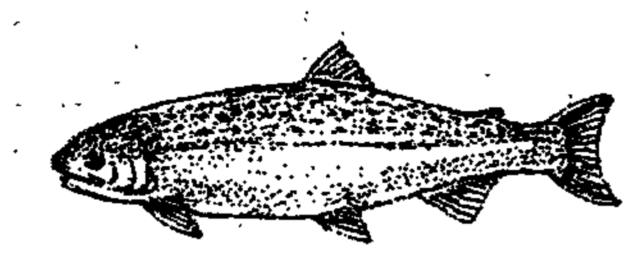
San Geronimo Bedload Sediment Reduction Program

2000 Monitoring Report

prepared for the

Marin County Resource Conservation District and
Marin Municipal Water District



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October 2000

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1.0 Introduction

In 1993 the Marin Municipal Water District (MMWD) created the San Geronimo Bedload Sediment Reduction Program (program), which includes a 10-year annual maintenance and streambed monitoring effort. Prunuske Chatham, Inc. (PCI) serves as Program Manager for the Marin County Resource Conservation District (MCRCD). The monitoring program was developed specifically for Lagunitas Creek and designed to closely parallel geomorphic studies conducted between 1979 and 1982.[1] The streambed monitoring is part of MMWD's Lagunitas Creek Sediment and Riparian Management Plan as required by the State Water Resources Control Board under Order WR 95-17. The intent of the order is to protect fishery resources in Lagunitas Creek.

The monitoring program is intended to be an objective assessment of streambed conditions in Lagunitas and San Geronimo Creeks. The program includes an evaluation of general streambed conditions and measurements of the channel bed elevation, bed surface composition, and bed core composition. There are seven streambed monitoring sites located along the reach of Lagunitas Creek from Shafter Bridge to Tocaloma (see Figure 1) and two streambed monitoring sites in San Geronimo Creek.

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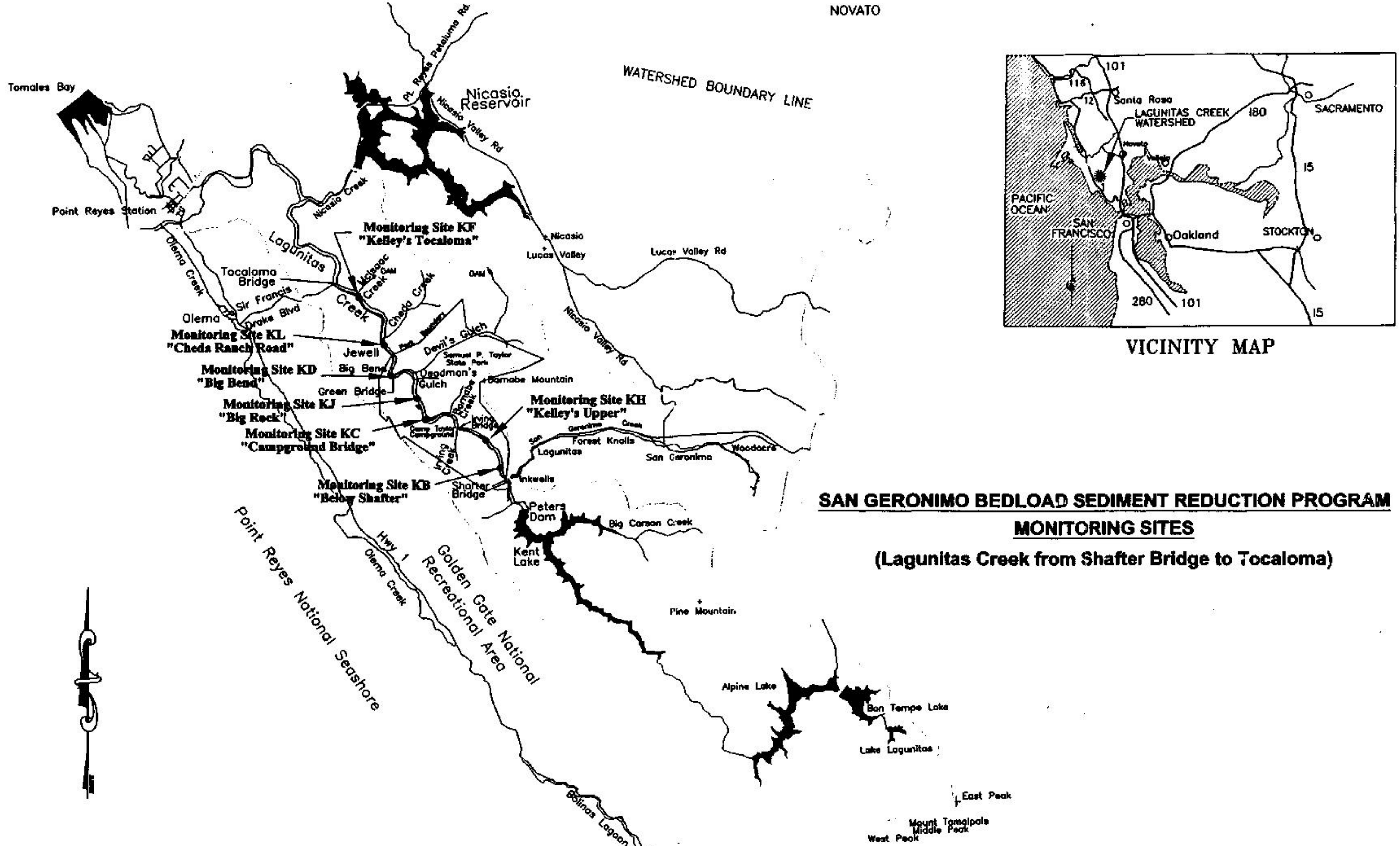
[1] These are the geomorphic studies used by the State Water Resources Control Board (SWRCB) in determining the actions required of MMWD under Order WR 95-17. (See Hecht, 1992, for details.) Monitoring was also conducted by Balance Hydrologics, Inc., in 1991 prior to the SWRCB hearings and in 1993.



SAN GERONIMO BEDLOAD SEDIMENT REDUCTION PROGRAM

MONITORING SITES

(Lagunitas Creek from Shafter Bridge to Tocaloma)

PRUNUSKE CHATHAM, INC. P.O. BOX 828 OCCIDENTAL, CA 95465	DATE: SEPTEMBER, 2000 SCALE: 1" = 6,000' CHECKED BY: MN	REVISIONS	DATE	BY	PREPARED FOR: MARIN COUNTY RESOURCE CONSERVATION DISTRICT AND MARIN MUNICIPAL WATER DISTRICT	MONITORING SITES LOCATION MAP	Figure 1

This is the annual report for the 2000 streambed monitoring. The purpose of the report is to present data collected this year, not to analyze it. The report contains a discussion on bedload transport in order to orient the reader as to why the data is collected and how the data can be utilized in the future, a general description of current channel conditions, and a brief summary of bed elevations and measurements of streambed composition. We have made simple observations of trends where they appear significant or interesting to help the lay reader make sense of the data. These trend observations are in no way a comprehensive analysis of the data.

The channel evaluation field notes are presented in Appendix A. The summary data tables for the mean bed elevation, bed surface, and bed core composition are presented in Appendix B. The Lagunitas Creek cross-sections are included on 24-inch x 36-inch format. In order to enhance interpretation of the data, the sections are not of equal vertical and horizontal scale.

2.0 Summary of 2000 Channel Conditions

As part of the monitoring program, an evaluation of the general streambed conditions is made each year. This evaluation consists of a visual survey (a two day creek walk) that helps assess whether the quantitative measurements at the monitoring sites are representive of general streambed conditions. If significant local-scale disturbances (i.e., fallen trees, landslides, etc.) are impacting the monitoring sites, the site may be deemed to be unusable, and substitute monitoring sites or cross-section locations are identified. This survey is also useful in describing large-scale visible changes such as major changes in the size or location of a tributary delta, pool, riffle, or glide within each monitoring site. The notes of the visual survey are included in Appendix A.

No significant changes in monitoring occurred from 1999 except as stated in the following summary:

- Site KB (below Shafter Bridge): The 4-foot fir that fell in 1998 continues to significantly impact the site. Subsurface and surface samples were taken from a riffle, pool, and glide just downstream and beyond the immediate effects of this obstruction (as was done in 1999). Three additional cross-sections were added; one is downstream of the original site, and two others are near the fallen tree where omitted (sections 5 and 6).

3.0 Discussion of Channel Dimensions and Bedload Transport

In order to understand why bedload is monitored on Lagunitas and San Geronimo Creeks, it is important to understand how bedload transport occurs, how bedload transport can impact the stream habitat, and how the physical habitat features (i.e., riffles and pools) are formed.

3.1 Bedload Transport

Stream channels transport both water and sediment. In Lagunitas and San Geronimo Creeks, water is transported on a year-round basis. Sediment is also transported on a year-round basis; however, larger material is only moved during larger storms. The bed of the stream channel provides temporary storage for these sediments. Over time, all the sediment stored in the bed of the creek is transported to the ocean and replaced by sediment from upstream sources.

During lower flows, predominantly fine sediment (i.e., sand and smaller) is transported from and over stable riffles composed of gravels and cobbles. At higher flows, larger particles (i.e., gravels and cobbles) are also mobilized. During the higher flows, the entire streambed has the potential to be mobilized, and the channel shape can be both maintained and formed.

3.2 Channel Formation and Maintenance

An alluvial stream channel forms in response to a wide variety of factors including the stream's sediment supply, lithology, existing geometry, and the character of storm flows. A natural channel is formed and maintained by relatively frequent flows rather than infrequent large storms. Most of the work to shape the channel is accomplished when the channel is flowing full but still within the banks. Most of the sediment in a stream system is transported by these relatively frequent high flows. It is these flows that have enough power to transport large particles, erode banks, and scour the depths of pools.[2]

3.3 Changes in Hydrology, Sediment Supply, and Habitat

If a dam is constructed or expanded, stream flows and sediment input below the dam will decrease because of the storage behind the dam. This can cause changes in streambed conditions that are detrimental to aquatic habitat. For example, lower flows cannot move sediment as efficiently, and pools can fill. Reduced sediment input can reduce the amount beneficial gravels that are used for spawning.

Once the hydrology of a stream is altered, the power to transport and scour sediment is modified, and the ability to maintain and form a channel shape is altered. We would then expect to see a change in channel dimensions, including but not limited to, average bankfull width, average bankfull depth, maximum depth of rearing pools, mean particle size of spawning riffles, and mean bed elevation. These are critical aspects of aquatic habitat.

3.4 Understanding the Purpose of Data Collection

The effects of dam construction or expansion can only be verified by data collection in the field. The data collected by this monitoring program focuses on comparing data before and after dam expansion. The comparison can then be used to definitively show the effects of the dam on

[2] The flow that does most of the work at shaping and maintaining the channel is at or just greater than the "bankfull discharge" (Wolman and Miller; 1960; Carling, 1987). The "bankfull discharge" tends to be uniform among streams in vastly different regions and occurs on average every 1 to 2 years (Wolman and Miller, 1960). "Bankfull" is a geomorphologic term and is determined in the field by such indicators as active floodplains and vegetation. It does not correspond to the tops of the high banks in Lagunitas Creek.

streambed conditions. Additionally, monitoring can potentially describe the effects of restoration (such as erosion control and woody debris placement) and can help determine its effectiveness and if changes need to be made to the enhancement program.

4.0 Summary of Streambed Conditions[3]

The quantitative portion of the streambed monitoring program is composed of three parts: a characterization of the channel's streambed elevation, an analysis of the particle size distribution on the surface of the streambed, and an analysis of the bed core. Monitoring occurs at each of the seven sites in Lagunitas Creek, and bed core samples for rock type identification are also taken at two sites in San Geronimo Creek. In addition, the monitoring team now collects measurements of gravel rock types at one site in Lagunitas Creek. Each of the sites in Lagunitas Creek has seven to eleven monumented cross-sections, and each site includes a pool, riffle, and glide habitat sequence.[4] Changes in the relative depth and location of these habitat units are noted in Tables 2 and 3 of Appendix B.

4.1 Changes in Bed Elevation

To evaluate changes in the bed elevation within each monitoring site, a survey of monumented cross-sections is conducted. Cross-section data can be used to help determine whether sections of the streambed of Lagunitas Creek are scouring (degrading) or filling (aggrading). The mean bed elevation is calculated for each cross-section. Elevations are relative to National Geodetic Vertical Datum (NGVD). Aggradation or degradation of sediment over time can be computed by comparing the mean bed elevation of each year's survey with that of previous

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[3] The following discussion is based on the monitoring protocol developed by Barry Hecht for MMWD. See Proposed Bed-Conditions Monitoring Program, Lagunitas Creek Below Kent Lake, Marin County, California (Hecht, 1992) and the Lagunitas Creek Sediment and Riparian Management Plan (Prunuske Chatham, Inc., 1997).

[4] Note that the pool, riffle, and glide habitat sequences are geomorphic bed segments established for the streambed monitoring program and do not necessarily correspond to the pool, riffle, and glide habitat typing used by the California Department of Fish and Game and other entities.

surveys. For this report, mean bed elevations were calculated from the 2000 data (see Appendix B: Table 1).

4.2 Streambed Surface Composition and Bed Core Composition

The program includes measurements of several physical factors that describe sediment characteristics on the surface and within the streambed at the seven Lagunitas Creek monitoring sites.[5] Each of the parameters is described below, followed by a brief summary of the data collected at each site during the low flow period in 2000.

4.2.1 Bed Surface Composition.

Bed surface composition is used to evaluate changes in sediment deposition and physical parameters that can influence the quality of fish habitat. Data collection is based on a high precision modification of the Wolman pebble count, which involves the systematic collection of rocks from the surface of the streambed. The collected rocks within each habitat unit (a pool, riffle, glide sequence within the monitoring site) are measured, and the mean size and distribution of sizes are evaluated. The three types of information evaluated from the pebble count (see Appendix B: Table 5) include:

4.2.1.1 Embeddedness. Embeddedness can be an important limiting factor. When rocks are buried, juvenile salmonids have less space to hide from predators or to take shelter from the current. Embeddedness is measured as a proportion of rock (for rocks larger than 45 mm) that is buried in the streambed. Measurements of embeddedness are reported in increments of 10%. Mean embeddedness for each habitat unit at each monitoring site is calculated.[6]

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5 Prunuske Chatham, Inc. retains Balance Hydrologics, Inc. to collect the streambed surface, rock-type composition, and bed core composition data.

6 Cobble embeddedness is not a direct measurement of the deposition of fines in a stream system because rocks can be buried by a variety of particle sizes. This is particularly evident in areas located downstream from major sediment supplies such as tributaries or landslides.

4.2.1.2 The proportion of bed surface occupied by sand, cobble, organic material, and bedrock. These values are computed from the total number of samples taken at each pool, riffle, or glide. Each of these materials influences the quality and persistence of fish habitat in different ways.

- Cobbles provide refuge for fish and important habitat for aquatic insect larvae that flourish in riffles. These insects provide the foundation of the aquatic food web and are an essential source of nutrients for developing fish.
- Large organic material provides shelter for fish and aquatic insects during periods of high flow and can provide shade and shelter during the summer. For the purposes of this study, woody debris is counted as large organic material whenever a piece large enough to generate a resting place for young-of-the-year steelhead or coho is encountered, generally a limb larger than about 3/4 to 1 inch in diameter. Woody debris provides important nutrients for aquatic insects and can contribute to the formation and maintenance of pools.
- Bedrock on the surface of the channel influences the flow characteristics of the stream. The combination of smooth substrate and increased velocity contributes to the formation and persistence of pools that provide important habitat for fish and other organisms.
- The proportion of the bed surface that is occupied by sand is used as a descriptor for the amount of fines (impairing sediments) that are present on the bed surface at the seven monitoring sites. “Sand” represents the portion of the material that is less than 4 mm in diameter.

4.2.1.3 Particle size distribution. This data is used to analyze trends in the size of sediment deposited on the surface of the bed. Data is expressed in terms of the average particle size or geometric mean diameter (D_{50}), and the size of material that is one standard deviation below (D_{16}) and above (D_{84}) the sample mean.

4.2.2 Bed Core Composition.

Bed core samples are collected from the seven monitoring sites in Lagunitas Creek and two sites in San Geronimo Creek. The cores are intended to characterize the subsurface bed sediments. The distribution and quantity of different sized material (i.e., coarse or fine) in the subsurface are important because they represent the sediment that is transported by the stream during storm events, which then is covered by a surface layer during subsequent smaller flows. The subsurface data can be analyzed to indicate the quality of habitat and to indicate what type and relatively how much sediment is entering from the upper watershed. The bed core samples are taken at the downstream end of the pool at each site, just upstream of the glide.

Bed core samples are not taken in locations where spawning might occur and are not intended to characterize spawning habitat. No conclusions should be drawn about the relationship between this data and the survival of salmonid embryos in Lagunitas Creek. It should also be noted that gravel mixtures with the same D_{50} can have wide variations in fine sediment content.

Bed core composition is described by the size of material that is transported during periods of high flow and deposited in the streambed. The surface layer of gravels is scraped away before collecting the samples. Samples collected from each monitoring site are dry sieved to determine the size distribution of the particles. From this data, the geometric mean (D_{50}) and standard deviations (D_{16} and D_{84}) of the sample are calculated. Because samples are collected with a 6-inch sampler, caution is advised in interpreting data about the size of material that is one standard deviation above the mean (D_{84}) because larger particles may not be represented in the bed core sample (see Appendix B: Table 6).

5.0 Observations of Streambed Conditions

Observations regarding elevations, bed surface, and bed core composition data from 1993 to 2000 include:

- Site KB (below Shafter Bridge): This site has been (temporarily?) changed by the 4-foot diameter fir tree that fell between sections four and five in 1998. Due to these changes, comparisons of data should be interpreted with caution. Both the surface and subsurface samples show a decrease in the median particle size in both the pool and glide.
- Site KH (Kelley's Upper): Long-term comparison of data indicates the mean bed elevation is slightly degrading since 1993. In addition, the proportion of coarse bed material in the riffle appears to be slightly increasing since 1993.
- Site KC (Campground Bridge): Long-term comparison of data indicates the mean bed elevation is slightly degrading over time. In addition, the proportion of coarse bed material in the riffle, pool, and glide appears to be either stable or increasing since 1993.
- Site KJ (Big Rock): Although variations occur from year to year, long-term comparison of the data indicates the site appears to be more or less stable since 1993, and the composition of sediment is not greatly fluctuating.
- Site KD (Big Bend): Long-term comparison of data indicates this site can be quite responsive to annual and short-term (i.e., three to four-year) fluctuations; however, no long-term trend regarding bed aggradation/ degradation appears to be established at this site. Portions of this site experience heavy recreational use.
- Site KL (Cheda Ranch Road): Long-term comparison of the mean bed elevation indicates the site is aggrading. In 2000, the proportion of coarse bed material, as well as the median size in the riffle, pool, and glide, is increased in relation to previous years. This year's trend can also be seen in the increased median particle size of the subsurface sample. A long-term trend of the particle size characteristics of the surface or subsurface is not evident.
- Site KF (Kelley's Tocaloma): Long-term comparison of the mean bed elevation indicates the site is aggrading since 1993. In addition, the mean surface particle size in the pool, glide, and riffle is either decreasing or remaining the same.

5.1 Rock-type Composition.

Gravel lithology data were collected at three sites—two in San Geronimo and Site KF (Kelley's Tocaloma) (see Appendix B: Table 7). While not required under the monitoring protocol, lithologies of bed core samples at site KF were analyzed because of the large quantities of sediment entering from the Big Bend area.

6.0 Data Considerations

The type of data currently being collected must match the type of data collected before dam expansion and is valuable in extracting an understanding of the impacts of dam construction and expansion to Lagunitas Creek. In this report, the data is simply presented with some very general trends explained to help the reader make sense of the data. In the future, this data may be analyzed to tell us additional information such as the following.

- Mean bed elevation may be examined to gain insight into the short-term stability of critical habitat units (i.e., riffles).
- Mean particle size of the surface and subsurface (and embeddedness) can be examined to extract long-term trends over the entire lower area of Lagunitas Creek and specific habitat units (i.e., glides, pools, and riffles). This information could be compared with the data collected under the habitat typing conducted by MMWD. In addition, short-term trends may be able to be identified to answer questions about the rate of fines filling pools between scouring events.
- The percent of surface area of pools, glides, and riffles could be extracted from the data and compared over time. This would give us insight into how the amount of potential rearing or spawning habitat is changing and how it might be affected by bedload transport and channel dimensions.
- A comparison of channel dimensions over time would help to understand how the channel shape is responding to the dam expansion. Measurements such as mean

bankfull depth can be extracted from the cross-sections and meaningful ratios (i.e., width/depth ratio, entrenchment ratio) can be determined.

Additional data that could be collected could also help answer habitat-related questions. These include:

- Flow measurements before and after the dam construction/expansion are helpful in understanding trends identified in the bedload monitoring program.
- An analysis of whether summertime low-flow pools (perceived to be a limiting factor) are filling up with fine sediment from San Geronimo Creek between flow events that have enough power to scour the pools. This could be examined by surveying selected pools in detail several times a year (long enough to cover several potential scour and fill events), as was conducted in 1981.
- An examination of whether fine sediment from San Geronimo Creek is negatively impacting the overall habitat. One way to answer this question would be to collect data that serves as an "indicator" of overall habitat health. Indictors include physical indicators such as the amount of fine material in riffles or biological indicators such as the collection of aquatic insects (which live in the streambed).
- An analysis of whether the amount of fine sediment in the riffles is high enough to jeopardize juvenile salmonid survival. Subsurface samples in the riffles could be collected, analyzed, and compared to a large body of research that has quantified how much fine sediment is detrimental to salmonid survival. Alternatively, inexpensive monitors that directly sample inter-gravel dissolved oxygen (I.G.D.O.) can be installed.

7.0 References

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APPENDIX A

BALANCE HYDROLOGICS, Inc.

Memo

To: Lagunitas Creek, 2000 File
From: Barry Hecht and Eric Austensen

Date Dictated: May 30, 2000 and June 29, 2000
Date Transcribed: June 2, 2000 and June 30, 2000

Subject: Subjective Reconnaissance ("Creek Walk") of Lagunitas Creek WY2000

Note: These field notes are dictated during the annual subjective reconnaissance while wading along Lagunitas Creek upstream from Tocaloma to Shafter bridges. The notes are not part of the formal 10-year bed-monitoring program performed by MCRCD. Rather, they are informal notes of specific field observations by the monitoring team members, with emphasis on observations repeated each season and on factors which help assess (a) whether the quantitative censuses at the bed-monitoring sites are representative of general stream conditions and (b) whether effects of landslides, logjams or other unstable conditions are affecting the bed-monitoring sites. The monitoring team makes the notes available because they are a useful record of current conditions and may help future observers to better understand variability of bed conditions in these reaches of Lagunitas Creek during the monitoring period. The transcribed notes are edited for clarity and accuracy, with only limited changes made in the informal field syntax and grammar.

Conventions to help the reader:

1. Right and left banks are designated when facing downstream.
2. Unless otherwise noted, the pools, riffles, and glides described are larger elements, generally formed during high flows, which generally extend fully across the width of the stream. In alluvial sub-reaches, one sequence of a riffle, pool, and glide typically occupy a length of channel equal to about 5 to 7 bankfull widths. We use standard "phi" or the geomorphic definition of these features, distinct from pocket pools or other small bed units typically defined in low-flow habitat studies.
3. Gravel and cobble sizes (e.g., 23's, 32's, 45's, 64's, etc.) are a shorthand notation for Wolman-count classes, which vary by half the square root of two. The sizes given (in millimeters) are the lower limit of the class. For example, 23's are the gravels with intermediate diameters of 23 to 32 mm.
4. Pool depths, unless otherwise described, refer to nominal depths typical of the deepest part of the pool. Generally, about one-third of the pool will be at or slightly deeper than the depth given.
5. In the interest of safety, bedrock reaches (a) between Devils Gulch and the Green Bridge above Big Bend and (b) the State Park entrance kiosk and bike path bridge across SFD and the Creek are observed from the road or the bike path. Other reaches are described while wading.
6. LOD (large organic debris) includes limbs, trunks, stumps and snags
7. YOY: Young-of-the-year salmonids (generally <60mm)

Day One: May 30, 2000

The lower half of the 2000 walk was conducted on this cool, clear and windy day beginning at approximately 10:00 a.m.

1. Upstream from Tocaloma Bridge:

The pool beneath the bridge at Tocaloma is now a large bar with a slightly rippled surface; this could possibly be the result of accelerated gravel delivery from the Big Bend area.

Both small left bank tributaries show a little if any sign of instability during the past season. Flows remain below what appears to be bank full, with only minimal signs of sand in the high water marks. There has been lots of understory growth, and it appears to be as dense as it was prior to the disturbance in 1998. Currently, the flows are estimated to be 1.5 and 5 gallons per minutes (gpm) in the downstream and upstream tributary, respectively.

2. Triple Alternate Channels at the McIsaac Barn:

There has been relatively little change at this site. Flow remains in the north (right bank) branch passing beneath the large alder that fell during the winter of 1999. The middle branch bar has coarsened and is lower, apparently due to the long duration of high flows of this past February. The left bank alternate channel did convey some of the high flows of this past winter, but the effects are barely discernible.

3. Pool Below McIsaac Creek:

Over the past 2 or 3 years, this pool has both shoaled and narrowed, with large bars of fine and medium gravel filling every possible lee and eddy. During the 1993 and (probably) 1995 stream walks, I recall there being two places where water was just a little higher than the tops of our chest waders; there are now no spots deeper than about 32 inches. I would estimate the net change and bed elevation to be perhaps 1.3 to 1.5 feet. In addition to the shallow, narrower channel, the water levels in the pool had risen, such that the roots and lower trunks of virtually all of the alders on the east bank are submerged and the trees are dead or dying. Aggradation is likely attributable to downstream progression of the three coarse sediment pulses of 1995, 1996, and 1997 from Big Bend, or this year's coarse sediment delivering from the left-bank tributary at lower Tocaloma.

These alders separate the present channel from an alternate channel to the north, which currently supports seepage pools; it appears to be about 18 inches lower. The medial bar separating the two channels, with willows that are 5 to 10 feet high, likely results from 1993 or 1995 high waters — at a time before we understood about the nature of the alternate channels, so it would not have been reported.

4. McIsaac Creek:

We walked 30 or 40 yards upstream on McIsaac Creek, where the bed is composed of subangular 45-millimeter clasts. The bar at its mouth is dominated by 45s and 64s, with just a dusting of sand at the February 2000 high-water mark. This high-water mark which is consistently about 1.6 to 1.8 feet above its bed, which has a mean width of about 5.5 feet. Lithologies (rock types) are mixed, with only greenstones being deficient and multi-colored cherts and serpentinites conspicuous. Estimated flow at the moment is 25 to 30 gallons per minute.

We have seen a few salmonids, both young-of-the-year and yearlings, but not quite as many as I recall from previous years. We saw 6 to 8 newts on the bed, and a number of lamprey (eel) redds. When removing some of the bed gravel from the center of the pool with the sharpshooter shovel, we dislodged a young, 3-inch lamprey.

5. Kelley's Tocaloma Bed Monitoring Site:

The main changes here are a marked coarsening of the bed within the downstream from cross-section KF-4, development of a shallow riffle or riffle glide extending upstream almost as far as section KF-5, a deepening of the glide and pool to depths of 1.5 to 2.3 feet, which respectively, and additional ongoing mortality of the mature alders and ashes which line the bank of the stream at this site.

The bed segmentation has changed. The main riffle still runs from about KF-8 to KF-9; the shallow riffle with broken water extending fully across the channel extending up to KF-6. The glide is from KF-6/7 to KF-4/5. The pool is very well developed upstream from a point halfway between KF-3 and 4. Downstream from KF-5, the bed is visibly coarsened, such that perhaps 20 to 25 percent of the bed seems coarser than 45 millimeters. Occasional broken water occurs at flows prevailing today.

There are 8 to 10 large limbs that have fallen within the low-water channel at this bed-monitoring site. All of these seem to have fallen since the high water of the past winter, and have left no expression on the bed. This is indicative of the pruning by wind of dead branches and widowmakers going on at this site.

6. Pools Above Site KF:

The 200 yards upstream from site KF is a pool, primarily, with depths of about 24 inches, deepening upstream to 6 feet. No significant changes were noted, except for a few more large (90-millimeter) rocks and cobble clusters coming through the pool. We saw 2 fresh lamprey carcasses.

7. Large Left Bank Tributary at Lower Tocaloma:

The delta is longer, coarser, and lower than we recall from last year. It appears to have received a fresh load of angular small cobbles, such that it now extends across about 90 percent of the channel width of Lagunitas Creek, and about 150 feet downstream.

Upon walking upstream, we found that the 80 yards up to the bike path were mantled with fresh coarse debris. The channel has incised about 18 inches through this material, but an additional 6 to 12 inches of incision will be needed to bring the bed back down to its 1999 level. During this past winter season, approximately 60 to 70 cubic yards of bedload sized material -- principally coarse gravels — were delivered to Lagunitas Creek solely from erosion of this depositional prism. Logically, an equal or greater amount would have moved in to Lagunitas Creek during the peak flows. At the culvert, the channel has filled to approximately 6 inches above the invert, in contrast to the waterfall of perhaps 2 feet in previous years. This lower reach will be a recurring source of coarse gravel and small cobbles for the next several wet years.

Flow in the stream at the surface is estimate to be 10 to 15 gallons per minutes at the culvert, infiltrating entirely within the first 50 feet.

Eric explored several hundred feet further upstream. He found some large fresh gravel bars fifty feet long 5 or 10 feet wide, similar to the one just below the outlet of the culvert. Obviously, a lot of fresh erosion has occurred along this tributary. It probably, however, won't qualify for treatment because of its position far downstream in the Lagunitas watershed.

8. Large Left Bank Tributary to the Flashboard Abutments, Community of Lower Tocaloma:

There is much sediment storage going on in this reach of Lagunitas Creek, at several different scales. First, large oblique bars occur throughout, typically occupying 70 to 80 percent of the width of the channel. They are of very low relief, and are covered with this year's annual plants growing on the bed. The bed surface is composed primarily of 23s and 16s, and occasionally coarser material at some bars. Second, the large medial bar separates the active channel, which flows against bedrock on its left bank, f rom an alternate channel further north, which seems to have been occupied perhaps several decades ago. Third, perhaps half a foot of fill has accumulated during the past winter at the flashboard dam, since the tops of the supports are presently only an inch or two above the bed of the creek.

9. Reach Through the Community of Upper Tocaloma:

There are 3 very significant logjams that have developed through this reach, spaced at roughly equal intervals along Lagunitas Creek as it passes through this community. In each case, 2 or 3 large alders have lodged crosswise, accumulating other debris. Several lines of evidence indicate that at least 2 of the logjams happened quite late in the season, since they have deposited bars at locations were the MMWD's fishery's biologists observed coho spawning earlier in the year.

Large gravel bars, which occupy somewhat more than half the channel width and are typically about 3 feet high, are associated with each of the logjam. It is unclear at this point whether the large amount of coarse sediment moving through this system is responsible for dislodging of the alders, or visa versa. The surface of the bars is paved with 32s and 45s, with isolated 64s being common. In some cases, the bars are broad, fan shaped, and very well sorted; in others, they are sharply crested, at the angle of repose and appear to have formed and ceased forming abruptly.

Although I saw similar density of logjams in this reach after the 1995 storms, the amount of the gravels in motion is very new and striking.

Despite the bed mobility, we are seeing lots of lamprey redds, even in locations where the converging flow seems ephemeral or unstable. We're often seeing 6 to 10 young-of-the-year salmonids as we walk through pools. No yearlings have been observed throughout this reach.

10. Baywood Beach:

This location is approximately 100 yards upstream of the uppermost home in upper Tocaloma. It is bounded on the south bank by 2 large terraces high on the left bank supporting a grove of large bays with occasional oaks.

In previous years, a large sandy bar has developed against the left bank, a place where stopping for lunch or for a drink was a shady delight. Currently, the channel has removed all of this bar — once 6 feet high — and is actively eroding the base of the bank, just below the deepest roots of the largest bay. If this continues, the largest bays will be undermined, and this bank could potentially unravel. The north half of the channel at this location is occupied by a bar of gravel, which is simply being stored in the channel, and supports this year's annual growth.

11. Bay Tree Beach to Cheda Ranch Creek:

Large oblique bars and universally filled pools characterize this reach. The narrow brushy channel lined with willows that usually characterizes the portion of this reach where the stream close against the right bank bedrock is now a series of open pools that average about 18 inches deep. Once again, some of the bars are well sorted and sculpted; others are knife-edged, chaotic and appear to have been formed quickly.

Beginning approximately 400 yards downstream from Cheda Ranch, small angular cobbles begin to become dominant on the riffle bars. Riffles in this reach generally occupy a single channel or a single thread, in contrast with the multi-threaded channels with gravel beds, which occur downstream from the Bay Tree Beach.

The density of the young salmonids increases drastically within this reach, with commonly 200 or 300 young fish observable as we walk through the pools. Very rarely do we see yearlings.

12. Cheda Ranch Creek:

There is a considerable amount of gravel coming entering Lagunitas Creek from Cheda Ranch Creek. We walked about 150 yards upstream of the culvert and saw fresh bars and active cuts on the inside and outside of each bend, respectively. All of the bars support annual vegetation which dates to this year; I see relatively little sign of 1998 events, except at one bend near the gate. It is likely that several hundred yards of gravel came out of Cheda Ranch Creek, based solely on channel incision beneath 2 feet beneath the bar tops; and likelihood sediment delivery was probably several times as much.

Material being transported by Cheda Ranch Creek is primarily coarse gravels and cobbles, to approximately 150 millimeters in intermediate diameter. Most of the material larger than 90 millimeters is rounded or subrounded. Lithologies are mixed, with all of the common rock types being present, with the possible e xception of the porphyritic diabase or 'dike rock'. There are numerous scoriaceous metavolcanic rocks amongst the large gravels and small cobbles streams in the area, an unusual and potentially diagnostic rock type.

Today's flow in Cheda Ranch Creek is approximately 80 to 100 gallons per minutes. The reading at the survey rod/staff plate located approximately 50 yards upstream at the culvert is 9.93; however, the banks to which it has been attached are eroding away rapidly enough that it is doubtful that whoever placed this gage will enjoy it through next season.

13. Cheda Ranch Monitoring Site:

The first 100 yards upstream of Cheda Ranch Creek to cross section KL-8 are much wider than before and significantly eroded on both banks. The band of 5 year-old willows which was colonizing the right bank bar has been scoured away as logjams resulted in about 3 feet of downcutting at this bar. Several of the alders on the left bank have been undermined and have toppled, allowing the stream to attack the toe of the banks and form a southward bend cutting into the terrace, which is gradually becoming enlarged. It is likely that approximately 800 cubic yards of bank material has been washed into the stream within this small section of the reach, of which probably 60% was material of bedload sizes. This material augments the larger volume (probably of generally finer material) entering from Cheda Ranch Creek to form the large, beveled delta, extending approximately 60 yards downstream from the mouth of Cheda Ranch Creek.

Changes at the bed-monitoring site itself are subtler, but equally fundamental. The glide has widened, but still appears to encompass the area between sections KL-6 and KL-8. A large bar of fine gravel has formed in the center of the pool, perhaps a reflection of the more abrupt plunge that now occurs as two 12-inch ash and bay logs have been added atop the large fallen redwoods which previously were there. The pool has scoured at its upstream end and has shoaled at i ts downstream end, but still forms basically a single morphological unit. The 2 new logs added to the top of the logjam at cross section KL-2 have been cut with a chain saw, and the stream seems to have down cut through the prism that it may have deposited behind the wood earlier in the season. There is small riffle approximately 50 feet upstream of the logjams, but it seems ephemeral and of only passing significance; hence, I hope we can find a suitable riffle in the logjammed reach below the pool.[1] Eric will add a new left-bank pin at KL1, because of ongoing bank retreat occurring at and upstream from this pin.

14. From Cheda Ranch Site to the Old Bridge Abutments Downstream at Jewell:

At several places in this short reach, it is clear the high-water mark of the season is just about at morphologic bankfull level. It is marked by light debris and a sand line, primarily from material re-worked from the 1998 debris.

There are 3 or 4 large alders in this short reach that have drowned and died over the past several years. I would not be surprised to see a large logjam form and the divert the stream into the alternate left bank course through which it seems to have run during the

[1] After additional searching, we did locate an appropriate riffle beginning 47 feet downstream from cross-section KL8, which we used as the site for a bed census conducted on July 6.

1969 or 1973 storms (based on my recollection of the conditions when this site was established in 1980).

15. Bridge Abutments below Jewell:

The actual piers of the bridge abutment extend about a foot above of the bed of the stream, with the entire 10-foot long foundation presently exposed, just barely.

16. Left Bank Tributary below Jewell:

Entering 50 yards upstream of the old Jewell Bridge abutments, this tributary transported a moderately large amount of large gravel and cobble this year, perhaps contributing several hundred cubic yards of coarse sediment to Lagunitas Creek. The present delta is very small, obscured by logjam-related deposition. Walking upstream, we noted a higher brush-covered delta, likely attributable to the 1995 and/or 1998 events. A much larger volume of material likely entered during the larger storms of two years ago.

Estimated flow in this tributary is presently about 25 gallons per minute.

17. Lower Big Bend Reach:

Aggradation has continued to increase through out the lower Big Bend reach, manifested by:

a. Up to 2 feet of gravels accumulated at the base of large riparian trees

b. Wide gravel bars with well sorted surfaces, typically occupying 80 to 85 percent of the width of the stream

c. Substantial sediment accumulations behind limbs or other obstructions, which have fallen on to the bed during the past, season.

Particle sizes on the bar surfaces are predominantly 45s, 32s with some 64s. Stringers of sand are often visible in the lee of obstructions. Virtually no growth on the bars has occurred except for this year's annuals. In several places, the widening creek has under cut the toll of the bank, often toppling alders, and inducing bank erosion (which we had not seen in this reach before). In summary, it appears that aggradation is continuing in the lower below Big Bend reach, perhaps of this far as the large left bank logjam located perhaps 200 yards upstream of the western State Park boundary.

18. Below Big Bend Reach, Upper Portion:

Somewhat surprisingly, we are beginning to notice the first signs of recovery in the upper portion of this reach, particularly upstream of the "Little Big Rock". The large bars are beginning to show some narrowing and plucking at their edges; they now constitute 60 percent of the channel width rather than the 70 percent prevailing last year. Very few, if any areas of the deposition are visible. In several locations, the stream has cut down and graded to controls imposed by logs that have been buried in the bars.

Many of the alders and the ashes forming the riparian fringe are showing signs of distress. Approximately 35 percent of the larger trees either have died or are clearly dying. It is likely that this reach will look considerably different several years from now.

Young-of-the-year salmonids are present in what seem to be moderate numbers throughout both the upper and lower portions of the below big bend reach. We often noted several dozen young-of-the-year in each pool. We saw some, but relatively few fish in the former channel of Lagunitas, which was abandoned at Big Bend in 1997. The vegetation and water color suggest that the quiet water in the slough is defiant in oxygen. Where we saw young-of-the-year, the water was least stagnant and presumably most oxygenated.

19. Big Bend Monitoring Site:

Very few observable changes have occurred at this site. The pool, glide and riffle will remain the same as last year. Although there is some disturbance at the standard kiddy dam sites, it is evident from the algae that it is localized to within 10 feet of the actual kiddie dams themselves.

Both of the left-bank (south-bank) tributaries which have "blown out" during the past years are becoming increasingly stable. The downstream channel probably has contributed less than 50 cubic yards during water year 2000 and the upper channel perhaps as much as 100 to 200 cubic yards of bedload sized material.

Day Two: June 29, 2000

Overcast for much of the day and cool; otherwise excellent conditions.

20. Devils Gulch:

Devils Gulch has continued to gradually downcut. Much of the bed is composed of subangular 45s to 64s, with essentially no sand on the "beach" at the mouth of the stream. The deltaic bar at the mouth extends southward about 60 percent of the width of Lagunitas Creek, and is noticeably cut back in width and height from its position of the last two years. Lagunitas Creek just upstream of the deltaic bar has a surprisingly clean bed surface, composed of mobile and unembedded 64s and 90s. Maximum depth at the monolith across from the mouth is about 2.2 feet. The large logjam which formed just downstream of the confluence is almost entirely gone, with only 2 six-inch logs remaining, one on each side. The flow today is about 40 gallons per minute. The single logs installed as cross-stabilizers in lower in Devil's Gulch are fully exposed, with fish having access to their undersides; the bed here is probably at its lowest position since at least 1995. The pools that are downstream of the cross logs are about 2 feet deep, and Eric reported seeing a large number of young-of-the-year juveniles holding in these pools.

Measurements of specific conductance ('conductivity') and temperature were made in Devil's Gulch at Lagunitas Creek above Devil's Gulch at 5:30 p.m. These were 310 µmhos/cm at 14.2°C, and 170 µmhos/cm at 16.1°C, respectively.

21. Reach from Devils Gulch to Deadmans Creek:

The large pool in the lower portion of this reach is about 18 inches deep, with a bed of pebbles and small cobbles. It extends fully from bank to bank, and is deeper and wider than any previous years. The fringes of fines (silt and fine sand) that we have seen in prior seasons are not evident. At the head of this pool, several deeply sculpted bedrock outcrops are fully evident for the first time, and are sufficiently above the low water channel such that they have formed a small riffle, which is flagged as a January 12 redd (MMWD #52). The bedrock pools in the upper portion of this reach are typically 18 to

22 inches deep, with a few pockets of fines in the lees. We saw several lamprey redds, and a few young-of-the-year salmonids. Willows and other undergrowth species (ash, currants, and thimbleberries) are noticeably encroaching into the channel, re-growing after the floods of 1998.

22. Deadmans Creek:

The riffle at the mouth of the stream is composed of substantially finer than most of the bed material seen to date, presumably, due to deportation from this important tributary. From the mouth of the creek down the next pool there is a large band of algae growing on the side of the divided stream, which receives the flow from Deadmans Creek— something we have not seen before. The sawgrass on the bar at the mouth of the creek is expanding. Instantaneous flow in Deadmans Creek is estimated to be about 20 to 25 gallons per minute.

23. Deadmans Creek to USGS Gage:

Only scattered pockets of material finer than 16 to 23 millimeters are visible, both in the main pools and rock-cut overflow channels. The bed surface is generally formed of 45s and 64s. The pool at the USGS gage is about 7 feet deep, about the limit of discernibility and clarity. A small amount of sand is visible in the pool amongst the interstices of the boulders and amongst the bedrock. The gage height as we passed was 1.58 feet, a typical gage height for the summer. At the head of this reach--60 yards upstream of the staff plate— sculpted and rounded bedrock extends virtually the full width of the channel, the first time that we have seen this.

A number of young-of-the-year salmonids were visible in the staff plate pool. Large rock and root undercuts would appear to be this ideal habitat for yearling fish although none were seen in the 10 minutes that we observed this pool.

24. USGS Gage to Big Rock Site (KJ):

The bed has discernibly continued to gradually downcut and coarsen, reflecting improving habitat conditions. The changes this year are apparent, principally through increases in pool depth and width and the complete absence of the large oblique bars which filled this reach during the mid 1990s:

a. Depth of the glides: increased to 16 to 18 inches from the 6 to 9 inches previously during the mid-1990s.

b. Depth of the pools: typically 36 to 48 inches, increased from the 22 to 28 inches several years earlier.

c. Percent of the bed covered by bedrock: now, in each pool, about 2 to 10 percent of the bed is bedrock, whereas only a very occasional patches were observable in 1995.

Additionally, the pools extend at the full width of the channel, rather than being constrained to the deeper one-half or two-thirds. Small cobbles now make up between 5 and 20 percent of the bed surface, whereas it used to be almost entirely 16s and 23s. Most of the bed material is closely spaced, non-imbricated, and minimally embedded mid-size gravels. Although the bed surface looks very clean, this extends only 1 or 2-grain diameters deep; when digging deeper, very turbid and silt-filled water rises into the stream.

Despite the broad and extensive improvements in bed conditions, there are several sandy bars or pool eddy fills just upstream of the gage pool that are composed largely of sands. This appears to be almost a late season overlay, whose source is yet to be discerned.

A right-bank tributary approximately 100 yards below KJ8, which drains the slope across Sir Frances Drake Highway (SFD) on which a road was put back to grade last year, has built a delta with about one cubic yard of material evident. It is likely that several times as much coarse material entered Lagunitas Creek from this tributary during the season. This volume of delivery seems to be a reasonable tradeoff for eliminating a source of sediment and peak flows.

We saw relatively few fish in this reach, all of them young-of-the-year salmonids.

25. Big Rock Site (KJ):

Overall, there is little change at this site. The large fallen alder forming the left bank at KJ7—which had been present since the site was established 20 years ago—has been washed away, and there is a hint of bank cutting along the left bank down to KJ8. The main change at the site is that the glide between KJ4 and Big Rock has gotten coarser and shallower, and the hole around Big Rock has also shoaled. Eric speculates that this change may be due in part to continuing delivery of 45s and 64s from the left bank tributary entering Lagunitas Creek at a KJ4 -- an idea which seems quite reasonable. Upstream, the pool exhibits relatively little change, except along its left bank where last year's bar has been replaced by water a foot deep, and where patches of bedrock are visible near cross-section KJ2. Because of downcutting on the left (south) half of the channel, the mean bed elevation will probably decrease this year.

From cross-sections KJ6 through KJ8 as well as at several sub-reaches down to the USGS site, there is a discernable increase in undergrowth and/or sawgrass where small willows which have grown into stabilize the point bars originally formed during the 1998 (and earlier) floods.

Fish densities both in the upper pool and the pool surrounding Big Rock were moderate to high; we saw several yearlings in the upper pool while taking a dictation break at cross- section KJ1.

26. Reach from Big Rock to Campground Bridge:

As with the reaches downstream, the bed has coarsened, deepened, gained local relief and probably improved in habitat value. In previous years, this reach has been largely barer of cover and bed features, with a relatively flat coarse gravel bed; in contrast, the reach now has increasingly well-defined pools with a significant proportion of the bed surface composed of small cobbles and bedrock that is a sufficiently rough to provide habitat when exposed. A part of this change is due simply to the presence of additional large wood in the reach, perhaps related to the new State Parks policy of not removing fallen bay limbs and snags. In part, this is also due to increased input of redwoods and alders from upstream; we saw several new trees.[2] Gradual exhumation of bedrock on the bed in

[2] One of these trees appears to be the 24-inch redwood formerly cabled to right bank at the Campground Bridge site between cross sections KC1 and KC2, which was washed downstream this year. This tree has come to rest crosswise and midstream stream on recently exposed bedrock knobs. This location is just upstream of the largest midchannel rock and near the downstream end of the campground (called 'layered dome rock' in other Balance reports). Eric suggests that this segment of the redwood tree might be removed

this reach is both diagnostic of downcutting and helpful for habitat. The bedrock is now exposed in virtually every pool, commonly in one side or the other, whereas before it was quite rare in this reach. The bedrock is composed largely of thinly bedded phyllites and greywackes, typically dipping steeply towards the north; as the beds are exposed, the stream erodes lots of nooks and crannies which can be used by fish of various ages for cover. This jagged bedrock is quite different than the smoother, gently curved bedrock which occurs in the bed of the channel in reaches (such as between Big Bend and Deadmans Creek, or upstream of Irving Bridge) that are underlain by greenstones and other metavolcanics.

The bed surface was strikingly unembedded, often hard to walk on. The lack of fines, however, is limited to the upper layers of the bed; deeper material was finer, poorly-sorted and filled with the sands and silts that we have come to know and expect in Lagunitas Creek. Digging with shovel into this deeper material resulted in a large, long-duration, opaque and turbid plume passing down the stream.

Also very striking here is the presence of both young-of-the-year salmonids and yearlings. We saw many hundreds of young-of-the-year and perhaps a dozen or two yearlings in virtually every pool. This reach has traditionally been relatively barren of fish, and it was a pleasant surprise to see the changes this year.

27. Campground Bridge Site (KC):

We observed little change in bed or bank conditions at this site. Minor changes include:

a. The toe of the riffle just upstream of this site is gradually migrating downstream, particularly on the left-bank side; we had to move the upstream boundary of the pool downstream this year;

b. The bar which typically forms on the left bank under the bridge was not evident this year; and

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and reused elsewhere as part of the MMWD instream structures program. At present, it is inducing some bank erosion on either side, and will continue to do so if left in place.

c. There are more patches of bedrock exposed in the riffle just downstream of the Campground Bridge; this seems quite typical of what is happening in the state park reach as a whole.

28. Wildcat Creek Pool:

Along the left (deeper) bank, the pool just below Wildcat Creek is typically 3 to 4 feet deep, where it has a bed of large cobbles. The beach on the right bank this year is composed almost entirely of fine to medium gravels; sand is absent both on the beach and in the pool—strikingly so.

The sedimentation basin at Wildcat Creek was constructed during the past season, and the downstream side of the roadfill has been freshly rocked with two ton riprap. Flow in Wildcat Creek today is estimated to be between 5 and 10 gallons per minute.

29. Kiosk Reach:

The bedrock forms the bed in approximately half of the stream between the Wildcat Confluence Pool and the Samuel P. Taylor State Park entry road. Very little sand was in evidence this year. Gravels are primarily in the 11, 16, and 23 mm. size classes.

An area of bank erosion has developed along the right bank, right at the park entrance road intersection with Sir Francis Drake. The eroding bank appears to be a result of increased flow in the right bank channel associated with the two logjams which have formed just upstream (see discussion below).

As usual, the kiosk and Barnabe reaches were assessed from the bike trail since most of their beds are composed unchanging, slick bedrock.

30. Barnabe Reach:

A logjam has closed off portions of the left bank channel at the head of the bedrock controlled island in the lower end of this reach. This 6-foot high open-work logjam clearly happened this year, and has rerouted the majority of the flow from the left bank alternate channel to the right bank alternate channel. A secondary logjam has developed on the mid-channel bar near the downstream end of this island. The combined effects of these two new jams has been minor bank erosion along the right bank within this reach, and significant fresh bank erosion at the entry road downstream (see above).

Pool fill in this reach does not appear to have changed much in volume, although we saw discernibly less sand this year than last year. The Irving Pool has developed a significant cobble-embedded riffle at its downstream end, near the western wooden steps of the former picnic grounds. The new riffle implies that additional gravel and cobble have entered this reach, but the source(s) is not evident.[3] A large alder cluster has fallen across the pool a short distance upstream, but Eric found evidence showing that it clearly postdates the sediment-transporting storms of the year. The bed is likely to scour beneath the newly fallen alder cluster, likely resulting in more cobble deposition on this new riffle next year. In general, the pool is only waist deep, perhaps half a foot shallower than last year.

31. Irving Creek:

This year's high water cut a very definite 4-foot wide bench approximately 5 feet above low water. The bench is winnowed of virtually all material finer than 45 mm., except for a small area veneered with coarse sand and fine gravel immediately downstream from Irving Creek. The 3 or 4 smaller storms at the end of the year also created a discernible bench about 3 feet above low water.

Deposition at the mouth of Irving Creek this year occurred directly beneath the bridge, and is approximately 5 to 10 cubic yards in residual volume. This year's deposition was clearly reworked and winnowed by Lagunitas Creek during the later stages of the largest storm(s) of the year.

The lowermost 30 yards of Irving Creek appears to have downcut during the past winter. We did not walk upstream to assess whether this may be due to lowering of the delta or if it more broadly affects Irving Creek further upstream.

Flow today in Irving Creek is approximately 30 to 40 gallons per minute.

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[3] Our impression is that coarse-sediment delivery from Irving Creek and its delta alone is not sufficient to form this riffle. Other possibilities are erosion of the right-bank crested bar on the inside of the Irving bend at the bedrock outcrop just upstream, the right-bank tributary above Irving (see paragraph 31), the San Geronimo sediment pulse (see paragraph 33), or some other unidentified source(s).

32. Upstream of Irving Bridge:

Both of the pipelines across the stream are still visible. A large alder rootwad has been caught on the downstream pipe, generating a small logjam this year, with a new midchannel bar. The channel near the 2 boulder clusters has not changed much in depth; the bed is comprised almost solely of 32s, 45s, and 64s, with very little sand. The stream may be somewhat shallower, but not clearly so. The lead rock in the downstream boulder cluster appears to have rolled into its own hole downstream turning the "V" into a "U". The hole downstream from this cluster is much deeper than it has been in the past. Similarly, we now see several bedrock knobs exposed near the base of the banks in the bed on either side.

33. Right Bank Tributary Above Irving Bridge:

The bed has downcut several inches near the mouth of the largest unnamed right-bank tributary in this reach, which enters the channel just above the first major riffle upstream of Irving. The origin of this riffle seems now to be clear—a result of large subrounded cobbles and small boulders entering from this tributary and accumulating on the right bank just downstream of its mouth to support a riffle. There are some holes just downstream from the confluence of this tributary which are as deep as 2.5 feet, and clearly show the buildup of these large cobbles/ small boulders entering from this tributary.

The deepening and coarsening that we saw last year between the right bank tributary mouth and site KH are being maintained, but do not seem to be increasing or extending.

34. Kelley's Upper State Park Site (KH):

There has been little change at this site. The left-bank middle rock in the lower boulder cluster has continued to r oll downstream, and probably moved 30 feet downstream and toward the left bank during the past season. Both Eric and I believe that the glide and pool have aggraded somewhat with coarse gravels. The hint of broken water that characterized the glide last summer may have been somewhat extended or magnified this past season. However, no redds were observed at this site (KH-6 and KH-7), as they were in December of 1998. There has been little change if any in the riffle at the head of the site (KH-1 to KH-3), although there is a slight overwash of the fine gravels which may have entered the stream system perhaps from a point source late in the season.

The high-water marks from the peak storms of this past winter are quite evident at this site, very clearly demarcated by drift lines and by the absence of duff where trimmed away by high flows. The highest high-water mark is very consistently at or within two inches above the morphologic bankfull level that I have called out at this site in previous years. Prunuske-Chatham should survey in these high-water marks at cross sections where they are evident and in the line of the section (or within a few feet either way).

35. High-Water Mark Beach:

The highest watermark of the year at this point is about 3.3 feet above the summer low-water level. At least 2 if not 3 subsequent high-water marks are also evident lower on the beach. Over half of the beach below this year's high-water mark is bare of sand, with bedrock exposed, except for the lowermost fringe. We assume that the high flows were sand-stripping rather than sand depositing-events.

36. High-Water Mark Beach to Site 15.72[4]:

In general, there is not much change from last year. There is, however, what appears to be a late season influx of fine gravels with some sand (perhaps from San Geronimo Creek) which accumulates in the lower gradient reaches, but is not present in the pools of the higher-gradient stretches where the creek crosses bedrock outcrops. Further, there are well-developed arid continuous depositional bars that are now evident in lees of larger obstructions. At Site 15.72, the middle 70 percent of the channel is crowned, covered with approximately 4 to 5 inches of this material beneath which the coarse cobble bed that we noted last year is still present. The material above it clearly has moved in during the past season, apparently late in the season (evidence discussed below in paragraph 39). The left-bank portion of a large redwood which fell in 1995 across the creek at site WD-13 (PCI notation; located near road paddle 15.49) has rotated downstream, and is now

[4] Site 15.72 is a location approximately 0.4 miles downstream from Shafter where bed cores were collected annually during the early years of the Lagunitas bed-conditions studies (1979-1986). Until this year, bed conditions at the site have been too coarse to sample effectively using our 150-mm sampler since the current bed-monitoring effort began in 1995. The site number refers to milepost 15.72 on SFD, the nearest landmark.

resting on the bed - although providing little habitat. We anticipate that this very large woody debris element will be moved downstream within a few years.

37. Below Shafter Site (KB):

Significant changes at the site appear to be all based on the late season (?) influx of gravels from San Geronimo Creek. The pool and glide downstream of cross-section KB-7 are both filled to depths of perhaps a foot or slightly more. Depths of water range between 6 and 10 inches throughout both segments, with no distinction between the pool and glide. A large bar of rounded gravel has accumulated at cross-section KB-6 atop the angular cobbles which form this new riffle -- made up of angular metavolcanic rock fragments scoured from the bedrock at cross-section KB-4 and deposited primarily during 1999. The fallen 4-foot fir at cross section KB-4 has rotated slightly downstream and portions of the large volume of snags, limbs and other vegetal debris of all sizes which had accumulated behind it has floated downstream.[5]

The left-bank point bar that typically forms between KB1 and KB4 now occupies at least half the width of the creek. Its surface is composed of material that is dominately in the 23s to 45s class, about half the diameter as in previous years. Except in the immediate vicinity of obstructions, there are very few places between KB4 and KB 1 where the flow is deeper than 4 inches.

Deposition in this subreach, the pool and glide downstream of KB6, and in several of the pools further downstream represents a substantial volume of bed-material sediment from late WY2000 storms in San Geronimo Creek, which can be roughly quantified from our reconnaissance as approximately 500 to 1000 tons.

The original segmentation of this site remains fundamentally altered by the fallen 4-foot fir and the associated scour, erosion, and deposition. The original riffle (to KB1), pool (to KB3/4), and glide (KB3/4 to KB7) cannot meaningfully (or physically, due to the

[5] At several locations downstream, including locations as far downstream as the head of the riffle upstream of the Big Rock site (KJ), we have noticed mats of organic matter stranded at this year's high-water mark. It seems likely that these maps have torn loose from the accumulated debris at this station and have floated on downstream, to be deposited in parcels of perhaps a quarter to a full cubic yard apiece. The volume of debris presently caught behind the log is on the order of 20 cubic yards; it was probably twice as large prior

presence of the logjam) be used for the bed census. Suggested segments for this year should be the same that were used last year: Pool KB7 to KB9, glide (KB9 to 110 ft downstream of KB 10), and the downstream riffle which controls the pool and glide (below the glide). We suggest that Prunuske Chatham install cross sections KB 11 and KB 12 at locations approximately 55 and 110 feet downstream from KB 10, such that KB 12 corresponds with the glide/riffle transition. Correspondingly, surveying of sections KB5 and KB6 may be skipped this year, as they are substantially and temporarily altered by the fallen log/logjam, to help offset the additional effort. At PCI's discretion, an additional section KB 13 may be installed approximately 40 to 50 feet further downstream, crossing the central portion of the riffle, such that long-term changes in this control riffle can be assessed. I see little long-term merit in establishing a section in the lower portion of the riffle, as it is influenced by backwater conditions from WD-13, and is physically separated a short distance from the rest of the riffle; we anticipate it will change as the woody debris at WD-13 is moved or washed away. We will exclude this portion of the riffle from the bed census. Surveying of sections KB1 through KB4 will be helpful in quantifying the volume of material introduced by the late-season pulse (see paragraph 36), and assessing whether this deposition is continued through the winterof 2001. These changes are likely to be semi-permanent, since we expect several years to elapse before the fallen fir is washed downstream and normal bed conditions become reestablished.

38. Reach Upstream of KB Monitoring Site to Mouth of San Geronimo:

Bed sedimentation is quite evident is the first and third pool downstream from Shafter, and less so in the intervening pool. Sedimentation consists largely of pool fill and the development of bars that are up to 4 to 6 inches above the existing low water level; there is only limited evidence of a deposition above that level. The downstream-most pool on San Geronimo Creek is partly aggraded with the same material, and deposits up to 1 or 2 feet above today's low-water level are apparent. Upstream of the mouth of San Geronimo Creek, no fine-grained sedimentation is apparent in the lower 2 pools in

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to this season. This suggests that the 4-foot fir may have been rotated downstream at the very height of the highest water of the year.

Lagunitas Creek that are visible from Shafter Bridge, indicating that this year's influx of fines is from San Geronimo Creek.

39. The Late Season Pulse of Sediment: An Initial Interpretation

Field evidence suggests that there was a late season pulse of coarse sediment which probably entered Lagunitas from San Geronimo Creek. The pulse likely occurred during one of the three or four significant late-seasons storms that occurred following the two much larger storms in early February. The evidence for a pulse delivered from San Geronimo Creek late in the season includes:

a. Depositional bars developed behind obstructions in the 0.6 miles of Lagunitas Creek downstream from Shafter Bridge; these bars have sharply defined tops but are well below the seasonal high-water mark (left by the February 12/13 event).

b. The sediment has not been sculpted into pools and riffles, which would easily have occurred at the prior (near-bankfull) flows experienced during the two early storms of the year.

c. Predominance of deposition in the pools but not on bars that are any higher than 6 inches above low water.

The leading edge of the pulse is evident as the subtle overwash of coarse sand, which we were able to discern as far downstream as Irving Bridge, but which clearly was not in evidence further downstream in the reach adjacent to the entry kiosk. The pulse is sorted by size downstream from the mouth of San Geronimo Creek, with the sand transported further downstream than the small pebbles in evidence at site KB. The volume of this pulse is likely to be on the order of 500 to 1,000 cubic yards, equivalent to about 700 to 1,300 tons. For perspective this is equivalent to about 20 to 40 percent of the bedload thought to have been transported in San Geronimo Creek during water year. It is also equivalent to about 1/6 to 1/3 of the estimated mean annual bedload yield from the San Geronimo Valley based on data available in 1983.

We anticipate that the material in the pulse will continue to gradually move downstream during the coming year or two. Portions of it will be incorporated in the pools above Irving Bridge, and may remain in residence until some high volume spills occur from Kent Lake to scour out the pools (see our earlier reports for 1980, 1982, and 1983 spill effects).

We do not know the local source of the sediment contributed by San Geronimo Creek. Hence, we cannot project whether this pulse simply represents a minor addition during a long series of years with declining sediment yields, or if it represents the leading edge of the larger sediment pulse in San Geronimo Creek.

Senior ecologist Greg Andrew (MMWD) reports that the largest left bank tributary above Shafter Bridge also deposited considerable coarse material in Lagunitas Creek early in the season. Little evidence of this event was visible in the lowest 100 yards of Lagunitas Creek above Shafter Bridge at the time of this "Creek Walk".

Recommendations:

1. The high-water mark for the water year 2000 season occurred during the February 12/13, 2000 storm. The peak water levels during this event seems to correspond almost exactly to a morphological "bankfull" event. To the extent possible, the location of the 2000 high-water mark at bed monitoring sites should be surveyed in, during cross section monitoring so that we can use this information for designing restoration at or near each of the sites in coming years. *(Suggested Assignment: Prunuske Chatham*).

2. Significant amounts of sediments are entering Lagunitas Creek from the left bank tributary in upper Tocaloma, from Cheda Ranch Creek, from the left bank Jewell tributary, and from San Geronimo Creek. Additionally, MMWD staff report substantial deltaic sedimentation at the mouth of the largest left-bank tributary above Shafter Bridge. If the Marin RCD seeks to ascertain the present sources of bed sediment in Lagunitas Creek, it may be worthwhile investigating the origins for each of these greater-than-normal pulses of bed material. Related costs could be

substantial. *(Suggested Assignment: RCD to decide; Prunuske Chatham, National Park Service and/ or MMWD to investigate, if indicated).*

3. Each of the seven monitoring sites are suited for both cross sectional (Prunuske Chatham) and bed-census (Balance) measurements, which should be done as soon as feasible during the summer of the year 2000. *(Suggested Assignment: Prunuske Chatham and Balance).*

4. Changes in the riffle/pool/glide segments used for monitoring are indicated at the site upstream from Cheda Ranch Creek (KL) (see paragraph 13) and at the Below Shafter site (KB) (see paragraph 37), where logjams have caused sufficient changes to warrant temporary or semi-permanent adjustments. These changes are of the type envisioned when the monitoring system was designed and they can be accommodated within the provisions of the monitoring program. *(Suggested Assignment: Balance and Prunuske Chatham)*

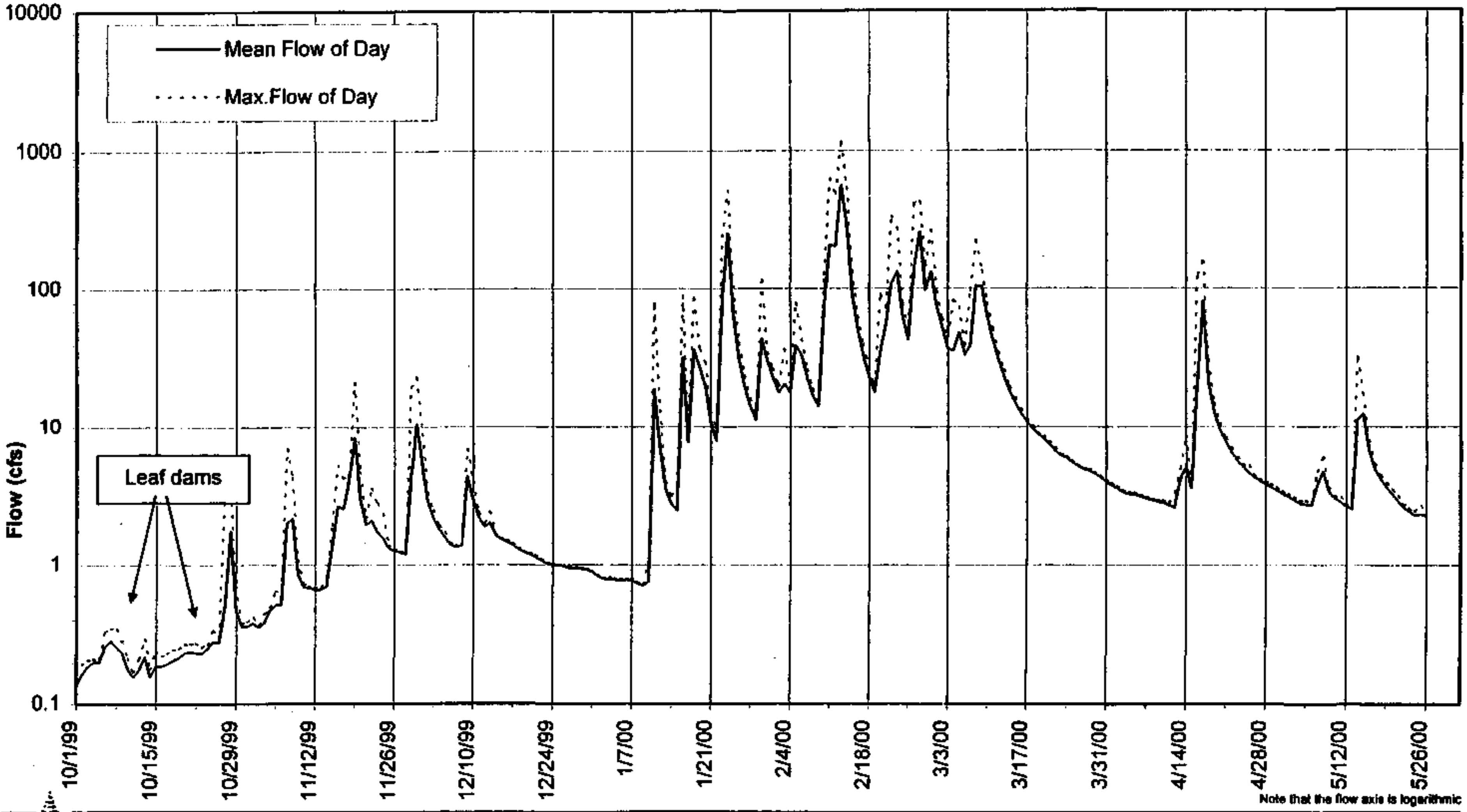
5. The bed monitoring results from this year should be oriented toward providing a basis for evaluating whether the observed late-season (?) pulse of coarse-sediment delivery from San Geronimo Creek will continue to aggrade and effect the bed of Lagunitas Creek during the coming winter, and what effects that is likely to have in the short to mid term. We have recommended additional cross sections and changes in the bed segments to be censused at site KB (see paragraph 37) to better enable this comparison.

6. To aid in communicating with agency staff, we suggest that it would be worthwhile to develop general (Level I) Rosgen stream classification of the stream from Tocaloma to Shafter Bridges. If Eric takes the lead in doing this, we believe that this could be done in the course of next season's stream reconnaissance, without appreciably lengthening the field time. Provided that work be directed at general communication and characterization, additional costs to write up this analysis would be small, and can be absorbed within the existing budgets. We note that any static stream classification system has limited management value in Lagunitas Creek, where the primary issues are time-transient - effects of logjam formation or breakup; influx of sediment from tributaries, or changes in the current position of the stream within its

alternate channel - so the emphasis will be on using the classification to help describe the basic channel properties.

Attached:

Figure 1: Peak-flow hydrograph for San Geronimo Creek, Water Year 2000



Balance Hydrologics, Inc.

Figure 1. Preliminary daily flow hydrograph for WY2000: San Geronimo Creek at Lagunitas Road bridge

APPENDIX B

Data Summary

Appendix B: Table 1

San Geronimo Bedload Sediment Reduction Program

Lagunitas Creek Mean Bed Elevations for 1993 and 1995 through 2000

SUE KB - BELOW SHAFTER

SITE	1993	1995	1996	1997	1998	1999	2000			
KB1	155.5	156.4	155.8	155.2	155.7	155.6	155.9			
KB2	ND	155.7	155.7	155.5	155.7	155.7	155.9			
KB3	157.2	155.9	155.7	155.5	155.6	155.9	155.9			
KB4	155.9	155.9	155.6	155.5	155.6	155.7	156.9			
KB5	155.6	155.6	155.6	155.5	155.1	154.5	ND			
KB6	155.8	155.7	155.7	155.5	155.1	154.7	ND			
KB7	ND	155.5	155.5	155.5	154.8	155.0	155.3			
KB8	155.5	155.4	154.8	155.0	154.5	154.4	154.7			
KB9	155.5	155.1	154.4	154.8	154.3	154.3	154.7			
KB10	155.4	154.9	154.1	154.1	154.0	ND	154.5			
KB-11	ND	ND	ND	ND	ND	ND	154.5			
KB-12	ND	ND	ND	ND	ND	ND	154.6			
KB-13	ND	ND	ND	ND	ND	ND	153.7			

SITE KH - KELLEY'S UPPER

SITE	1993	1995	1996	1997	1998	1999	2000			
KH1	143.1	143.0	142.9	142.9	143.0	143.0	142.9			
KH2	142.6	142.4	142.3	142.2	142.3	142.4	142.4			
KH3	142.3	141.9	141.7	141.8	141.8	141.8	141.8			
KH4	142.1	141.5	141.7	141.4	141.2	141.3	141.3			
KH5	142.3	141.8	141.8	141.7	141.7	141.6	141.6			
KH6	142.4	142.1	142.0	142.1	141.9	141.9	141.9			
KH7	142.3	142.1	141.8	141.7	141.8	141.8	141.8			

Appendix B: Table 1

San Geronimo Bedload Sediment Reduction Program

Lagunitas Creek Mean Bed Elevations for 1993 and 1995 through 2000

SITE KC - CAMPGROUND BRIDGE

SITE	1993	1995	1996	1997	1998	1999	2000			
KC1	117.8	117.7	117.7	117.6	117.6	117.6	117.6			
KC2	117.2	117.2	117.0	116.9	116.8	116.8	116.8			
KC3	117.0	116.9	116.7	116.7	116.5	116.5	116.6			
KC4	116.9	121.5	116.5	116.5	116.5	116.4	116.4			
KC5	116.8	116.6	116.3	116.2	116.4	116.3	116.4			
KC6	116.6	116.5	116.3	116.2	116.3	116.3	116.2			
KC7	117.2	117.0	116.8	116.7	116.7	116.6	116.6			
KC8	117.0	117.1	116.8	116.7	116.8	116.7	116.7			
KC9	116.9	116.8	116.8	116.6	116.6	116.4	116.5			
KC10	ND	116.8	116.3	116.4	116.4	116.0	116.2			

SITE KJ - BIG ROCK

SITE	1993	1995	1996	1997	1998	1999	2000			
KJ1	109.9	110.3	109.7	109.5	109.1	109.4	109.0			
KJ2	109.4	110.5	109.3	109.6	109.3	109.7	109.4			
KJ3	110.4	110.7	110.0	110.3	109.6	110.1	109.9			
KJ4	109.9	110.3	110.8	109.9	109.8	110.1	110.0			
KJ5	110.2	110.8	109.8	110.0	110.0	110.3	110.3			
KJ6	109.8	109.9	109.9	108.8	110.0	109.7	109.7			
KJ7	111.1	110.9	109.9	110.5	109.9	110.3	110.3			
KJ8	109.0	108.7	108.2	109.3	108.7	108.8	108.8			

SITE KD - BIG BEND

SITE	1993	1995	1996	1997	1998	1999	2000			
KD1	ND	ND	ND	91.6	90.9	90.5	90.6			
KD2	90.5	91.0	91.1	90.5	90.6	89.1	90.1			
KD3	88.8	89.9	88.9	90.9	90.1	89.4	89.6			
KD4	89.2	89.8	89.1	91.0	90.5	90.4	90.4			
KD5	90.8	90.1	89.7	90.9	90.7	90.5	90.7			
KD6	89.8	89.9	89.5	90.3	90.5	90.5	90.6			
KD7	ND	ND	ND	ND	ND	ND	88.2			

Appendix B: Table 1

San Geronimo Bedload Sediment Reduction Program

Lagunitas Creek Mean Bed Elevations for 1993 and 1995 through 2000

SITE KL - CHEDA RANCH ROAD

SITE	1993	1995	1996	1997	1998	1999	2000			
KL1	77.2	78.0	77.7	77.1	77.9	77.9	77.9			
KL2	ND	78.0	77.6	77.1	77.8	77.5	77.4			
KL3	76.6	ND	ND	75.9	76.4	76.3	76.5			
KL4	ND	ND	ND	74.9	75.5	75.6	75.9			
KL5	76.1	ND	75.3	75.6	75.9	76.1	77.4			
KL6	76.0	75.9	76.0	76.0	77.0	77.3	77.5			
KL7	76.0	76.3	76.6	76.5	77.6	77.2	77.3			
KL8	76.7	76.8	76.8	76.3	77.9	77.0	77.2			

SITE KF - KELLEY'S TOCALOMA

SITE	1993	1995	1996	1997	1998	1999	2000			
KF1	64.1	64.0	64.4	64.6	65.0	65.0	65.0			
KF2	64.0	63.8	64.3	64.6	64.8	65.0	64.9			
KF3	64.0	64.4	64.7	64.8	65.1	65.4	65.3			
KF4	64.1	64.4	64.6	65.0	65.2	65.4	65.5			
KF5	64.7	64.7	65.1	65.2	65.3	65.5	65.6			
KF6	64.3	63.5	64.8	65.1	65.5	65.6	65.7			
KF7	64.5	64.7	64.5	65.1	65.5	65.7	65.6			
KF8	64.0	64.5	64.4	65.2	64.1	65.7	65.6			

Table 2. Locations of deep and shallow halves at reaches sampled for bed-surface composition, Lagunitas Creek

	Summer 2000	Fall 1999	Fall 1998	Fall 1997	Fall 1996	Fall 1995	Fall 1993
	Deep Half / Shallow Half	Deep Half / Shallow Half	Deep Half / Shallow Half	Deep Half / Shallow Half	Deep Half / Shallow Half	Deep Half / Shallow Half	Deep Half / Shallow Half
(1) KB: Below Shafter							
Riffle	R: 3,4 L: 1,2	C: 2,3 L: 1; R:4	C: 2,3 L: 1; R: 5; C: 4	L: 1,2,3 R: 4.5	L: 1.2,3 R: 4,5	L: 1,2,3 R: 4,5	R: 3,4,5 L: 1,2
Pool	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2	C: 2,3,4 L: 1. R: 5	R: 4,5 L: 1,2,3	L: 1,2 R: 3,4,5	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2 (bar)
Glide	R: 4,5 L: 1,2,3	C: 3,4 L: 1,2; R: 5	C: 2,3 L: 1; R: 5; C: 4	R: 4.5 L: 1,2,3	L: 1.2,3 R: 4,5	R: 4,5 L: 1,2,3	C: 3 L: 1,2 R: 4,5
2) KH: Kelley's Upper							**KH only 1/6/94**
Riffle	L: 1,2,3 R: 4,5	R: 4,5 L: 1,2,3	L: 1; C: 2,3 R: 5; C: 4	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2	L: 1,2 R: 3,4,5	L: 1,2 R: 3,4,5
Pool	C: 2,3 L: 1 R: 4,5	L: 1,2,3 R: 4,5	L: 1; C: 2,3 R: 5; C: 4	R: 3,4,5 L: 1,2	C: 2,3,4 L: 1 R: 5	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2
Glide	C: 2,3 L: 1; R: 4,5	C: 3,4 L: 1,2 R: 5	C: 3,4; R: 5 L: 1; C:2	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2	C: 2,3,4 L: 1; R: 5
(3) KC: SPTSP Campground Bridge							
Riffle	L: 1,2,3 R: 4,5	L: 1,2,3 R: 4.5	L:1; C:2 R: 5; C: 3.4	L: 1,2,3 R: 4,5	L: 1,2,3 R: 4,5	C: 3,4 L: 1,2 R: 5	L: 1,2.3 R: 4,5
Pool	L: 1,2,3 R: 4,5	R: 3,4.5 L: 1,2	R: 5; C: 4 L: 1; C:2,3	R: 3,4,5 L: 1,2	*not distinguished*	R: 3,4,5 L: 1,2	R: 4.5 L: 1.2.3
Glide	L: 1,2,3 R: 4,5	R: 4,5 L: 1,2,3	C: 3,4; R: 5 L: 1; C: 2	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2
(4) KJ: Big Rock							**KJ only 1/6/94**
Riffle	L: 1.2,3 R: 4.5	C: 2,3 L: 1; R:4,5	C: 2,3 L: 1; R: 5; C: 4	L: 1,2 R: 3,4	L: 1,2,3 R: 4,5	L: 1,2,3 R: 4, 5	L: 1.2 R: 3.4.5
Pool	R: 3,4,5 L: 1,2	R: 3.4,5 L: 1,2	C: 2,3,4 L: 1; R: 5	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2	R: 3, 4,5 L: 1,2	R: 3,4,5 L: 1.2
Glide	R: 4.5 L: 1,2,3	R: 3.4.5 L: 1,2	L: 1; R: 5 C: 2,3,4	R: 4,5 L: 1,2,3	L: 1,2 R: 3,4,5	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1.2
(5) KD: Big Bend							
Riffle	R: 3,4 L: 1,2	R: 3,4,5 L: 1,2	C: 2,3 L: 1; R: 4	R: 3,4,5 L: 1,2	C: 2,3 L: 1; R: 4,5	L: 1,2 R: 3,4,5	L: 1,2 R: 3,4,5
Pool	L: 1,2 R: 3,4	L: 1,2,3 R: 4,5	C: 2,3 L: 1; R: 4	R: 3,4,5 L: 1,2	L: 1,2,3 R: 4,5	C: 2,3 L: 1; R: 4,5	C: 2,3,4 L: 1; R: 5
Glide	C:2,3 L: 1 R: 4,5	L: 1,2 R: 3,4,5	C: 2.3 L: 1; R:5; C:4	R: 4,5 L: 1.2.3	L: 1 R: 2,3, 4,5	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2
(6) KL: Cheda Ranch Road							
Riffle	L: 1,2,3,4 R: 5,6	R: 3,4,5 L: 1,2	L: 1; C: 2,3,4; R: 5	L: 1,2 R: 3	L: 1,2 R: 3,4,5	R: 4,5 L: 1,2,3	R: 4,5 L: 1,2,3
Pool	R: 2.3 L: 0,1	R: 4,5 L: 1,2,3	L: 1; C: 2,3 C: 4; R: 5	R: 2,3,4,5 L: 1	L: 1,2 R: 3,4,5		R: 3,4,5 L: 1,2
Glide	L: 1,2,3 R: 4,5	L: 1,2 R: 3,4,5	L: 1; C: 2 C: 3; R: 4	L: 1,2 R: 3,4	L: 1,2 R: 3,4,5	L: 1,2,3 R: 4,5	C: 3,4 L: 1,2; R: 5
(7) KF: Kelley's Tocaloma							
Riffle	C: 2,3 L: 1; R: 4,5	C: 3,4 L: 1,2; R: 5	C: 3,4; R: 5 L: 1; C: 2	L: 1,2 R: 2,3	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2	L: 1,2; R: 5 C: 3,4
Pool	R: 3,4,5 L: 1,2	R: 4,5 L: 1,2,3	C: 4; R: 5 L: 1; C: 2,3	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2	R: 4,5 L: 1,2,3	R: 3,4,5 L: 1,2
Glide	R: 4,5 L: 1,2,3	R: 4,5 L: 1,2,3	C: 4; R: 5 L: 1; C: 2,3	R: 4,5 L: 2,3	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2	R: 3,4,5 L: 1,2

Notes:

R: = right side of channel (tape passes 3 - 5)

L: = left side of channel (tape passes 1 - 3)

C: = center of channel (tape passes 2 - 4)

Table 3. Locations of riffles, pools and glides at reaches sampled for bed-surface composition, Lagunitas Creek

Site and Segment	Summer 2000	Fall 1999	Fall 1998	Fall 1997	Fall 1996	Fall 1995	Fall 1993	1991	1980
(1) KB: Below Shafter Bridge									
Riffle	225' ds x10 • 355' ds x10	265' ds x10 • 365' ds x10	85' us x1 • x1	85' us x1 • x1	65' us x1 • x3/4	85' us x1 • x3/4	85' us x1 • x3/4	x1 • x4	85' us x1 • x2
Pool	25' ds x10 • 130' ds x10	25' ds x10 • 130' ds x10	x9 to 170' ds	xl • LBx3/RB5	x3/4 • x5/6	x3/4 • x5/6	x3/4 • x5/6	x4 • x5	x2 • x5
Glide	130' ds x10 • 225' ds x10	130' ds x10 • 225' ds x10	x7 • x9	LBx3 • RBx5, LBx5 • RB	x9 • 50' ds x10	x8 • x10	x8 • x10	x5 • x6	x5 • x10
Unsampled	x1 • 25' ds x10	x1 • 25' ds x10; 225' ds x10 265' ds x10 (see text)	xl • x7	LBx5, RBx6 • x10	x5/6 • x9	x5/6 • x8	x5/6 • x8	x6 • x10	
(2) KH: Kelley's Upper State Park									
Riffle	x1 • x3	35' us x1 • x3	35' us x1 • x3	35' us of x1 • x3	35' us x1 • x3	15' us x1 • 2/3	15' us x1 • x2/3	xl • x3/4	x1 • x3
Pool	x3 • x5	x3 • x5	x3x5/6	x3 • x5/6	x3 • x5	x2/3 • x5/6	x2/3 • x5/6	x3/4 • x6	x3 • x6/x7
Glide	x5 • x7	x5 • x7	x5/6 • x7	x5/6 • x7	x5 • x6/x7	x5/6 • x7	x5/6 • x7	x6 • x9	x6/x7 • x9
Unsampled	x7 • x9	x7 • x9	x7 • x9	x7 • x9	x7 • x9	x7 • x9	x7 • x9		
(3) KC: SPTSP Campground Bridge									
Riffle	20' ds x8 • 40' d/s x10	10' ds x8 • 30' ds x10	x8 • 20' ds x10	15' us x8 • 10' ds x10	x8 • 5' ds x10	x8/9 • 100' ds	x8 • 100' ds x8	*not monitored*	100' ds x8 • 5' us
Pool	LBx3;RBx2 • LBx4;RBx6	LBx3/4;RBx3 • x4/6	LBx2/3 • x5/6; RBx2/3 • x1	LBx3/4 • x5, RBx3 • x5	btw LB x3 • RB x2 & x4	x3 • x6	x2 • x5	*not monitored*	x2 • x6
Glide	LBx4;RBx6 • 20' ds x8	x4/6 • x8	x5/6 • x8	x5 • 10' us x7	x5 • x8	staff plate us to K6 (-60')	x5 • x8	*not monitored*	x6 • 5' us x8
Unsampled	x1 • LBx3;RBx2	xl • x3/4	x1 • x2/3	xl • x2, 10' us x7 • 15'	x1 • x2; x4 • x5;	x1 • x2;60' ds x6 • x10	x1 • x2; 100' ds x8 • x		x1 • x2; 5' us x8 • x
(4) KJ: Big Rock									
Riffle	20' ds x9 • x8	25' ds x7 • 10' ds x8	x7 • 10' ds x8	30' ds x7 • 10' ds x8	30[1] ds x7 • 10' ds x8	x7 • 110' ds	x7 • x8	x7 • x8	x7 • x8
Pool	x1 • 10' ds x3	xl • x3	x1 • x3/4	xl • LBx3/RBx4	x1 • x3	x1 • x3	x1 • x3	x1 • x3	x1 • x3
Glide	10' ds x3 • x5	x3 • x5/6	x3/4 • x5/6	LBx3/RBx4 • 15' us x6	230' ds x8 • 60' ds	x3 • 15' us x6	x3 • 15' us x6	x3 • x6	x3 • x6
Unsampled	x5 • 20' ds x9	x5/6 • 25' ds x7	x56-x7	15' us x6 • x8	x3 • 30' ds x7	15' us x6 • x7; 110' ds x7 -	15' us x6 • x7	x6 • x7	x6 • x7
(5) KD: Big Bend									
Riffle	x5 • 90' ds x5	20 ' ds x5 • 90' ds x5	LB x6, RB x • 5 • 40' ds x	t x4 - x6	55' us x7 • 45' ds x8	45' us x7 • 40' ds x8	55' us x7 • 45' ds x8	*not monitored*	115' us x1 • x1
Pool	10' us x1 • RBx4, LBx5	x2 • RB x4, LB x3	x3 • x4	15' us x3 • x1	Approx 90' us and 60' ds of MP18.56	x1 • x3	x1 • x4	*not monitored*	x1 • x4
Glide	RBx4, LBx5 • x5	RBx4/5, LBx3 • x5	x4 LB x6, RB x5	x4 • 15' us x3	120' ds of pool	x4 • x6	x4 • x6	*not monitored*	x4 • x6
Unsampled		xl • x2	xl x3	ds x6	x1 • 55' us x7	x3 • x4; x6 - 45 us x 7	x6 • 55' us x7		
(6) KL: Cheda Ranch Road									
Riffle	47' ds x8 • 77' ds x8	45' us x2 • x2	x2 • x6	16' ds x8 • 61' ds x8	140' ds x7 • 175' ds x7	xl • x2	x1 • 15' us x2	surveyed but not	x1 • x2
Pool	x2/3 • 10' us x8	x2 • RBx6, LBx5	x6 • x8	x3 • x6	45' us x1 • x1	*not monitored (too deep)*	x2 • x5, unsampled	sampled; no distance	x2 • x6
Glide	10' us x8 • 30' ds x8	RBx6, LBx5 • x8	x8 • 65' ds x8	x6 • 16' ds x8	6' us x6 • x7	x6 • x8	x5 x8	information for pool.	x6 • x8
Unsampled	x1 • x2/3; 30' ds x8 • 47' ds x8	x1 • 45' us x2	xl • 2	xl • x3	x1 • 6' us x6; x7 • 140' ds;	x2 • x6	15' us x2 • x5, (too deep)	riffle, glide in file box	
(7) KF: Kelley's Tocaloma									
Riffle	5' us x8 • x9	x8 • x9	x6/7 • 30' ds x9	x6/x7 • 45' ds x8	x6/x7 • 40' ds x8	x6/x7 30' ds x7	x6/7 • 35' ds x8	50' us x1 • x1/2	x1 • x3
Pool	20' us x2 • x4/5	25' us x2 • x4/5	25' us x2 • x4/5	x4 • 25' us x2	x2 • 15' us x5	x2 • 15' us x5	x2 • x4/5	x1/2 • x4	100' us x4 • x4
Glide	x4/5 • x6/7	x4/5 • x7	x4/5 • x7	x4/5 • x6/7	15' us x5 • x6/x7	15' us x5 • x6/x7	x4/5 • x6/7	x4 • x6/7	x5 • x7
Unsampled	x1 • 20' us x2: x6/7 • 5' us x8	x1 • 25' us x2; x7 • x8	x1 • 25' us x2	x1 • 25' us x2	x1 • x2	x1 • x2	xl • x2	x6/7 • x7	x5 • x4; x7 • x8

Notes:

ds = downstream from

us = upstream from

RB = right bank

LB = left bank

x1 = cross section one at this site

x1/2 = midway between cross sections one and two

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Date (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By: Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	Particle-Size Descriptors (h) D-16	D-50	D-84
(1) KB	Below Shafter	Riffle	810223	103	0.41	0.52	0.00	0.00	0.10	12.9	69.8	198.4
			810724	157	0.25	0.47	0.05	0.08	0.20	25.5	89.1	268.1
			820730	118	0.21	0.39	0.04	0.17	0.10	13.4	30.8	85.0
			911126	153	0.29	0.10	0.02	0.04	0.06	11.9	20.4	40.4
			931015	111	0.34	0.27	0.00	0.06	0.05	13.8	22.8	68.4
			951101	108	0.37	0.36	0.00	0.05	0.09	11.3	37.6	143.7
			961031	130	0.37	0.30	0.00	0.01	0.16	13.1	29.5	80.8
			970905	145	0.28	0.52	0.01	0.17	0.01	13.0	50.8	101.9
			980904 (s)	145	0.17	0.35	0.00	0.08	0.01	14.4	35.9	75.6
			990908 (v)	78	0.31	0.69	0.03	0.00	0.06	30.3	77.8	141.7
			000713 (v)	120	0.22	0.60	0.04	0.02	0.04	22.8	60.6	149.3
		Pool	810223	114	0.48	0.29	0.00	0.00	0.18	11.2	30.4	105.6
			810724	136	0.42	0.43	0.01	0.01	0.19	13.8	52.9	155.1
			820730	138	0.29	0.23	0.00	0.01	0.03	13.9	31.1	54.2
			911126	113	0.18	0.24	0.01	0.01	0.24	9.8	23.9	78.6
			931015	119	0.31	0.28	0.01	0.04	0.04	14.5	34.3	64.0
			951101	108	0.42	0.44	0.00	0.02	0.04	14.B	40.7	104.4
			961031	140	0.25	0.42	0.01	0.01	0.05	15.2	40.0	80.0
			970905	127	0.33	0.60	0.03	0.01	0.06	17.6	39.6	77.8
			980904 (s)	128	0.49	0.30	0.00	0.07	0.13	10.2	24.9	81.7
			990908 (v)	110	0.53	0.23	0.01	0.05	0.11	12.7	25.1	68.7
			000713 (v)	101	0.50	0.03	0.00	0.03	0.09	6.0	12.1	22.5
		Glide	810223	114	0.42	0.42	0.00	0.00	0.04	12.4	37.5	124.8
			810724	128	0.39	0.29	0.02	0.00	0.15	13.8	32.0	90.9
			820730	151	0.25	0.48	0.01	0.03	0.10	14.6	43.8	84.5
			911126	103	0.30	0.01	0.04	0.00	0.15	6.2	10.2	19.1
			931015	98	0.47	0.06	0.01	0.00	0.09	10.8	20.6	33.5
			951101	110	0.62	0.19	0.00	0.05	0.00	7.1	15.3	52.0
			961105	129	0.42	0.19	0.00	0.10	0.15	7.3	17.5	68.2
			970905 (r)	123	0.31	0.47	0.00	0.02	0.02	14.1	31.7	62.7
			980904 (s)	120	0.43	0.39	0.01	0.12	0.06	17.4	42.7	114.9
			990908 (v)	96	0.51	0.25	0.00	0.00	0.07	14.7	30.8	63.8
			000713 (v)	125	0.48	0.21	0.00	0.00	0.04	8.0	17.4	63.4

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Date (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By: Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	Particle-Size Descriptors (h) D-16	D-50	D-B4
(2) KH	Kelley's Upper (n)	Riffle	790829	112	0.21	--	--	--	--	--	--	--
			801201	132	0.33	0.61	0.02	0.05	0.04	27.7	60.3	126.1
			810223	130	0.36	0.63	0.01	0.01	0.02	25.1	73.8	170.2
			810728	182	0.31	0.59	0.02	0.07	0.03	21.4	72.5	150.5
			820723	137	0.32	0.65	0.01	0.18	0.01	24.0	72.2	150.7
			911127	109	0.12	0.61	0.00	0.00	0.05	24.5	60.2	125.4
			931001	114	0.24	0.61	0.00	0.00	0.03	23.3	62.6	113.5
			951027	102	0.16	0.67	0.00	0.10	0.02	34.3	71.3	114.0
			961030	128	0.18	0.70	0.01	0.05	0.00	35.9	68.0	130.2
			970805	113	0.20	0.75	0.00	0.03	0.01	21.0	57.9	92.1
			980903	126	0.20	0.78	0.00	0.10	0.02	48.3	80.3	128.2
			990908	134	0.21	0.75	0.03	0.03	0.02	40.3	73.6	124.7
			000713	130	0.31	0.72	0.00	0.06	0.03	31.8	83.9	165.5
		Pool	801201	132	0.39	0.42	0.00	0.11	0.12	19.3	49.8	126.8
			810223	89	0.42	0.34	0.01	0.06	0.21	12.9	37.0	102.5
			810728	157	0.40	0.22	0.00	0.01	0.07	12.9	25.3	82.5
			820723	137	0.22	0.28	0.00	0.00	0.01	20.6	61.8	77.8
			911127	120	0.24	0.40	0.01	0.02	0.14	10.6	41.1	87.2
			931001	117	0.31	0.36	0.00	0.04	0.06	12.2	35.8	81.3
			951027	98	0.27	0.36	0.00	0.12	0.06	13.5	40.3	72.9
			961030	118	0.30	0.42	0.00	0.08	0.10	15.5	46.1	88.0
			970908	108	0.21	0.37	0.00	0.06	0.08	8.6	22.6	66.4
			980903	102	0.26	0.47	0.03	0.09	0.16	12.0	62.3	109.8
			990908	102	0.30	0.45	0.00	0.10	0.13	16.5	52.6	89.5
			000713	105	0.35	0.31	0.00	0.12	0.14	6.6	36.6	89.5
		Glide	801201	127	0.51	0.40	0.00	0.00	0.07	12.6	23.8	68.9
			810223	105	0.36	0.28	0.00	0.00	0.09	11.5	29.1	78.2
			810728	151	0.32	0.22	0.01	0.04	0.03	11.9	23.3	72.3
			820723	135	0.21	0.35	0.00	0.04	0.03	12.8	33.7	76.0
			911127	96	0.22	0.34	0.01	0.00	0.03	11.1	30.9	59.6
			931001	103	0.22	0.18	0.00	0.00	0.04	9.8	20.6	50.5
			951027	86	0.22	0.43	001	0.00	0.01	14.3	39.7	82.0
			961030	136	0.29	0.32	0.00	0.00	0.02	11.1	33.1	68.3
			970908	110	0.33	0.33	0.01	0.00	0.02	7.8	18.2	50.0
			980904	113	0.33	0.46	0.01	0.00	0.04	12.8	43.3	88.7
			990908	98	0.34	039	0.01	0.01	0.03	17.5	38.1	87.8
			000713	121	0.38	0.33	0.01	0.00	0.07	6.1	27.5	79.7

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Dale (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By: Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	Particle-Size Descriptors (h) D-16	D-50	D-84
(3)KC	Samuel P. Taylor State Park Campground Bridge	Riffle	800325	126	0.23	0.76	--	--	--	263	47.9	100.3
			800723	181	0.21	0.58	--	--	--	18.8	37.1	95.6
			801216	130	0.31	0.57	0.00	0.02	0.02	23.7	58.1	147.6
			B10227	135	0.24	0.54	0.01	0.02	0.02	15.3	49.2	122.9
			810724	138	0.20	0.60	0.00	0.00	0.00	19.8	59.2	125.9
			820709	148	0.32	0.47	0.01	0.00	0.01	16.4	41.5	91.2
			931012	124	0.33	0.42	0.02	0.00	0.03	16.6	41.6	86.2
			951103	138	0.23	0.64	0.01	0.01	0.01	26.3	57.0	114.0
			961029	156	0.24	0.51	0.01	0.01	0.00	24.6	46.6	107.7
			970903	135	0.29	0.52	0.01	0.01	0.03	12.4	35.2	93.6
			980604	130	0.29	0.57	0.00	0.02	0.03	25.1	55.6	123.9
			990901	113	0.22	0.63	0.01	0.00	0.04	24.5	61.7	133.6
			000604	122	0.17	0.56	0.00	0.02	0.02	21.5	52.2	120.7
		Pool	801216	134	0.33	0.56	0.02	0.02	0.04	24.8	57.2	136.4
			810227	158	0.32	0.35	0.00	0.02	0.02	16.5	32.3	87.9
			810724	134	0.21	0.39	0.01	0.02	0.03	18.2	37.7	104.0
			820709	154	0.24	0.53	0.01	0.01	0.06	20.7	37.7	126.9
			931012	133	0.20	0.55	0.01	0.01	0.03	23.8	50.5	84.0
			951103	170	0.21	0.65	0.01	0.09	0.01	34.5	64.0	124.0
			961030	39	0.18	0.64	0.03	0.03	0.00	31.6	60.0	118.2
			970903	101	0.27	0.57	0.02	0.02	0.01	12.4	43.9	97.7
			980604	127	0.27	0.63	0.02	0.01	0.08	28.7	73.2	146.4
			990901	159	0.22	0.77	0.01	0.01	0.01	38.6	72.6	150.2
			000604	109	0.19	0.65	0.00	0.02	0.02	25.5	57.9	118.1
		Glide	791011	110	0.26	--	--	--	--	--	--	--
			801216	105	0.35	0.36	0.00	0.00	0.04	19.9	35.1	78.9
			810227	167	0.31	0.35	0.00	0.04	0.03	13.4	32.0	99.2
			810724	217	0.18	0.40	0.01	0.01	0.01	13.8	36.1	97.9
			820709	130	0.30	0.46	0.01	0.00	0.06	17.6	41.3	113.8
			931012	115	0.32	0.44	0.02	0.01	0.09	17.8	44.9	78.6
			951103	117	0.24	0.65	0.00	0.01	0.01	30.5	60.6	101.6
			961030	158	0.16	0.51	0.00	0.01	0.03	25.7	47.2	81.5
			970903	111	0.27	0.47	0.03	0.03	0.02	9.8	32.4	89.4
			980604	100	0.25	0.65	0.00	0.00	0.00	33.0	57.2	108.2
			990901	117	0.21	0.67	0.01	0.00	0.01	328	65.1	112.3
			000604	140	0.23	0.64	0.00	0.01	0.05	26.2	67.3	131.9

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Date (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By: Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	Particle-Size Descriptors (h) D-16	D-50	D-84
(4) KJ	Big Rock	Riffle (low-flow)	801212	80	0.33	0.50	0.00	0.00	0.02	31.2	45.0	80.2
			810225	79	0.24	0.56	0.02	0.01	0.07	15.8	54.5	105.1
			810727	154	0.11	0.50	0.02	0.03	0.03	13.6	53.8	107.1
			820723	119	0.23	0.51	0.00	0.17	0.03	15.1	46.1	88.4
			911111	152	0.12	0.49	0.03	0.11	0.04	16.0	55.8	112.2
			931008	135	0.16	0.38	0.01	0.05	0.01	20.8	38.9	63.0
			951101	118	0.27	0.40	0.08	0.09	0.02	15.3	44.2	77.9
			961105	122	0.42	0.41	0.00	0.18	0.02	20.6	46.5	101.1
			970903	124	0.08	0.53	0.01	0.23	0.03	24.8	48.5	81.8
			980903	155	0.10	0.56	0.02	0.18	0.01	32.3	69.2	111.5
			990901	70	0.13	0.36	0.04	0.17	0.00	21.3	42.1	91.4
			000706	124	0.16	0.43	0.01	0.12	0.00	22.0	45.6	90.1
		Riffle (bar)	801212	81	0.18	0.36	0.00	0.01	0.00	24.2	61.0	110.0
			810225	79	0.35	0.45	0.00	0.00	0.06	11.3	35.1	67.1
			810727	93	0.11	0.33	0.00	0.03	0.01	16.1	34.1	70.4
			B20723	134	0.14	0.37	0.00	0.00	0.04	19.8	37.6	74.9
			911111 (I)	59	0.08	0.27	0.00	0.00	0.02	17.2	30.2	67.3
			970903 (I)	51	N/A	0.43	0.00	0.00	0.00	15.4	29.2	43.2
			000706	72	N/A	0.54	0.03	0.00	0.01	24.0	48.7	77.0
		Pool	801212	169	0.30	0.06	0.00	0.10	0.12	7.8	16.5	34.4
			810225	149	0.27	0.02	0.00	0.18	0.32	9.7	18.2	31.3
			810729	190	0.11	0.05	0.02	0.23	0.20	9.0	18.3	38.7
			820805	137	0.19	0.14	0.00	0.20	0.03	8.5	17.2	42.6
			911113(j)	107	0.21	0.14	0.03	0.18	0.03	11.9	26.7	47.8
			931008	83	0.33	0.18	0.02	0.07	0.14	7.2	18.8	52.7
			951101	110	0.29	0.14	0.01	0.05	0.05	9.5	19.0	44.1
			961105	122	0.36	0.10	0.02	0.11	0.04	12.4	24.8	41.8
			970908	128	0.32	0.23	0.00	0.09	0.01	9.4	20.0	42.5
			980309	116	0.18	0.09	0.01	0.21	0.15	9.6	20.6	44.3
			990901	105	0.19	0.15	0.02	0.14	0.11	13.9	25.8	49.9
			000706	90	0.31	0.13	0.02	0.18	0.18	9.5	22.6	52.6
		Glide	801212	159	0.33	0.15	0.00	0.01	0.04	11.8	23.0	45.1
			810225	131	0.41	0.06	0.00	0.01	0.11	9.7	17.4	30.4
			810729	172	0.20	0.06	0.00	0.01	0.01	9.8	20.4	36.9
			820805	204	0.16	0.16	0.00	0.01	0.01	12.3	24.2	45.0
			911113	160	0.24	0.17	0.03	0.04	0.04	12.2	24.1	48.4
			931008	99	0.47	0.15	0.01	0.00	0.12	11.2	20.8	46.8
			951101	90	0.28	0.12	0.03	0.01	0.02	11.7	25.2	43.5
			961115	112	0.42	0.15	0.01	0.09	0.07	15.2	24.9	51.2
			970908	132	0.24	0.13	0.02	0.06	0.02	9.6	16.4	30.3
			980903	115	0.26	0.14	0.02	0.01	0.07	11.9	21.8	44.8
			990901	144	0.21	0.22	0.04	0	0.04	16.3	28.7	54.6
			000706	175	0.27	0.15	0.02	0.01	0.05	8.5	22.0	45.3

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Date (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By:				Particle-Size Descriptors (h)		
						Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	D-16	D-50	D-B4
(5)KD	Big Bend	Riffle	801216	95	0.14	0.65	0.06	0.00	0.05	33.5	67.0	120.2
			810225	158	0.24	0.55	0.06	0.00	0.07	24.7	59.4	122.0
			810729	197	0.16	0.57	0.09	0.00	0.03	27.1	58.5	122.1
			820915	101	0.19	0.58	0.07	0.01	0.01	32.5	61.2	130.2
			931012	117	0.18	0.79	0.02	0.04	0.00	44.8	72.7	122.4
			951103	148	0.14	0.64	0.03	0.03	0.05	29.6	63.1	111.0
			961105	143	0.37	0.56	0.02	0.08	0.08	25.2	73.3	117.3
			970905	102	N/A (disturbed bed)	0.56	0.00	0.00	0.00	18.9	34.4	57.4
			980604	97	0.07	0.56	0.00	0.00	0.01	28.8	49.0	81.6
			990908	136	0.14	0.77	0.04	0.00	0.02	43.3	70.8	117.4
			000614	128	0.09	0.66	0.02	0.00	0.02	25.7	59.8	115.6
		Pool	801216	129	0.22	0.62	0.06	0.00	0.01	30.4	63.0	131.0
			810225	127	0.35	0.45	0.03	0.00	0.11	12.8	47.8	114.7
			810729	164	0.26	0.38	0.07	0.00	0.04	14.6	36.6	119.6
			820915	110	0.19	0.56	0.00	0.00	0.14	29.2	59.3	149.6
			931012	100	0.25	0.64	0.05	0.01	0.03	32.0	57.0	107.6
			951103	106	0.23	0.19	0.05	0.02	0.11	8.0	21.1	61.3
			961115	142	0.48	0.17	0.02	0.00	0.12	10.7	24.8	49.9
			970905	107	N/A (disturbed bed)	0.07	0.05	0.00	0.41	7.4	14.1	28.1
			980604	99	0.23	0.57	0.02	0.01	0.03	256	50.9	85.0
			990908	132	N/A (disturbed bed)	0.49	0.05	0.13	0.06	22.8	59.6	146.2
			000614	84	N/A (disturbed bed)	0.23	0.02	0.05	0.01	12.4	27.5	63.0
		Glide	801216	83	0.30	0.43	0.01	0.00	0.01	20.9	40.1	101.8
			810225	103	0.43	0.33	0.00	0.00	0.11	10.4	32.0	78.4
			810729	161	0.19	0.27	0.02	0.00	0.17	9.9	22.6	62.6
			820915	112	0.28	0.38	0.03	0.00	0.07	11.9	36.4	97.6
			931012	92	0.30	0.36	0.01	0.00	0.01	18.6	34.9	77.3
			951103	108	0.22	0.49	0.05	0.00	0.26	23.5	69.8	109.6
			961115	136	0.43	0.24	0.01	0.00	0.10	11.4	25.4	60.8
			970905	94	N/A (disturbed bed)	0.19	0.00	0.00	0.01	6.7	14.5	35.7
			980604	72	0.13	0.31	0.00	0.00	0.00	22.2	36.3	56.0
			990908	98	0.16 (disturbed bed)	0.58	0.03	0.00	0.00	23.8	50.9	96.2
			000614	62	0.12 (disturbed bed)	0.32	0.00	0.00	0.00	15.9	33.8	62.2

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Date (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By: Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	Particle-Size Descriptors (h) D-16	D-50	D-84
(6) KL	Cheda Ranch Road	Riffle	810224	126	0.41	0.17	0.00	0.00	0.12	13.1	25.1	57.8
			810803	185	0.33	0.23	0.00	0.04	0.04	12.6	28.9	54.8
			820730	156	0.37	0.34	0.00	0.00	0.01	19.8	33.3	86.3
			911108	118	0.19	0.32	0.03	0.01	0.05	15.6	31.7	67.6
			931015	170	0.21	0.14	0.03	0.00	0.00	12.0	24.3	44.1
			951103	116	0.33	0.22	0.05	0.00	0.03	8.2	18.4	61.6
			961115	105	0.54	0.53	0.06	0.00	0.01	16.5	51.1	89.5
			970905	60	0.08	0.23	0.03	0.00	0.02	13.0	26.5	51.8
			980904	84	0.14	0.19	0.04	0.00	0.04	13.0	28.5	52.7
			990908 (x)	--	N/A (visual estimate)	--	--	--	--	135	27.5	60.0
			000706	66	0.17	0.36	0.04	0.00	0.03	17.2	36.6	77.6
		Pool	801212	135	0.19	0.06	0.02	0.00	0.36	11.8	23.1	38.3
			810224	181	0.32	0.07	0.00	0.09	0.26	6.6	17.4	37.3
			810803	161	0.35	0.09	0.01	0.02	0.19	9.9	20.4	38.7
			820730 (m)	--	--	--	--	--	--	--	--	--
			911108	113	0.40	0.03	0.04	0.06	0.11	10.6	24.3	43.90
			931015	--	--	--	--	--	--	--	--	--
			951103	--	--	--	--	--	--	--	--	--
			961115	123	0.53	0.08	0.01	0.00	0.09	9.7	19.4	31.7
			970905	81	N/A (disturbed bed)	0.06	0.05	0.15	0.38	5.4	12.0	59.3
			980904	71	N/A (visual estimate)	--	0.00	0.00	0.87	5.1	7.6	13.7
			990908 (w,y)	--	N/A (disturbed bed)	0.05	0.00	0.12	0.26	--	--	--
			000614 (w)	37	N/A (disturbed bed)	0.22	0.05	0.22	0.30	17.8	45.3	112.8
		Glide	790830	93	0.69	--	--	--	--	--	--	--
			801212	124	0.50	0.01	0.00	0.00	0.35	8.4	16.0	26.1
			810224	116	0.20	0.02	0.02	0.00	0.23	7.2	17.2	34.4
			810803	172	0.30	0.02	0.00	0.00	0.04	9.9	17.4	30.0
			820730	122	0.35	0.04	0.04	0.00	0.16	7.9	16.3	28.4
			911108	130	0.38	0.01	0.02	0.00	0.09	9.3	18.3	38.5
			931015	97	0.42	0.15	0.03	0.01	0.14	11.9	24.0	50.4
			951103	118	0.46	0.06	0.02	0.01	0.17	6.4	13.6	29.0
			961115	108	055	0.02	0.00	0.00	0.06	7.1	11.8	22.0
			970905	134	N/A (disturbed bed)	0.04	0.04	0.00	0.12	5.4	10.3	21.4
			980904	88	N/A (disturbed bed)	0.02	0.03	0.00	0.09	9.2	16.8	29.3
			990908 (w)	37	N/A (disturbed bed)	0.00	0.03	0.00	0.05	6.8	14.7	25.2
			000614	50	0.06	0.10	0.04	0.00	0.22	9.4	16.8	38.6

Table 5. Variations of Embeddedness and Bed Surface Composition: Lagunitas Creek, 1979-2000

Site	Location	Segment (a)	Date (b)	Sample Size	Mean Embeddedness of Cobbles (>44 mm.)(c)	Proportion of Bed Area Occupied By: Cobble (d)	Large Organics (e)	Bedrock (f)	Sand (g)	Particle-Size Descriptors (h) D-16	D-50	D-84
(7) KF	Kelley's Tocaloma	Riffle (low-flow)	801216	64	0.26	0.39	0.02	0.00	0.17	15.3	43.3	78.5
			810224	68	0.28	0.47	0.01	0.00	0.06	16.9	46.6	90.4
			810812	72	0.20	0.43	0.00	0.00	0.03	16.1	39.9	89.8
			820721	134	0.38	0.45	0.00	0.00	0.01	17.3	40.3	80.0
			911101(i)	136	0.20	0.15	0.09	0.00	0.07	14.2	30.6	51.2
			931019	146	0.18	0.20	0.01	0.00	0.05	14.1	28.3	51.0
			951027	96	0.12	0.16	0.05	0.00	0.03	17.7	30.5	46.3
			961031	115	0.07	0.21	0.01	0.00	0.01	13.4	28.7	50.7
			970903	100	0.14	0.16	0.02	0.00	0.00	9.6	19.0	32.3
			980903	92	0.25	0.27	0.03	0.00	0.03	14.2	33.1	56.2
			990901	84	0.16	0.21	0.05	0.00	0.10	12.1	25.8	60.3
			000706	106	0.11	0.17	0.08	0.00	0.06	12.4	28.2	51.0
		Pool	801216	138	0.30	0.28	0.01	0.00	0.31	11.5	30.7	69.1
			810224	128	0.30	0.23	0.01	0.00	0.07	10.0	23.7	55.0
			810812	137	0.2B	0.20	0.04	0.00	0.04	10.7	24.9	51.1
			820721	102	0.46	0.42	0.00	0.00	0.15	9.4	35.2	86.3
			911101	139	0.24	0.13	0.09	0.00	0.13	11.4	22.3	65.8
			931019	79	0.53	0.17	0.05	0.00	0.09	9.6	25.1	49.9
			951027	130	0.38	0.09	0.02	0.00	0.07	7.3	16.0	36.8
			961031	122	0.52	0.10	0.01	0.00	0.05	13.0	23.3	39.7
			970903	140	0.54	0.08	0.02	0.00	0.10	6.8	11.9	22.9
			980903	120	0.03	0.03	0.03	0.00	0.27	6.8	12.3	30.9
			990901	90	0.28	0.07	0.01	0.00	0.08	34.6	18.7	11.8
			000706	111	0.45	0.02	0.03	0.00	0.25	5.0	10.2	26.6
		Glide (deep)	801216	46	0.05	0.09	0.00	0.00	006	9.2	18.1	38.3
			810224	80	0.30	0.10	0.00	0.00	0.01	9.6	18.4	37.0
			810812	157	0.29	0.10	0.00	0.00	0.02	9.3	18.7	37.7
			820721	128	0.70	0.06	0.01	0.00	0.03	7.7	14.3	26.1
			911101 (k)	122	0.35	0.05	0.01	0.00	0.05	9.0	17.7	30.3
			931019	152	0.40	0.12	0.00	0.00	0.07	11.1	24.3	41.5
			951027	118	0.12	0.08	0.01	0.00	0.05	9.5	19.0	37.6
			961031	143	0.10	0.02	0.01	0.00	0.04	11.4	17.9	30.0
			970903	104	0.34	0.12	0.04	0.00	0.06	8.6	15.3	28.1
			980903	147	0.52	0.03	0.01	0.00	0.16	6.0	13.0	26.2
			990901	139	0.30	0.007	0.00	0.00	0.16	7.0	13.8	24.6
			000706	117	0.28	0.09	0.05	0.00	0.08	8.5	17.5	38.5

NOTES:

(a) Pool, glide, riffle; riffles are sometimes differentiated into low and high flow, depending on whether they fall within the wetted perimeter at low flow.

(b) Year, month, day.

(c) Embeddedness is the ratio of the depth of fine material surrounding a rock in the channel to the height of the rock.

(d) For the limited purposes of this chapter, cobble includes all material larger than 45 mm.

(e) Organic elements, large enough to afford rearing habitat such as snags, limbs, and branches, root clusters and sawgrass clumps.

(f) For a rock to be considered bedrock, it had to be of the same type of rock exposed in the banks or lower hillslopes, and the orientation of bedding planes had to be similar.

(g) For the limited purposes of this chapter, sand includes all material finer than 4 mm.

(h) Particle size for which 16. 50, and 84 percent of the distribution is finer. Excludes sand, bedrock, and organic elements.

(i) Bed configuration influenced by 2 large snags perpendicular to flow.

(j) Southern one-half of pool has been affected by upstream logjam.

(k) Growth of point bar (likely related to upstream snag) has affected glide.

(l) A large percentage of 1982 bar has been colonized by nettles and blackberries, this area not included In 1991 sample.

(m) These pools scoured to bedrock during WY 1982, and were too deep to sample.

(n) Riffle, pool, glide sequence considerably changed from earlier surveys; cluster of 5 boulders placed for enhancement has noticeably changed the bed configuration and may have caused fining of the glide. The five- boulder cluster immediately downstream (KH8 and KH9) may have affected bed conditions.

(o) 1996 bed sampling by Barry Hecht, Chris White (Balance); recorded by Eric Austensen and Martha Neuman (PCI)

(p) 1997 bed sampling by Barry Hecht, Chris White (Balance); recorded by Katie Etienne (PCI)

(q) Non-standard or alternate location; values may differ substantially from those at regular monitoring location not used this year due to local disturbance.

(r) Large debris jam at LB KB7 - KB9 obstructed flow in left 1/2 of channel, resulting in wholesale scour and fill. Glide temporarily moved to a location just upstream of KB6.

(s) Affected by backwater (riffle) or plunge pool of 4-foot fir which fell across channel near KB4. "Pool" site moved downstream to the 170 feet extending downstream from KB-9.

(t) Bar and channel populations converged during the 1998 storms, which sharply widened the channel and lowered the streamward portion of the bar. Note similarity of the 980903 riffle D-sizes to those on the bar after the 1980 storms.

(u) 1999 bed sampling by Barry Hecht. Chris White, and David Shaw (Balance); recorded by Karen Wilson.

(v) Because of tree falls and widespread changes to the previously monitored pool and riffle, the riffle downstream of the KB site was sampled, and the upper end of the existing pool and glide moved downstream, such that the 105-foot pool began 25 feet downstream of KB 10, followed by 95' of glide.

(w) Proportions of the pool bed area were visually estimated from high points on the bank or censused by diving, and embeddedness was not measured due to extensive disturbance by hooves.

(x) Particle-size descriptors were estimated at the riffle as a standard bed census was prevented by three large recently-fallen alders.

(y) Several small tree trunks and large limbs observed in the pool during a June visit had been removed and stacked on the bank at the time of the September census.

(z) 2000 bed sampling by Barry Hecht, Chris White, David Shaw, Bonnie Mallory (Balance), and Johnny Fort (PCI).

Table 6. Changes In Size Composition of Bulk Bed Material at Bed-Monitoring Sites, Lagunitas and San Geronimo Creeks, Marin County (all data expressed in millimeters) (a)

Bed Monitoring Site (b)	Below Shafter			Kelley's Up. St. Pk.			Campground Bridge			Big Rock			Big Bend			Cheda Ranch			Kelley's Tocaloma			San Geronimo Creek S Water Treatment Plant			San Geronimo Creek at Lagunitas Rd		
Cross Section (c)	KB4			KH5 (5&6) (m)			KC5 (6) (j)			KJ5 (6/7) (k)			KD4 (3) (6/7) (l)			KL6 (7) (e)			KF5			K1			K4		
Percentile Size (d)	D-16	D-50	D-84	D-16	D-50	D-84	D-16	D-50	D-84	D-16	D-50	D-84	D-16	D-50	D-84	D-16	D-50	D-84	D-16	D-50	D-B4	D-16	D-50	D-84	D-16	D-50	D-84
Sampling Dates Fall 1980	--	--	--	2.8	16.0	30.0	--	--	--	3.1	21.4	43.6	5.0	12.4	21.4	1.6	5.6	12.0	1.7	15.3	76.9(f)	--	--	--	--	--	--
Feb. 1981	1.1	6.2	23.4	4.3	23.2	53.3	5.5	23.3	47.4	3.4	13.7	27.0	5.3	16.3	34.9	2.0	8.9	20.6	0.6(h)	5.6(h)	15.0(h)	--	--	--	--	--	--
Summer 1981	0.6	4.2	17.5	12.6	25.4	79.8(f)	1.6	10.8	47.1	4.2	15.8	44.9	2.8	15.1	28.8	1.7	8.5	18.5	2.6	14.6	33.9	--	--	--	--	--	--
Summer 1982	1.9	23.1	52.9	2.6	11.7	45.5	1.7	15.0	28.0	1.9	9.1	29.8	1.8	14.1	36.7	0.7(g)	5.1(g)	13.5(g	1.4	10.7	37.6	--	--	--	--	--	--
Fall 1991	1.1	6.7	18.2	2.9	15.4	40.4(i)	--	--	--	2.8	15.1	39.4	--	--	--	0.9	4.8	17.4	2.5	12.5	28.2	--	--	--	--	--	--
Fall 1993	1.4	17.9	72.8	3.7 2.2	18.6 11.3	58.0 64.6	2.2	10.1	43.4	1.3	10.5	37.2	4.5	33.9	75.5	4.3	10.0	20.8	2.2	10.7	28.9	--	--	--	--	--	--
Fall 1995	0.9	7.7	19.3	2.4	11.7	24.2	1.7	11.2	24.4	1.7	6.5	14.6	1.9	5.7	12.4	0.3	1.6	5.3	0.9	7.2	21.0	1.2	3.0	7.1	0.9	5.3	14.0
Fan 1996	3.2	17.8	42.1	2.8	10.1	22.9	6.3	20.2	44.5	1.9	8.5	25.0	1.9	5.5	11.9	0.6	2.7	8.0	1.1	6.1	13.7	0.9	2.9	7.3	2.1	10.2	23.0
Fan 1997	1.7	17.4	41.0	4.5	17.8	39.5	2.0	8.8	13.2	2.7	10.1	24.8	1.7	5.6	14.3	1.4	5.2	16.0	1.1	6.5	21.9	--	--	--	--	--	--
Fall 1998 (n)	1.6	12.3	38.5	2.6	17.4	43.0	3.7	14.6	46.6	1.1	7.4	18.1	3.5	9.6	18.8	0.4	2.8	9.0	4.3	10.2	24.1	--	--	--	--	--	--
Fall 1999	3.3	15.4	43.2	2.6	16.6	43.8	5.7	36.0	87.0	8.8	21.5	45.3	8.6	25.7	48.6	2.1	9.3	16.7	5.2	20.8	45.4	0.7	6.8	22.1	9.3	23.0	43.8
Summer 2000	1.9	10.0	23.7	8.8	39.2	71.4	12.0	31.7	51.2	2.0	14.6	42.2	8.5	28.2	69.2	5.8	15.0	26.8	1.5	12.1	34.5	1.7	5.9	15.3	3.1	21.9	48.4

Notes:

(a) From bulk samples, 6 inches in diameter and 4 inches deep, taken after the bed-surface material is scraped away. See text for methods of sampling, sieving.

(b) Sites, given in downstream order along Lagunitas Creek, and then along San Geronimo Creek, are described more completely in Appendix A.

(c) Sample taken from midpoint of bed within specific cross-section at or near the pool/glide transition, away from the influence of bars or snags.

(d) Size, in millimeters, for which 16, 50, and 84 percent of the sample is finer. See appendix C for more detailed description of particle-size distribution.

(e) Log jam formed during January 1982 flood, between sections 3 and 4 fundamentally changed bed configuration. Sampling was conducted at KL7, pool/glide boundary at the time. Logjam was no longer evident in 1991, and bed had reassumed the original configuration. During 1993 a large twin alder tree fell across the creek between sections KL2 and KL3, with effects similar to 1982; sample taken at KL6 in 1993 and 1995, and at KL6/7 in 1996.

(f) One or two large cobble included in this core sample influenced 84th percentile size. .

(g) Results may not be comparable to previous years, due to aberrant conditions following 1982 storms.

(h) Changes at this site attributable to washing away of a small logjam approximately 150 feet upstream of this site during the late- January 1981 storms.

(i) Two samples were taken at KH in Fall 1991, the second was taken approximately 13 feet upstream of the first.

(j) Sampled at section KC6 in 1995, due to pool/glide boundary change caused by fallen redwood at section KC 1/2. Sampled at section 6/7 in 1998.

(k) Sampled at section KJ6/7 in 1996, to retain pool/glide source, after several fallen logs altered the glides.

(l) Sampled at section KD3 in 1995 and 1997. due to large-scale bed changes at this site. Sampled at section KD6/7 in 1996, due to further bed changes associated with two fallen alders. All samples at pool/glide transition. Sampled at KD5 in 1998.

(m) Sample from midway between KH5 and KH6 in 1997 and 1998.

(n) 0.5 mm size class interpolated due to missing sieve. 64 mm size class sorted by hand. Decrease in size at site KJ due to logjam; at site KL to a combination of logs, upstream delivery from the Big Bend slide, and from a large left-bank tributary just upstream.

Sampling Year Rock Types	*1979 percent*	*1993 percent*	*1995 percent*	*1996 percent*	*1997 percent*	*1998 percent*	*1999 percent*	*2000 percent*
San Geronimo Creek below Woodacre (MMWD Water Treatment Plant access road)								
Gravels counted	*93*	*425*	*200*	*148*	*186*	*142*	*129*	*103*
Date sampled	*summer*	*931120*	*951101*	*961004*	*970903*	*980903*	*990730*	*000929*
Metabasalts	20.30%	21.90%	18.50%	11.49%	12.90%	4.93%	12.40%	9.00%
Diabases	0.00%	1.40%	0.50%	0.68%	0.00%	0.00%	1.55%	0.00%
Cherts+quartz	9.70%	9.40%	9.50%	16.89%	8.60%	12.68%	7.75%	7.00%
Sandstones	4.30%	12.00%	9.50%	12.16%	6.99%	7.75%	13.96%	15.00%
Greywackes	43.00%	35.30%	32.00%	27.03%	37.10%	44.37%	31.01%	32.00%
Phyllites+shales	18.30%	11.30%	19.50%	18.24%	31.18%	26.76%	29.46%	39.00%
Blueschists	0.00%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ultramatics	3.20%	7.50%	10.50%	12.84%	2.69%	3.52%	3.88%	1.00%
Human-made	0.00%	0.00%	0.00%	0.00%	0.54%	0.00%	0.00%	0.00%
Other	1.10%	0.30%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%
San Geronimo Creek at Lagunitas (Lagunitas Road bridge)								
Gravels counted	*657**	*117*	*165*	*146*	*233*	*103*	*88*	*100*
Date sampled	*summer*	*931120*	*951101*	*961004*	*970903*		*990903*	*0009299*
Metabasalts	17.0%	10.30%	25.45%	14.38%	10.73%	7.77%	11.36%	9.00%
Diabases	0.0%	1.70%	0.61%	0.00%	0.43%	0.00%	0.00%	0.00%
Cherts+quartz	10.7%	7.70%	7.27%	8.22%	7.30%	12.62%	6.82%	8.00%
Sandstones	14.7%	23.90%	3.03%	4.79%	8.15%	5.83%	18.18%	10.00%
Greywackes	26.3%	33.30%	31.52%	39.73%	43.78%	30.10%	35.23%	36.00%
Phyllites+shales	22.0%	16.20%	24.85%	25.34%	26.18%	36.89%	27.27%	34.00%
Blueschists	0.0%	0.00%	0.61%	0.00%	0.00%	0.00%	0.00%	0.00%
Ultramatics	6.8%	6.80%	6.67%	7.53%	3.00%	5.83%	1.14%	5.00%
Human-made	0.0%	0.00%	0.00%	0.00%	0.43%	0.97%	0.00%	0.00%
Other	0.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Lagunitas Creek at Kelley's Tocaloma (MP 20.03)								
Gravels counted	*671***		*150*	*163*	*170*	*107*	*107*	*104*
Date sampled	*Sept. 1979*		*951027*	*961031*	*970903*	*980903*	*990901*	*000929*
Metabasalts	35.0%		20.00%	12.96%	17.65%	5.61%	14.29%	10.00%
Diabases	0.0%		0.00%	0.62%	0.59%	0.00%	1.90%	0.00%
Cherts+quartz	5.1%		6.00%	9.88%	4.71%	5.61%	9.52%	4.00%
Sandstones	10.6%		8.67%	10.49%	8.82%	15.89%	9.52%	10.00%
Greywackes	26.4%		40.67%	36.42%	31.18%	28.04%	29.52%	29.00%
Phyllites+shales	18.6%		21.33%	25.93%	34.71%	40.19%	30.48%	49.00%
Blueschists	0.0%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ultramatics	3.3%		3.33%	3.70%	2.35%	4.67%	4.76%	1.00%
Human-made	0.0%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other	0.6%		0.00%	0.62%	0.00%	0.00%	0.00%	1.00%
Analyst	RE+BH	BH	BH	BH	BH	BH	BH	BH

Notes:

Analysts: Robert Enkeboll, Barry Hecht

*Mean of 5 subsamples collected at MP15.00, approximately 0.3 miles downstream from Lagunitas Road bridge. Intervening watershed underlain almost solely by metavolcanics. See Phase I report, p. A-25.

**Mean of 5 subsamples collected across the channel at the identical location along the stream. See Phase I report, page A-25