDC	1.78	above	2/17/04 11:49	18	LDC	5.65	below	217%
2/17/04 11:57	19	LDC	11.4	above	2/17/04 11:55	19	LDC	14.7	below	29%
2/17/04 12:35	2	LDC	8	above	2/17/04 12:30	2	LDC	16.1	below	101%
2/17/04 13:05	1	LDC	14.9	above	2/17/04 13:00	1	LDC	17.3	below	16%
2/17/04 10:45	7	NFL	9.24	above	2/17/04 10:50	7	NFL	19.3	below	109%
2/17/04 11:15	6	LDC	5.88	above	2/17/04 11:20	6	LDC	22.8	below	288%
2/17/04 10:28	9	NFL	25.2	above	2/17/04 10:26	9	NFL	38.6	below	53%
2/17/04 10:41	8	NFL	49.2	above	2/17/04 10:40	8	NFL	47.9	below	-3%
2/17/04 9:08	14	LDC	67.4	above	2/17/04 9:07	14	LDC	66.4	below	-1%
2/17/04 12:20	3	LDC	50.7	above	2/17/04 12:15	3	LDC	67.6	below	33%
2/17/04 12:56	20	LDC	63.5	above	2/17/04 12:55	20	LDC	75.8	below	19%
2/17/04 10:08	10	NFL	77.7	above	2/17/04 10:08	10	NFL	76.5	below	-2%
2/17/04 11:22	5	LDC	110	above	2/17/04 11:24	5	LDC	86.8	below	-21%
2/17/04 9:31	16	LDC	99.8	above	2/17/04 9:30	16	LDC	91.9	below	-8%
2/17/04 9:08	15	LDC	97.2	above	2/17/04 9:07	15	LDC	97.8	below	1%
2/17/04 11:36	17	LDC	91.2	above	2/17/04 11:36	17	LDC	107	below	17%
2/17/04 13:30	21	LDC	114	above	2/17/04 13:29	21	LDC	140	below	23%
2/17/04 13:50	22	LDC	154	above	2/17/04 13:48	22	LDC	163	below	6%
All samples:										AVE: 49%
										MIN: -21%
										MAX: 288%
Subset of samples with >25 NTU for downstream sample:										AVE: 10%
										MIN: -21%
										MAX: 53%

Appendix C: Onsite turbidity data by storm date (cont.)

STORM OF FEB. 26, 2004										Turb Incr (%)
Date/Time	Site #	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca	
2/26/04 10:10	25	SFL	1.69	above	2/26/04 10:00	25	SFL	1.8	below	7%
2/26/04 10:25	26	SFL	2.28	above	2/26/04 10:25	26	SFL	1.4	below	-39%
2/26/04 10:30	27	SFL	2.5	above	2/26/04 10:30	27	SFL	3.29	below	32%
2/26/04 10:40	28	SFL	25.7	above	2/26/04 10:40	28	SFL	7.47	below	-71%
2/26/04 11:00	29	SFL	4.64	above	2/26/04 11:07	29	SFL	7.17	below	55%
2/26/04 12:05	30	SFL	4.61	above	2/26/04 12:05	30	SFL	3.69	below	-20%
2/26/04 12:24	31	SFL	2.42	above	2/26/04 12:24	31	SFL	3.53	below	46%
2/26/04 12:38	32	SFL	1.11	above	2/26/04 12:39	32	SFL	1.9	below	71%
2/26/04 13:01	33	SFL	6.18	above	2/26/04 13:02	33	SFL	7.32	below	18%
2/26/04 13:39	23	SFL	2.05	above	2/26/04 13:39	23	SFL	2.85	below	39%
2/26/04 13:40	24	SFL	23.9	above	2/26/04 13:40	24	SFL	1.58	below	-93%
2/26/04 13:40	24	SFL	9.03	above	2/26/04 13:40	24	SFL	2.53	below	-72%
All samples:										AVE: -2%
										MIN: -93%
										MAX: 71%
Subset of samples with >25 NTU for downstream sample:										AVE: N/A
										MIN: N/A
										MAX: N/A

Unpaired Samples:

Date/Time	Site #	Subas	NTU	Loca	Date/Time	Site #	Subas	NTU	Loca
12/7/03 16:10	18	LDC	---	above	12/7/03 16:10	18	LDC	81.9	below
12/13/03 10:50	16	LDC	529	above	12/13/03 14:15	1	LDC	18.4	below

APPENDIX D: ADDITIONAL MATERIALS

Narratives, Assessment Forms, and Photopoints: A separate document ([‘LostManMonRpt_2004_Appendix D.pdf’](#)) contains site narratives, copies of the erosion assessment forms completed during and after the winters of 2002-2003 and 2003-2004, and photos taken before, during, and after the winter of 2003-2004.