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August 11, 2006
Tom Lippe
329 Bryant Street, Suite 3D
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Re: Napa River Sediment TMDL

Dear Mr. Lippe:

You have asked me to review and comment on the following documents (a) Proposed Basin Plan Amendment: Napa River Sediment Reduction and Habitat Enhancement Plan (b) and the Napa River Sediment Total Daily Maximum Load Staff Report dated June 30, 2006. Both of these documents were obtained from the San Francisco Bay Regional Water Quality Control Board web site.

Your review of the Basin Plan Amendment raised several questions. I respond to your questions below.

Question: Are there other Basin Plan Standards that the Napa River may not meet which should be addressed by the Sediment TMDL?

Response:

In my opinion, both the Turbidity and Toxicity Basin Plan Standards should be included in the Napa River Sediment TMDL. The Basin Plan Standard for turbidity is:

> **TURBIDITY**
>
> Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases from normal background light penetration or turbidity relatable to waste discharge shall not be greater than 10 percent in areas where natural turbidity is greater than 50 NTU.

The rationale for including the Turbidity Standard in the TMDL is that:

(a) The Basin Plan Amendment and the sediment TMDL staff report both identify fine sediment as the primary problem. Fine sediment is carried as suspended sediment load or wash load.

(b) Typically there is a strong correlation between suspended sediment load and turbidity.

(c) The Turbidity Standard says that a discharge shall not increase the turbidity by more than 10% above the background level when the observed turbidity is greater than 50 NTU.

(d) The Basin Plan Amendment and the TMDL staff report both state that the average annual sediment load during the 1994-2004 reference time period was 183% of the natural (background) sediment load. These two reports suggest that human caused non-point source discharges have increased the sediment load to 183% of background. Therefore, it is very likely that human caused non-point source sediment discharges have increased the wintertime turbidity, at least at some locations, by more than 10% on days when the turbidity was greater than 50 NTU which, means that the Turbidity Basin Plan Standard is being violated.

(e) The sediment load that is passed through the on-stream reservoirs is carried as suspended sediment with a low enough settling velocity that it does not drop out of suspension while passing through the reservoir. Such fine material is often termed *wash load* and is a source of turbidity. An e-mail from Michael Napolitano dated August 8, 2006 states that:

> `2. With regard to estimating trap efficiency, please note we estimate that total sediment input to channels upstream of reservoirs = 122,374 metric tons per year. We also estimate that approximately 1/3 of the > 2 mm size class is discharged through the dams, or approximately 18,047 metric tons per year. Comparing these two values, I find that by our approach, 15% of the total sediment input is discharged through the dams, and therefore, reservoir trap efficiency is estimated at 85%.`

Staff expects about 33% of the sediment less than 2 mm to be carried as suspended load that is fine enough to be classed as wash load. A spreadsheet (received from Michael Napolitano on August 7, 2006 by e-mail) giving the details of the information in Table 2 of the Basin Plan Amendment presents the total sediment load by size class, see Table 6 below. The total sediment load for the Napa River watershed, generated above Soda Creek, that is less than 2 mm, is 170,600 mt/year (45.7% of the total load). Staff estimates that the natural sediment load of the Napa River above Soda Creek contains about 54,600 mt/year of material that is less than 2 mm. This gives an estimate of the human caused sediment load, from the watershed above Soda Creek, that is less than 2 mm, of 116,000 mt/year. Using staff's estimate that 33.3% of the material less than 2 mm can be transported as wash load gives an annual human-caused wash load of 38,600 mt/year from the Napa River above Soda Creek. This is the roughly the same amount of sediment that is generated by channel incision. It is also about the same amount as the load generated by surface erosion associated with vineyards and livestock grazing. By not including turbidity, and hence the wash load, in the TMDL, as described in the proposed Basin Plan Amendment, an important human caused element of the sediment budget is being ignored.

The expected natural wash load contributed to the Napa River above Soda Creek is about 18,200 mt/year (= 33% x 54,600). The human-caused wash load is 38,600 mt/year (= 33% x 116,000 mt/yr) which is 212% of the natural wash load. If the overall annual human caused wash load is more than twice the natural wash load, it is reasonable to expect that the Basin Plan Standard for turbidity is being violated, at least in some locations, on a regular basis.

The above facts support the claim that turbidity levels are in violation of the Basin Plan on many days during the winter. Hence, the Napa River is turbidity impaired. Consequently, turbidity should be one of the Basin Plan Standards included in the TMDL and a numeric target should be set for turbidity.

The Basin Plan Amendment does not mention turbidity at all. Curiously, the TMDL Staff Report lists the turbidity Basin Plan Standard (Staff Report, page 6) but does not discuss it and does not explain why it was not included in the TMDL. Table 1 of the TMDL Staff Report claims that the Basin Plan Standard for turbidity is being attained, but no substantive proof is offered. Apparently, the small number of turbidity samples taken, during a relatively dry year, for the Limiting Factor Analysis were taken as definitive evidence that the Basin Plan Standard for turbidity is being met everywhere in the Napa River watershed, at all times.

However, to definitively demonstrate that the Basin Plan Standard for turbidity is being attained everywhere in the Napa River watershed would require quantitative evidence showing that the present level of turbidity is no more than 10% above the background turbidity, everywhere in the watershed. The first problem with demonstrating this claim is the Basin Plan Standard for turbidity itself. What is *background turbidity*, in terms of the non-point source sediment problems that the TMDL is designed to address? How is *background turbidity* to be measured in the context of non-point source sediment impairment? Does the Regional Board Staff have a scientifically defensible method of determining background turbidity, in the case of non-point source sediment?

The Basin Plan Standard for turbidity can be applied to spills or point sediment discharges from say a failed culvert where turbidity above and below the point of discharge can be measured and compared. The Basin Plan Standard for turbidity is unworkable for non-point source sediment discharges because the background turbidity can not be determined at any given site.

The limited number of sampling locations and the limited frequency of sampling (only 6 storms) are insufficient to establish that the Basin Plan Standard for turbidity is being attained in all locations in the Napa River watershed.

The Limiting Factors Analysis performed original field work to investigate, "The duration of elevated turbidity following storms was measured at 18 sites in 16 tributaries following 4-to-5 storm events, and 6 mainstem sites following 5 storms." Turbidity was measured by a modified grab sample. Grab samples were taken on the day of the storm and then 1, 3 and 9 days after the storm peak. Details of the turbidity sampling are given in Appendix A of the Limiting Factors Analysis (Stillwater Sciences and Dietrich, 2002).

The Executive Summary of the Limiting Factors Report states:

> B. Sediment-related Factors
>
> *Turbidity*
>
> The impact of turbidity on salmonids and other aquatic species is a major concern in watersheds where land use activities have increased fine and/or total sediment supply to channels. Effects of increased turbidity on fish and other aquatic organisms, including reduced feeding efficiency and disrupted territorial behavior, can occur at relatively low turbidity levels. These changes have the potential to impact the population dynamics of affected species primarily by reducing growth rates.
>
> The Napa Valley is heavily developed for agricultural and residential land uses. Hillslope erosion has been identified as a clear concern of many stakeholders in the watershed. Based on initial information review and field reconnaissance surveys conducted in summer 2000, we hypothesized that feeding opportunities for juvenile steelhead during the rainy season (particularly in the late fall and early spring when temperatures are not too cold to inhibit feeding and growth) have been reduced by elevated turbidity levels. Reduced growth may affect subsequent survival (see juvenile summer growth study description below for discussion of possible mechanisms). If prolonged high turbidity occurred only after infrequent flood events (e.g., flood events with a recurrence interval of 5 years or greater), then high turbidity would probably not have a significant impact on steelhead production in the Napa River watershed. We hypothesized that to be deleterious, prolonged high turbidity would have to occur after relatively common storms. To assess whether turbidity levels at commonly occurring flows could be sufficiently elevated (i.e., at levels above a threshold of 20 NTUs [nephalometric turbidity units, a common measure of turbidity], a conservative estimate of the turbidity threshold at which prey capture efficiency by steelhead would become impacted), we measured turbidity under winter baseflow conditions immediately following four storms in 2001 and one larger storm in 2002, to see if these storms could

> increase turbidity enough to cause a chronic reduction in steelhead feeding efficiency. During water year 2001, we conducted turbidity monitoring at a total of 24 sites (Figure ES-4); 19 sites were sampled to fully characterize the recessional limb of 4 different storms, and the remaining 5 sites were sampled for fewer storms. Turbidity was re-measured at 22 of the 24 original sites in a limited sampling effort to capture conditions after a larger storm event during water year 2002, which was much wetter than 2001.
>
> Our results indicate that feeding opportunities were probably not lost for more than one or two days following even the largest storms (based on the 20 NTU estimate). Therefore, turbidity probably did not pose a significant limitation to feeding by steelhead during the period studied (Figure ES-5). No sediment source analysis was done, hence we do not know if potential significant sources of fine sediment and clays (dirt roads, freshly ploughed agricultural fields, etc.) were exposed during the period of measurement. Within the narrow time frame of this study, no turbidity effects were found, despite our examination of 17 tributaries and 7 sites on the mainstem Napa River. This suggests that there is not a permanently elevated chronic source of sediment causing deleterious turbidity levels. However, our results reflect conditions during only two water years and may not have captured the effects of episodic or rare phenomena such as periods with higher rates of land conversion or road construction or infrequently occurring natural events, such as landslides or extremely large storms.

The limited turbidity sampling program was judged to show no problem with chronic turbidity. However, the Limiting Factor Analysis report acknowledges that the most of the turbidity samples were taken during the 2001 water-year which was relatively dry. In fact, 77% of the 63 water-years with complete daily stream flow records at the Napa River near St Helena stream gauge had larger mean annual discharge than the 2001 water-year. An additional storm was sampled in January 2002 water-year.

In my opinion, the methodology used by Stillwater Sciences and Dietrich (2002) to investigate chronic turbidity was not sensitive enough to adequately address the issue of chronic turbidity. In addition, the turbidity sampling done for the Limiting Factors Analysis by Stillwater Sciences and Dietrich (2002) is inadequate to demonstrate that the Basin Plan Standard for turbidity is being attained in the Napa River watershed.

Klein (2003) presents a more robust method for investigating chronic turbidity. Klein gathered turbidity data from eight continuous turbidity (15-minute) and stage recording stations located on small streams in the northcoast region (Mendocino, Humboldt, and Del Norte counties). Klein performed a turbidity-duration analysis similar to a water-discharge duration-analysis.

Trush's method of identifying chronic turbidity by performing a turbidity-duration analysis was adopted by the Humboldt Watersheds Independent Scientific Review Panel (2003), commissioned by The North Coast Regional Water Quality Control Board. Trush recommended the following *chronic turbidity thresholds.*

> Trush (2002) has identified "chronic turbidity thresholds" for anadromous salmonid populations for each of the following flow conditions:
>
> - mean daily average streamflow (23%-24%): NTU < 10
> - winter base streamflow (10%): NTU < 25
> - receding winter peak streamflow (5%): NTU <70
> - winter peak streamflow (2.5%): NTU < 100.

> Identifying chronic turbidity thresholds for different portions of the annual hydrograph is an important step in developing TMDLs because it recognizes that the vulnerability of salmonids varies seasonally with position of the annual hydrograph. For example, the survival of salmonid embryos in gravel beds can be reduced by fine sediments entering streams during the critical species-specific incubation period (Everest et al. 1987). Also, chronically turbid water during the prime summer rearing period can reduce the density and growth of juvenile salmonids (Sigler et al. 1984), and cause a physiological stress response if turbidity occurs during periods when waters are normally clear (Redding et al. 1987). (Humboldt Watersheds Independent Scientific Review Panel Phase II Report, 2003)

The percentages in parentheses are water-discharge exceedence probabilities. For example, winter base streamflow is exceeded only 10% of the time during winter (October 1 through May 30). Trush's chronic turbidity standard for winter base flow says that the turbidity of the winter base flow should be less than 25 NTU. Since the winter base flow has a water-discharge exceedence probability of 10%, the turbidity of the base flow will have a turbidity-duration exceedence probability of 10%. In other words, if the 10% exceedence turbidity is greater than 25 NTU then the stream is in violation of Trush's winter base flow chronic-turbidity-standard.

Taking grab samples on the day of the storm peak and then 1, 3 and 9 days later does not provide enough information to define the turbidity exceedence probabilities used in Trush's chronic turbidity standards. Jackson (2005) investigated the time it took for turbidity values to drop from the maximum recorded value during a storm peak to 25 NTU for 6 storms measured during the 2004 water-year on the San Lorenzo River in Santa Cruz county. The City of Santa Cruz Water Department collected 15-minute turbidity data for 165 days from October 30, 2003 through April 15, 2004. The City placed its turbidity sensor in the San Lorenzo near their intake on Tait Street. The USGS San Lorenzo River at Santa Cruz stream gauge (No. 1116100, watershed area = 115 sq-mi) is located just a few feet away from the City's turbidity sensor. Figure 1 shows the San Lorenzo River turbidity and water discharge data collected in 2004. The City of Santa Cruz's 2004 turbidity data, for the San Lorenzo River, had the exceedence probabilities shown in Table 1.

Table 1. Turbidity exceedence values for the 2004 water year turbidity data collected by the City of Santa Cruz Water Department at their Tait Street diversion.

Turbidity Exceedence Probability	San Lorenzo River for 2004 Water Year	Trush's Chronic Turbidity Threshold
24% exceedence	14 NTU	< 10 NTU
10% exceedence	41.0 NTU	< 25 NTU
5% exceedence	72.1 NTU	< 70 NTU
2.5% exceedence	120 NTU	< 100 NTU

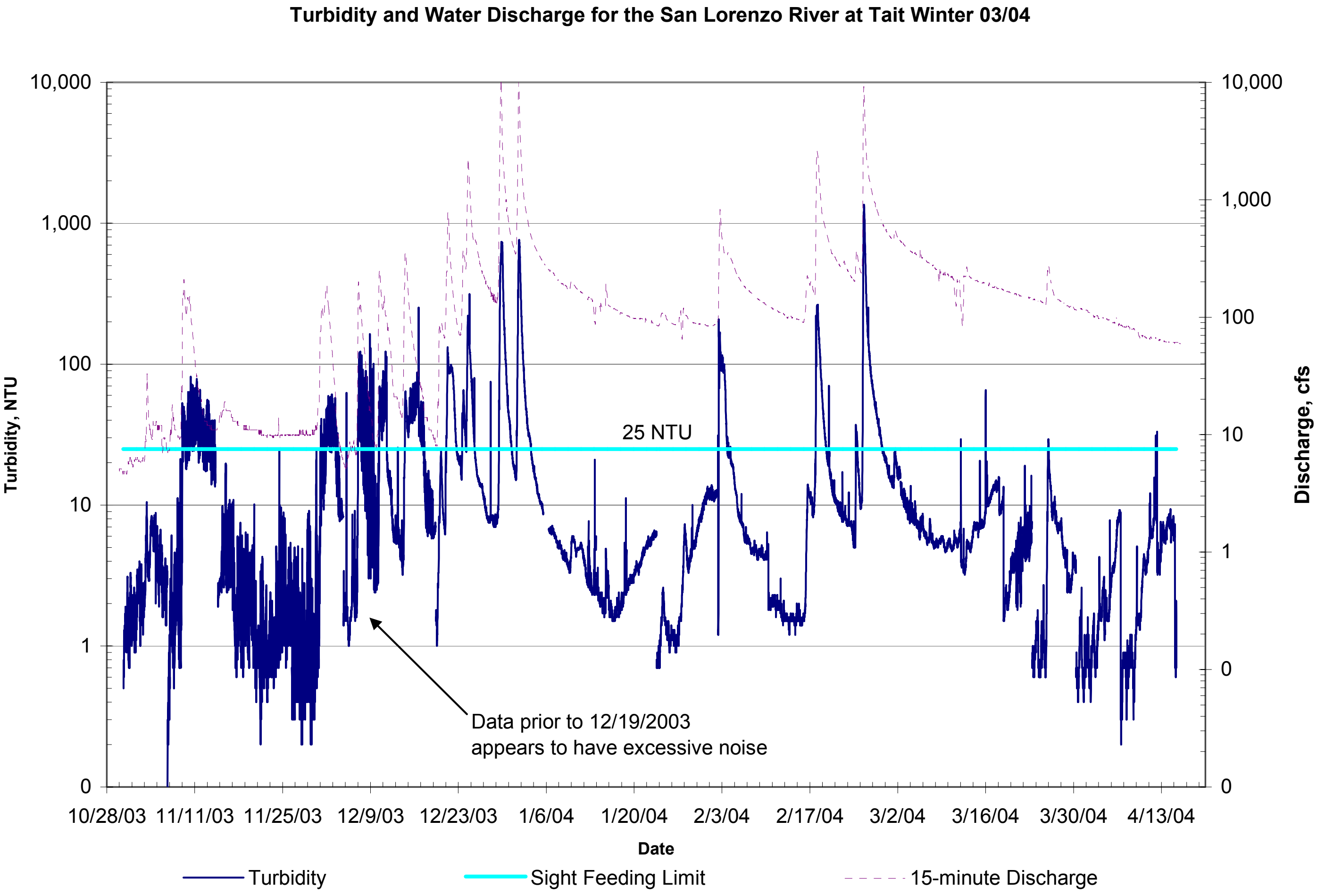

Figure 1. The City of Santa Cruz's 15-minute turbidity data for the 2004 water-year with the USGS 15-minute discharge data from the San Lorenzo River at Santa Cruz stream gauge. The excessive noise in the early part of the record was caused by a weak battery.

Table 2. The number of hours for the City of Santa Cruz's 2004 San Lorenzo River turbidity data to drop from the storm maximum to each of Trush's chronic turbidity levels.

Date	Ben Lomond (CDF) Daily Rainfall inches	Maximum Water Discharge cfs	Ratio of Discharge to 1.5-Yr Discharge	Return Period years	Maximum Turbidity NTU	Hours to 100 NTU	Hours to 70 NTU	Hours to 25 NTU
12/24/2003	2.48	2,250	53.57%	1.2	221	10.75	14.75	25.75
12/29/2003	4.91	10,100	240.48%	2.72	737	17.25	21	39.25
1/1/2004	3.51	10,900	259.52%	3.5	762	16.25	20.5	45.5
2/2/2004	1.44	827	19.69%		169	3.5		
2/18/2004	2.70	2,620	62.38%	1.25	263	12.75	17.5	35.49
2/25/2004	2.18	9,230	219.76%	2.5	1,355	22.75	31.75	70.99

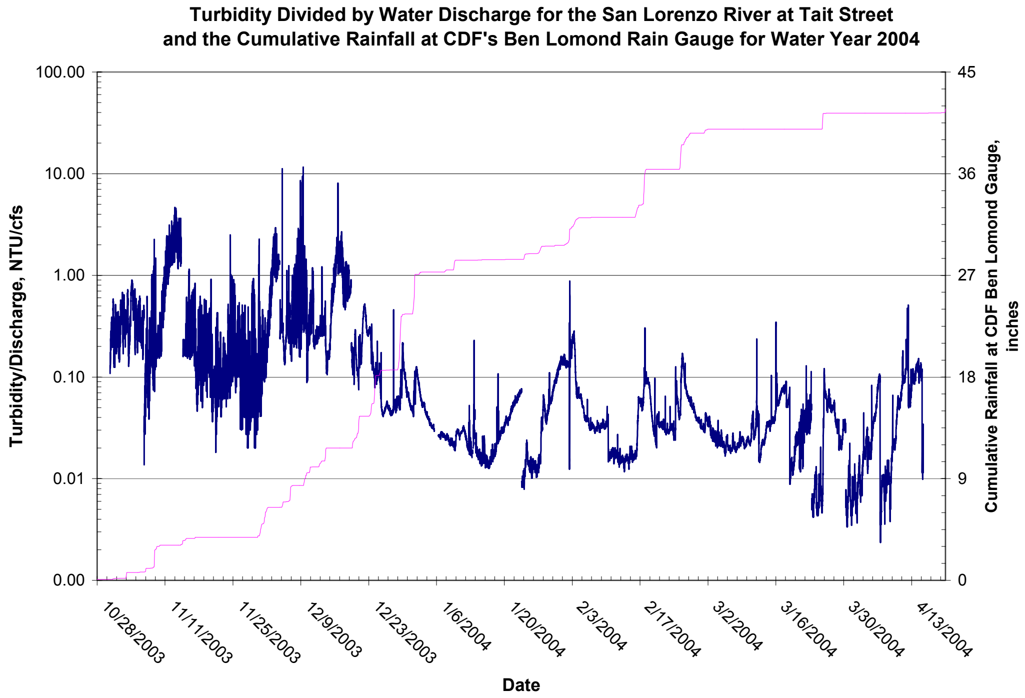

Figure 2. Turbidity divided by water discharge, for the San Lorenzo River near the City's intake at Tait Street, is a measure of the efficiency of fine sediment entering the channel network. Note the drop off in efficiency December 24, 2003, when the cumulative rainfall reaches about 15 inches. The early season turbidity-efficiency shows the need to monitor early storms. The pink solid lines that rises from the lower left to upper right is the cumulative rainfall.

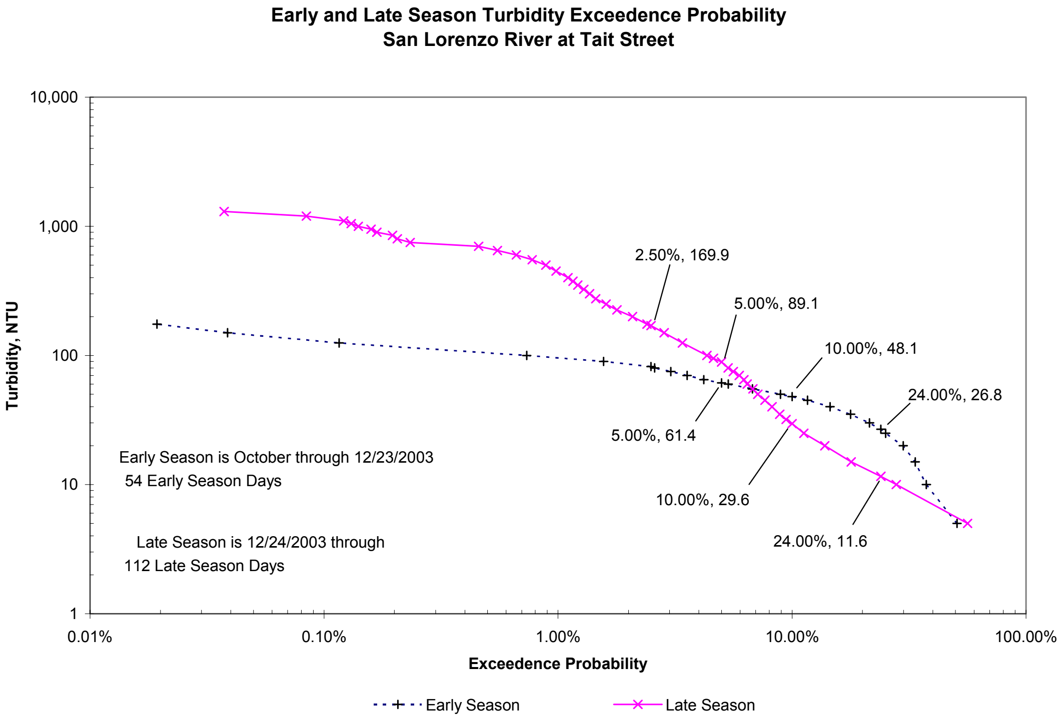

Figure 3. Turbidity exceedence curves for early season and late season. Early season is defined as October through 12/23/2003 and late season is 12/24/2003 through April.

The City's turbidity data exceeded each of Trush's chronic turbidity thresholds. This is not surprising since the San Lorenzo River is listed as impaired for sediment under section 303(d) of the Clean Water Act.

The time for the turbidity to drop from its maximum measured during a storm to each of Trush's chronic turbidity thresholds for the San Lorenzo River data should exceed the time it would take the turbidity to clear in an unimpaired watershed of equivalent size. Table 2 shows the time to reach each of Trush's chronic turbidity thresholds after the maximum turbidity, for six events from the 2004 water year

Table 2 shows that the maximum time to drop from a storm peak to 25 NTU was 71 hours or 2.96 days. The maximum turbidity for this event was 1,355 NTU and the return-period for the water discharge was 2.5 years (Log-Pearson Type-III) indicating that the peak was greater than bankfull. Thus, one would expect to find the turbidity to be below 25 NTU on the San Lorenzo River, a river with a chronic turbidity problem, if a sample was taken 3 days after a moderate storm peak. Therefore, sampling turbidity 3 and 9 days after a storm peaks that are less than bankfull would probably only detect severe cases of chronic turbidity. The San Lorenzo turbidity data suggests that the methodology used in the Limiting Factors Analysis is only sensitive enough to detect the most severe cases of chronic turbidity.

Another aspect of chronic turbidity not addressed by Stillwater Sciences and Dietrich (2002) is early season turbidity. They only sampled storms from January or later. Figure 1 shows that several days had turbidity greater than 25 NTU prior to January.

Figure 2 shows the turbidity divided by the water discharge for the 2004 San Lorenzo data collected by the City of Santa Cruz Water Department. The turbidity divided by water discharge is a measure of the efficiency of fine sediment entering and moving through the channel network. Prior to about 12/24/2003 the turbidity divided by the water discharge is generally higher than later in the year.

Figure 3 and Table 3 shows that chronic turbidity was a problem in the San Lorenzo River during the early season (prior to 12/24/2003). The early season turbidity is higher for the 24% and 10% exceedence levels than either the late season or for the entire winter period. The late season data is only slightly above the chronic thresholds for the 24% and 10% levels.

During the winter of 2004 (165 days), there were 26 days with turbidity greater than 25 NTU. A total of 13.5 of these days occurred during the 54 day period before 12/24/2003 and the remaining 12.5 days with elevated turbidity occurred after 12/24/2003 (112 days). So, correcting chronic turbidity during the early portion of the wet season appears to have a high return on investment. By not sampling during the fall, the Limiting Factor Analysis may have missed a significant portion of the chronic turbidity in the Napa River.

Table 3 shows that early season storms are an important source of chronic turbidity. While early season storms may not move bedload or a large percentage of the total sediment load for the year, they do carry elevated levels of suspended sediment relative to the water discharge. The elevated suspended sediment load, during the fall, adversely impacts salmonids juveniles. This further underscores the need to monitor early in the season.

Table 3. City of Santa Cruz's 2004 San Lorenzo River turbidity exceedence values for early season (prior to 12/24/2003) and late season (12/24/2003 and after).

Turbidity Exceedence Probability	San Lorenzo River Early Season Turbidity, NTU	San Lorenzo River Late Season Turbidity, NTU	Trush's Chronic Turbidity Threshold NTU
24% exceedence	26.8	11.6	< 10
10% exceedence	48.1	29.6	< 25
5% exceedence	61.4	72.1	< 70
2.5% exceedence	82.0	169.9	< 100

The Limiting Factors Analysis ignores an important possible confluence of adverse factors, namely the deleterious effects of low flow on juvenile salmonid growth rates during the summer followed by chronic turbidity reducing their ability to feed during the fall and early winter. Young fish that have had to expend a large amount of energy to obtain a meager amount of food through the late summer may not be able to locate food for many days during the fall, due t poor visibility from chronic turbidity, further limiting their growth.

Figures 1, 2 and 3, plus Table 3 demonstrate the "first-flush" effect of small early storms delivering a relatively large amount of fine sediment (turbidity) to the stream channel network. A reasonable hypothesis is that the majority of the fine sediment (turbidity) delivered to the channel in the fall and early winter is human caused and should therefore be regulated by the TMDL

Modern continuous recording turbidity meters make it possible to assess chronic turbidity. Prior to the availability of continuous turbidity meters it was impossible to set a adequately measure chronic turbidity in a river or to set a standard for it.

The existing Basin Plan Standard for turbidity does not adequately address the effects of chronic turbidity on federally listed salmonids. Therefore, not only should Trush's chronic-turbidity standards be used as numeric targets in the Sediment TMDL but, the Basin Plan should be amended to incorporate Trush's chronic-turbidity standards as the Basin Plan Standard for chronic turbidity. The existing turbidity standard should be retained as the turbidity Standard for acute point-source discharges.

Suspended sediment and turbidity may also adversely affect municipal and domestic drinking water supplies. The TMDL Staff Report notes that Water Supply (AGR - agricultural, MUN - municipal and domestic) is a Beneficial Use of the Napa River. However, the Staff Report does not include Water Supply (AGR or MUN) in the list of Beneficial Uses impaired by sediment.

The Napa River Pathogen TMDL Staff Report Problem Definition states that:

> Elevated levels of fecal coliform bacteria have been observed in the Napa River since the 1960s. These bacteria indicate the presence of fecal contamination and attendant health risk to recreational users of the river from water-borne pathogens. Fecal contamination is the primary mechanism for the spread of water-born illness (American Public Health Association, 1998; U.S. EPA, 2001, 2002).
>
> Recent monitoring programs (see Sections 3.3 and 3.4) confirm elevated fecal coliform and Escherichia coli (E. coli) levels in the river and its tributaries. The following sections discuss the use of

> pathogen indicator bacteria in water quality monitoring and regulation, relevant water quality standards, historic bacterial monitoring in the watershed, and current bacterial water quality studies.

Turbidity is well known for its ability to shield bacteria and other pathogens from the disinfection process. The human caused wash load is about twice the natural wash load of the Napa River. The wash load is an important component of turbidity. Consequently, it is reasonable to expect that the cost of filtering water diverted from the Napa River or its tributaries for municipal or domestic water supplies must be greater than if only the natural wash load (turbidity) was present.

The Basin Plan description of the MUN Beneficial Use is:

> MUNICIPAL AND DOMESTIC SUPPLY (MUN)
>
> *Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply.*
>
> The principal issues involving municipal water supply quality are (1) protection of public health; (2) aesthetic acceptability of the water; and (3) **the economic impacts associated with treatment- or quality-related damages**. (Emphasis Added)
>
> The health aspects broadly relate to: direct disease transmission, such as the possibility of contracting typhoid fever or cholera from contaminated water; toxic effects, such as links between nitrate and methemoglobinemia (blue babies); and increased susceptibility to disease, such as links between halogenated organic compounds and cancer.
>
> Aesthetic acceptance varies widely depending on the nature of the supply source to which people have become accustomed. However, the parameters of general concern are excessive hardness, unpleasant odor or taste, turbidity, and color. In each case, treatment can improve acceptability although its cost may not be economically justified when alternative water supply sources of suitable quality are available.
>
> Published water quality objectives give limits for known health-related constituents and most properties affecting public acceptance. These objectives for drinking water include the U.S. Environmental Protection Agency Drinking Water Standards and the California State Department of Health Services criteria.

The Napa River Sediment TMDL Staff Report and Basin Plan Amendment are ignoring the economic costs associated with the elevated treatment levels required to filter domestic and municipal water supplies to remove the human caused wash load (turbidity).

Therefore, excluding the watershed area above the municipal water supply reservoirs from the Sediment TMDL ignores the adverse impacts of human caused sediment above the reservoirs on the MUN Beneficial Use, specifically the increased cost of treating drinking water. The coarse sediment deposited in the reservoirs also has the potential to decrease the economic life of the reservoirs by reducing their capacity to store water.

Excluding turbidity from the Sediment TMDL exposes domestic water diverters, in all parts of the Napa River watershed, to elevated levels of turbidity that results from the high levels of human caused wash load. The increased volume of human caused wash load (turbidity) increases the cost of filtering domestic water supplies to provide safe drinking water.

The Basin Plan Standard for toxicity is:

> TOXICITY
>
> All waters shall be maintained free of toxic substances in concentrations that are lethal to or that produce other detrimental responses in aquatic organisms. Detrimental responses include, but are not limited to, decreased growth rate and decreased reproductive success of resident or indicator species. There shall be no acute toxicity in ambient waters. Acute toxicity is defined as a median of less than 90 percent survival, or less than 70 percent survival, 10 percent of the time, of test organisms in a 96-hour static or continuous flow test.
>
> There shall be no chronic toxicity in ambient waters. Chronic toxicity is a detrimental biological effect on growth rate, reproduction, fertilization success, larval development, population abundance, community composition, or any other relevant measure of the health of an organism, population, or community.
>
> Chronic toxicity generally results from exposures to pollutants exceeding 96 hours. However, chronic toxicity may also be detected through short-term exposure of critical life stages of organisms.
>
> As a minimum, compliance will be evaluated using the bioassay requirements contained in Chapter 4.
>
> The health and life history characteristics of aquatic organisms in waters affected by controllable water quality factors shall not differ significantly from those for the same waters in areas unaffected by controllable water quality factors.

The rationale for including the Toxicity Standard is that:

(a) the problems associated with the fine sediment in the bed of the Napa River, identified in the TMDL staff report and supporting documents, meets the definition of Toxicity given in the Basin Plan Standard

(b) the elevated sediment load and resulting elevated turbidity has probably produced a chronic turbidity problem.

Randy Klein monitored continuous turbidity data in eight north coast streams (A Report to the US Environmental Protection Agency (USEPA) Region IX, March 2003) to study “chronic turbidity’, or the tendency for some streams to remain turbid for a relatively large proportion of the winter runoff period. The following quote from Klein (2003) demonstrates the biological importance of chronic turbidity and how to measure chronic turbidity.

> In this study, I assembled turbidity data from eight continuous turbidity and stage recording stations located on small streams in the northcoast region. Data from individual streams spanning three water years (WY2000-2002) were processed to calculate lengths of time turbidity was higher than several thresholds. Turbidity exceedence analyses, similar to conventional flow exceedence analyses, were also performed, allowing comparison of turbidity levels at various exceedence probabilities. The lowest (and most frequently appearing in the literature on salmonid impacts) threshold was 25 NTU, though inconsistencies in the threshold of impacts to salmonids exist in the literature. To complement the turbidity data, GIS analyses of land and land use characteristics for basin areas upstream of each gaging station were performed. Both natural and human-affected characteristics were summarized.
>
> Differences between the study streams in duration of turbidity at several levels (the lowest being 25 NTU) spanned up to two orders of magnitude in some cases. A broad range of turbidities at the 1% and 10% exceedence probabilities was also observed between the study streams. These differences are considered to be far too great to be explained solely by natural variability (geology, climate), thus

> land use is concluded to be a dominant factor. Although limited by the number of sites assessed (eight), land use variables, particularly road density and annual rate of timber harvest, appeared to be the dominant controls on the gross differences in chronic turbidity observed among the study streams.
>
> Biological Effects of Turbidity
>
> A large body of scientific literature exists on effects of turbidity and suspended sediment on aquatic biota (see review by Henley and others, 2000). Relatively low turbidities (above about 20-25 NTU, according to most studies) and suspended sediment concentrations (above about 25 mg/l) reduce 'reactive distance' (the distance at which food can be sighted under varying levels of water clarity) for juvenile salmonids. Even relatively low turbidities may impair the ability of juvenile salmonids to forage for food and attain sizes needed for ocean survival (Newcombe and MacDonald, 1991; Newcombe and Jensen, 1996; Sigler and others, 1984), although a few studies suggest higher thresholds (e.g., 150 NTU in Gregory and Northcote, 1993). Large smolt outmigrant size has been shown to increase the chances of a fish returning as a spawning adult, so suppression of feeding and growth for a cohort can result in poor escapement numbers (returning spawners), even if smolt outmigration numbers are relatively high (Nicholas and Hankin, 1989). A host of other effects has been identified on salmonids, including behavioral effects (Berg and Northcote, 1984; Barrett and others, 1992) and mortality during egg incubation (Slaney and others, 1977). In addition to effects on juvenile fish feeding ability, turbid water diminishes the amount of sunlight reaching the streambed, which suppresses primary production (Henley and others, 2000).

The Toxicity Standard specifically states that there shall be no chronic toxicity. The Toxicity Standard also identifies, "…decreased growth rate and decreased reproductive success of resident or indicator species." as some of the possible indicators of toxicity. The quote from Klein (2003) shows that chronic turbidity can produce these types of toxic effects on steelhead, as defined in the Toxicity Standard. The TMDL staff report, proposed Basin Plan Amendment and supporting documents all show that the fine sediment in the bed of the Napa River meet the definition of the Toxicity Basin Plan Standard.

Question: Are the numeric targets in BP Amendment Table 1 reasonable?

Response:

Table 1 from the Basin Plan Amendment is reproduced below.

The spawning gravel permeability target appears reasonable if the following conditions are met,

(a) There is a well defined procedure for establishing the total number of sites where permeability will be measured;

(b) There is a well defined procedure for that defines the total number of permeability readings (or density of reading i.e. number of readings per sq-meter of spawning gravel) at each site.

(c) There is a well defined standard to judge if the permeability standard is met in the watershed. For example, the permeability target could be met when say, 95% of the measured sites each had 95% of measurements at the site meet the permeability criteria.

BP Amendment Table 1. TMDL sediment targets for the Napa River and its Tributaries

Spawning gravel permeability Median value	≥ 7000 cm/hr[a]
Streambed scour Mean depth of scour	≤ 15 cm[b]

[a] Target applies to all potential spawning sites for steelhead and salmon in the Napa River and its tributaries excluding those upstream of municipal water supply reservoirs.

[b] Target applies to the response of the streambed to peak flows less than the annual (one-year) flood at all potential spawning sites for salmon in gravel-bedded reaches of: 1) mainstem Napa River; and 2) alluvial reaches of tributaries where streambed slope is between 0.001 and 0.02. Potential spawning sites can be identified based on the following:1) dominant substrate size in the streambed surface layer is between 8 and 128 mm; 2) minimum surface area of gravel deposit is 0.2 square meters in tributaries and 1.0 square meter in mainstem Napa River; and 3) located within mainstem Napa River at a riffle head pool tail and/or pool margin or in tributary reaches where streambed slope < 0.03 or in tributary reaches where streambed slope > 0.03 in pool tails backwater pools and/or in gravel deposits associated with flow obstructions (e.g. woody debris boulders banks etc.).

The streambed scour target is **not** reasonable for the following reasons.

(a) The numeric target applies only to peaks less than the 1-year return period discharge. The "Return Period" is the expected average length of time required for an event of a given size to occur. The "return period" = 1/p, where p is the probability of the event occurring in any given year. For example, a flood that has a 1% probability of occurring in any given year has a Return Period of 100-years. This constraint is **not** reasonable because

(i) Technically, the 1.00-year return period can not be calculated. The closer the return-period gets to 1.00 the closer the discharge gets to zero. Table 4 demonstrates the problem, the 1.001-year return period discharge for the Napa River near St Helena is estimated to be 18 cfs. Clearly, discharge less than 18 cfs will not scour the channel of the mainstem at the Napa River near St Helena stream gauge.

(ii) The numeric criteria must be applied to discharges that can scour the bed. If the criteria is applied to discharges less than the critical discharge that just initiates bed load movement, there will be no scour and hence the numerical criteria will automatically be met. A rough rule of thumb is that bedload begins to move at discharges that are about 80% of bankfull. Therefore, a more realistic constraint would be to apply the numeric target to discharges between 80% of bankfull and bankfull. Table 4 shows that the return-period for a discharge of 80% of bankfull is about 1.36-years.

(b) Factors other than improvement in water quality could result in the target being met. The numeric target of keeping scour less than 15 cm for discharges near the critical discharge that just initiates bedload movement can be met if the slope of the stream bed is decreased; or the depth of the discharge is decreased; or the size of the bed material is increased. Only the last factor is a direct measurement of an improvement in water quality.

Table 4. Estimated discharge for selected Return-period events measured at the Napa River near St Helena stream gauge. Return-periods were estimated using the Log-Pearson Type-III distribution. Note that the 1.0-year discharge can not be calculated.

Return Period[2]	Instantaneous Peak Discharge[1]	Ratio of Peak Discharge to Bankfull	
10	12,026	278%	
5	10,431	241%	
2	6,387	148%	
1.5	4,323	100.0%	**Bankfull**
1.36	3,458	80.0%	
1.10	1,295	30.0%	
1.05	713	16.5%	
1.01	165	3.8%	
1.001	18.2	0.4%	

[1] Measured at the USGS St. Helena Gage (number 11456000).

[2] Based on the Log-Pearson Type-III applied the raw Annual flood series measured at the USGS St. Helena Gage (number 11456000) for water-years 1945-2004

(c) Part (2) of footnote (b) in BP Amendment Table 1 states that the numeric target will apply only to the alluvial reaches of tributaries with slopes between 0.001 and 0.02. Footnote (b) gives guidance on identifying potential spawning sites in tributaries with slopes up to 0.03. The numeric target for streambed scour does **not** apply to potential spawning sites in the tributaries where the slope is between 0.02 and 0.03. Is the portion of the channel network with slopes between 0.02 and 0.03 being intentionally excluded from the TMDL for a reason or is this an error? Footnote (b)(3) seems to imply that spawning sites have the potential to occur in streams with slopes between 0.02 and 0.03 but (b)(2) excludes these stream reaches.

(d) Operationally, the proposed numeric target for streambed scour will be hard to measure since it applies only to minor peaks. Measuring streambed scour must be done in the winter to avoid the confounding effect of measuring scour from larger events than the numeric target calls for.

(e) A well defined procedure for establishing the methodology that will be used to measure streambed scour must be developed. The protocol must define

(i) The method that will be used to determine scour at redds. For example, will scour-chains be used or will some other method be used?

(ii) the total number of sites on the mainstem and each tributary where scour will be measured.

(iii) A well defined procedure for that defines the total number of scour measurement (or density of measurements i.e. number of measurements per sq-meter of spawning gravel) at each site must be developed.

(iv) A well defined standard to judge if the streambed scour standard has been met in the watershed. For example, the streambed scour target could be met when say, 95% of the measured sites each had 95% of measurements at the site in compliance with the streambed scour criteria.

I recommend that Trush's chronic turbidity threshold standards be adopted as the numeric target for turbidity for the Napa River Sediment TMDL. I also recommend that Trush's chronic turbidity standards be adopted as the Basin Plan Standard for chronic turbidity.

Question: Table 4.1 in the BP Amendment does not apply to parcels above municipal reservoirs because they are allegedly adequately regulated by the County Conservation Regulations.

(a) Do you agree?

(b) Table 2 says human-actions on land areas upstream of dams contribute 11,000 mt/yr (4% of total or 6.3% of human caused sediment). Do we know what fraction of this 11,000 mt/yr is from parcels above municipal reservoirs and therefore unregulated?

Response:

I do not agree that the BP Amendment should exclude the area above the municipal reservoirs because:

(a) The Basin Plan standard for turbidity is being violated, as explained in my response to Question 2. BP Amendment Table 2 shows that 18,000 mt/yr of fine sediment is making it through all of the reservoirs combined. The fine sediment that makes it through the reservoirs must be silt and clay that is carried as wash load and so causes turbidity. Over 60% of the fine sediment that is carried through the reservoirs is assigned to human actions.

    a. If the County Conservation Regulations are effective in controlling non-point source sediment above the municipal reservoirs they should be equally effect downstream of the municipal reservoirs.

    b. I have reviewed projects to create new vineyards in Napa County. In my opinion, the hydrologic analysis done for these projects was inadequate to protect water quality. The importance of the subsurface water balance in hillslope processes is typically not considered in the vineyard Erosion Control Plan. Failure to account for changes to the subsurface water balance can lead to headward erosion of the stream channel or increases in peak flows. Both of these effects contribute sediment to the stream network.

(b) Table 5 shows the watershed area above the five largest municipal dams. The data was taken from the California Department of Water Resources, Bulletin 17 (digitized by the Berkeley Digital Library).

Table 5. Watershed area above the five large municipal reservoirs, as given in California Department of Water Resources, Bulletin 17 (digitized by the Berkeley Digital Library) which lists state regulated dams in California.

	Drainage Area, sq-mile	Drainage Area, sq-km
BELL CANYON	5.53	14.32
CONN CREEK	54	139.86
KIMBALL CREEK	3.44	8.91
MILLIKEN	9.3	24.09
RECTOR CREEK	10.7	27.71
Watershed Area above large Municipal Dams	82.97	214.89
Napa River Watershed area above Soda Creek	225.5	584
Area above Municipal Dams as Percentage of Area above Soda Creek		36.8%

Question: Staff Report, p 65 note 25 states:

"The sediment TMDL is 125 percent of natural background load, or that load that would have been discharged to mainstem Napa River absent dams or human caused erosion. Because about 30 percent of the watershed drains into dams, a significant fraction of natural load is deposited in tributary reservoirs, and therefore, only about 67 percent of natural sediment inputs to the channels are delivered to mainstem Napa River. As such, it's possible to allocate almost this amount (e.g., 59 percent of natural background) to land use sources, and still achieve the TMDL."

Earlier, the report said that these reservoirs capture all of the sand and gravel but fine sediments get through. We know from Table 2 that about 11,000 mt/yr of human caused *fine* sediment gets through. Since fine sediment is what we are concerned about, do the numbers in this footnote really add up. In other words, if most of the natural and human cause fine sediment from land above reservoirs is getting through, can you legitimately take credit for the gravel and sand that is not getting through to say 59% of the load can be allocated to human caused sediment.[1]

[1] Natural background = 99,000 mt/yr. If the numbers in this footnote are correct, 99,000 is 67% of total natural sedimentation, which puts total natural sedimentation at 147,760.

Response:

The argument presented in the footnote number 25 on page 65 is that the natural load captured by the dams can be used as a credit to offset the human caused sediment load. Staff only considers material between 11 mm down to fine sand (0.25 mm) to be a problem. Material smaller than the range they consider to be a problem is carried as wash load and not much of it settles into the bed, since wash load moves rapidly downstream. However, when the wash load is being transported it may cause chronic turbidity problems for salmonids. In my opinion, staff has underestimated the importance of the problem caused by chronic turbidity. When chronic turbidity is considered, the wash load delivered by the reservoirs becomes important. Staff also incorrectly concludes that the Basin Plan Standard for turbidity is being attained even though they have no evidence that supports their assumption. See my response to Question 2 for the reasons turbidity should be regulated by the TMDL.

The e-mail and spreadsheet from Michael Napolitano, cited in Question 2, reveal that Staff considers that only about 33.3% of the material that is smaller than 2 mm gets through the reservoirs (Sand is material from 2 mm to 0.062 mm, silt and clay are smaller than sand). Table 6 summarizes the calculation of the annual load that reaches the Napa River. The numbers in my Table 6 do not perfectly match the numbers in Table 2 of the BP Amendment. However, they are in fair agreement. Note that 10,000 mt/yr is about 6.8% of the watershed-wide natural load of 147,440 mt/yr which is probably less than the error in the sediment budget estimates.

The one-third of the material less than 2 mm that passes through the reservoirs (18,000 mt/yr) accounts for 15% of the sediment load delivered to the reservoirs. Staff estimates the total sediment load delivered to the reservoirs to be 122,374 mt/yr. The natural portion of the load delivered to the reservoirs is about 48,600 mt/yr and the human caused portion is about 74,000 mt/yr. The reservoirs capture 85% of the load delivered to them so there is 61,350 mt/yr of human caused sediment trapped by the reservoirs.

The human caused sediment captured by the reservoirs is about 54% of the 50% reduction of the total human caused sediment load of 225,833 mt/yr. Claiming a credit for the material captured by the reservoirs seems to be a form of circular reasoning. The current situation is that the Napa River is impaired by sediment. The reservoirs are part of the current picture. The sediment in the reservoirs is already captured. Making the argument that if the dams weren't there things would be better is the same as saying if the roads weren't there things would be better. Is not the goal to improve the current conditions?

Table 6. Calculation of the annual sediment load reaching the Napa River during the 1994 to 2004 period. Data supplied by a spreadsheet supplied by Michael Napolitano, SFBRWQCB.

	Total Sediment Supply (t/yr)	>64mm Sediment Supply (t/yr)	11.2-64 mm Sediment Supply (t/yr)	2-11.2 mm Sediment Supply (t/yr)	<2mm Sediment Supply (t/yr)
Load Generated Watershed-wide					
Natural Annual Load	147,440	10,970	34,440	47,410	54,620
Human Caused Annual Load	225,830	10,900	25,480	73,430	116,020
Total Annual Load	373,270	21,870	59,920	120,840	170,640
Sediment Load Delivered to Reservoirs					
Natural Load	48,340	3,600	11,290	15,540	17,910
Human Caused Load	74,030	3,570	8,350	24,070	38,040
Total Load	122,370	7,170	19,640	39,620	55,940
Load Captured by Reservoirs					
Natural Load	42,370	3,600	11,290	15,540	11,940
Human Caused Load	61,350	3,570	8,350	24,070	25,360
Total Load	103,720	7,170	19,640	39,620	37,290
Wash Load Passing Through Reservoirs					
Natural Load					5,970
Human Caused Load					12,680
Total Load					18,650
Load Reaching Napa River					
Natural Annual Load	105,070	7,370	23,150	31,870	42,680
Human Caused Annual Load	164,480	7,330	17,130	49,360	90,660
Total Annual Load	269,550	14,700	40,280	81,220	133,350

Question: Staff report at p 73-74 states:

> Hillside vineyard development at some sites, especially at those underlain by soft bedrock and/or where vineyards replace forest cover has also caused off-site channel enlargement (gully development) and associated shallow landslide failures31 (see source analysis this document; MIG, 2000). To avoid this problem when new hillside vineyards are proposed, the design review process should incorporate rigorous hydrological analysis (as appears to be the current practice by Napa County) to predict potential change in peak runoff rates, and the potential for off-site channel enlargement. Effective design features should then be incorporated to reduce off-site erosion risk to an acceptable level. A possible approach to this problem is outlined on pages 31-37 of the Phase II Final Report of the Napa River Watershed Task Force (MIG, 2000). Similarly, the Science Advisory Group to the Napa Green Certification Program has recommended that peak storm runoff

> rates following hillside vineyard development (at all sites) should not increase by more than 10-to-15 percent above pre-project rates to reduce the risk of off-site channel enlargement to an acceptable level (Napa Green Certification Program, 2003). At all existing hillside vineyards, as part of a larger sediment source inventory and control plan, the potential for concentrated runoff from the vineyard or road network should be evaluated through site inspection and analysis by qualified registered professional scientists or engineers. The goal for management of existing vineyards should be to reduce peak storm runoff rates into actively eroding gullies or landslides or other potentially unstable areas, as needed to accelerate natural recovery. Vineyard sediment control performance standards described above could be achieved through expanding the total vineyard acreage enrolled and independently certified under the Napa Green Certification Program32, by application of existing state regulatory authorities (Waste Discharge Requirements or Waivers thereof), and/or by adoption of some of the revisions to the Conservation Regulations that were recommended by the Napa River Watershed Task Force (MIG, 2000).

Do you have any comments on this?

Response:

(a) In my experience, both as the Hydrologist for the Mendocino County Water Agency and in private practice, I have observed that the rigor of hydrologic analysis has more to do with the individuals or firms involved in doing the analysis than the specifics of any governmental requirement. There are only two ways to ensure that any hydrologic analysis required by Napa County will be of sufficient rigor to prevent additional sediment related impact to the Napa River from any type of permitted project. The first way would be for Napa County to hire an in-house Hydrologist, who is knowledgeable about hillslope processes and subsurface flow, to review projects and hydrologic reports prepared by consultants. The second way is for the public to actively scrutinize every project and hire experts to review projects. The second way is how things are currently done. The second way is inadequate to protect the environment because private individuals do not have the resources to monitor and review all projects submitted to the County. The second way also moves the responsibility for project review from the County to private individuals.

(b) The Off-site Hydrologic Impact procedure outlined in pages 30-37 of the Phase II Final Report of the Napa River Watershed Task Force focuses on limiting downstream increases in peak storm discharge from surface runoff. There is no provision to consider subsurface effects such as: the increased soil moisture that results from the conversion of forests to vineyards or increases in subsurface flow. Increased subsurface flow has the potential to increase peak storm discharge in some cases. Increased subsurface flow also has the potential to saturate a greater area around the head of a channel and may result in upslope expansion of the channel which would release sediment into the stream channel. In fact, some of the recommended measures such as water spreading may actually exacerbate erosion or flooding from subsurface flows.

The proposed Off-site Hydrologic Impact evaluation procedure presented in the Phase II Final Report of the Napa River Watershed Task Force needs to be modified to address increases in soil moisture and subsurface flow that result from timberland conversion or other projects that would change the soil moisture balance. The revised Off-site Hydrologic Impact evaluation procedure would also have to be incorporated into a regulatory framework.

(c) Bob Curry and I participated in the Science Advisory Group to the Napa Green Certification Program and we took part in the discussion that in recommending that peak flows not be increased by more than 10%-15% above pre-project rates.

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