Appendix B

Revised Staff Report

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REVISED STAFF REPORT

Evaluation of Water Quality Conditions for Nutrients in Napa River and Sonoma Creek

Proposed Revision to Section 303(d) List

February 2014

Regional Water Quality Control Board
San Francisco Bay Region

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Contents

Executive Summary

The federal Clean Water Act requires that each state develop a list of impaired water bodies and associated pollutants under Section 303(d) of the Act. California's "303(d) list," after approval by the U.S. Environmental Protection Agency (U.S. EPA), sets the California Water Boards' (State Water Resources Control Board's [State Water Board] and nine Regional Water Quality Control Boards') action agenda for achieving or maintaining water quality standards in our state.

For more than 25 years the main stems of the Napa River and Sonoma Creek have been on the 303(d) list for impairment from elevated levels of nutrients (nitrates and phosphorus) that cause excessive algae growth, known as eutrophication. Eutrophic waters can significantly alter dissolved oxygen levels and pH, which are critical to aquatic wildlife and can impact recreational beneficial uses.

This report reviews all readily available data to assess current water quality conditions related to nutrients in the Napa River and Sonoma Creek main stem and tributaries. We used a weight of evidence approach because there are no numeric Water Quality Objectives or U.S. EPA criteria for algae-based indicators that could be used to determine whether these waters' beneficial uses are impaired by eutrophication. Because evaluation guidelines for appropriate amounts of algae in freshwater streams are available, we focused our analysis on the non-tidal, freshwater portions of the Napa River and Sonoma Creek. The reviewed data is of good quality, as indicated by quality assurance and quality control procedures, and meets the spatial and temporal requirements of the State Water Board's Listing Policy.

We produced eight lines of evidence, some of which directly examined how much algae was present in the Napa River and Sonoma Creek, while others assessed whether nutrients alone were present at toxic concentrations.

Our results show that benthic (i.e., bottom-growing) algae levels were below recently published evaluation guidelines for chlorophyll *a* and percent cover of algae. Those two indicators directly assess the amount of algae growing in the stream. Water column chlorophyll *a* levels were also below recently published evaluation guidelines. At locations where an exceedance of one benthic algae indicator was observed, a second benthic algae indicator and subsequent indicators, such as pH or dissolved oxygen, did not show consistent signs of eutrophication. Nutrients such as nitrite, nitrate, and ammonia were not found at concentrations that are directly toxic to humans or aquatic wildlife. In sum, we conclude that water quality conditions in the Napa River and Sonoma Creek are meeting the narrative biostimulatory Water Quality Objectives with respect to nutrients and eutrophication. Staff's analysis has determined that these water bodies are supporting designated beneficial uses that could be affected by nutrients for which there are numeric evaluation guidelines. Therefore, we propose to delist the non-tidal portion of the Napa River main stem and Sonoma Creek main stem for impairment caused by nutrients.

1 Napa River and Sonoma Creek: Proposed Delisting for Nutrients

1.1 Introduction and Rationale for Delisting

In 1976, the Napa River (River) main stem was identified on California's Clean Water Act Section 303(d) List (303(d) list) as impaired by excessive levels of nutrients, resulting in eutrophication (excessive algal growth). Ten years later, nearby Sonoma Creek (Creek) was added to the list, also for impairment by nutrients. San Francisco Bay Regional Water Quality Control Board (Water Board) staff began work developing water quality action plans ("total maximum daily loads" or TMDLs) for both water bodies that included data collection and analysis indicating that these waters were in fact no longer impaired by nutrient pollution. Building on these data, Water Board staff undertook the current project to complete a rigorous analysis of available data, water quality standards, and listing/delisting guidelines, aiming to develop a rationale for delisting non-tidal reaches of these waters. This review was complicated by a lack of numeric nutrient Water Quality Objectives in the Water Board's Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) sufficient to allow a bright-line determination of whether a river or creek is impaired by nutrients (Water Board 2013). The Basin Plan's narrative water quality objective for biostimulatory substances states that water bodies "shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses." Staff considered this objective along with regulatory guidance to make a determination of impairment.

Section 4.7.1 of the Listing Policy describes an approach to assessing excessive algae growth based on the binomial distribution found in Table 4.1. Although staff used Table 4.1 to evaluate nutrient-related toxicity, we used Section 4.11 (situation-specific weight of evidence delisting factor to evaluate impairment) to evaluate potential impairment of the narrative biostimulatory objective for the following reasons:

1) We are evaluating a narrative water quality objective using multiple lines of evidence and the evaluation guidelines for those lines of evidence are not formally adopted Water Quality Objectives or criteria;
2) The evaluation of the narrative biostimulatory objective is complicated by the fact that we are evaluating a substance that naturally occurs in streams and is affected by multiple co-factors;
3) Relatively few chlorophyll *a* samples are taken each year because results tend to be relatively consistent over weeks to months. As a result, there are insufficient samples to meet Table 4.1 requirements for each individual line of evidence. However, a single sample represents conditions over a substantial period of time;
4) Further, chlorophyll *a* data points are more expensive and time consuming to collect, so they are generally fewer in number than typical water chemistry measures;
5) This dataset does not contain enough samples to utilize Table 4.1 for each individual line of evidence related to algal biomass, although 134 algal biomass samples were collected across both watersheds; and

6) The negative effects of eutrophication on beneficial uses are interpreted by secondary indicators such as dissolved oxygen, pH, or nuisance odors.

Based on a weight of evidence approach to this work, Water Board staff believe that the non-tidal portions of the River and Creek should be delisted because these water bodies currently meet the Basin Plan's narrative objective for biostimulatory substances. This finding is based on the weight of evidence approach described in the State Water Board's Policy for Developing California's Clean Water Act Section 303(d) List (Listing Policy, Section 4.11; State Water Board 2004) and uses multiple lines of evidence as well as the most recent numeric evaluation guidelines. Further, both the River and Creek are currently attaining all applicable numeric Water Quality Objectives related to nutrient toxicity.

Data used for our analyses are high quality and meet Water Board quality assurance and quality control standards. Data collected in 2011-2012 were Surface Water Ambient Monitoring Program (SWAMP) compliant or qualified, meeting the rigorous criteria established by the SWAMP program. Previous data were analyzed by U.S. EPA (2009) and passed all relevant Quality Assurance (QA) and Quality Control (QC) requirements for that laboratory. The QC samples collected from the 2002-2004 collections were within expected ranges of precision and accuracy for the method (SFEI 2005).

In sum, staff's analysis determined that these water bodies support designated beneficial uses that could be affected by nutrients and for which there are numeric evaluation guidelines.

1.2 Weight of Evidence Approach to Delisting the Napa River

The datasets used to evaluate nutrient impairment in the River are both spatially representative of the watershed and span a decade. Staff compiled nutrient chemistry data from 2002-2004, 2009, and 2011-2012. We developed benthic algae-based lines of evidence using data collected most recently in 2011 and 2012, which represent current conditions in the watershed. Therefore, this dataset meets the spatial and temporal Listing Policy requirements.

We used three lines of evidence (i.e., water column chlorophyll *a*, benthic chlorophyll *a*, benthic percent macroalgae cover) to directly quantify the amount of algae in the stream, in order to determine if the narrative water quality objective for biostimulatory substances (i.e., eutrophication) is currently exceeded. However, because these algae-based metrics are not formally adopted numeric Water Quality Objectives or U.S. EPA Criteria, the binomial distribution approach used in Tables 4.1 or 4.2 of the Listing Policy does not apply (State Water Board 2004). In fact, the evaluation of eutrophic conditions requires the weight of evidence approach because the evaluation process examining a stream's trophic status requires measuring naturally occurring stream organisms (i.e., algae) and determining if the current amount of algae is affecting recreational beneficial uses or water quality parameters that influence aquatic life (e.g., pH and dissolved oxygen). Such an analysis requires the integration of secondary water quality indicators at sites with high algal biomass because the presence of algae alone does not demonstrate that aquatic impacts have occurred.

We developed a total of eight lines of evidence to evaluate the current listing for nutrients in the River (Table 6). We developed three direct lines of evidence (benthic chlorophyll *a*, benthic percent macroalgae cover, and water column chlorophyll *a*) and an indirect line of evidence (pH) using evaluation guidelines provided by Tetra Tech (2006), which showed that the narrative biostimulatory water quality objective was not exceeded. For the eutrophication-based lines of evidence (i.e., chlorophyll *a* and percent macroalgae cover) we collected 16 benthic chlorophyll *a*, 17 macroalgae percent cover, and 40 water column samples. However, these measures are fairly consistent over time, so they take into account water quality conditions for weeks to months around the sample date. The temporally integrative nature of the algal biomass lines of evidence is supported by growth rates of algae, and the minor change in percent algae cover observed across the summer in 2012 at six sites. As a result, we are confident that the weight of evidence approach is appropriate for this analysis. For the four lines of evidence regarding nutrients with direct toxic effects (e.g., un-ionized ammonia, total ammonia, nitrite, and nitrate + nitrite), we used Listing Policy Table 4.1 criteria for toxicants to show that exceedances have been below the maximum number of exceedances allowed to remove a water segment and that municipal, agricultural, and aquatic life beneficial uses were not affected by nutrient toxicity.

The nuisance algae indicators showed that the River is not impaired for nutrients because they had a low rate of exceedance of the applicable guidelines; for those instances, the secondary indicators were not consistently exceeded. Of the samples collected in 2011 and 2012, we observed two (12.5 percent) exceedances for chlorophyll *a* based on the Cold Freshwater Habitat beneficial use threshold of 150 mg/m^2, and two exceedances (11.8 percent) of the percent filamentous cover threshold of 30 percent. At the three sampling locations where we observed exceedances of these evaluation guidelines, the alternate algae indicator and secondary indicators (e.g., pH and dissolved oxygen) showed that potentially impacted beneficial uses were not affected by nutrients.

Following the guidance in 4.11 of the Listing Policy, we propose the following:

- Delist the Napa River water body segment from the River's headwaters to the City of Napa (at Trancas Street) for eutrophication related to nutrients.
- Do not change the original listing for the River from the City of Napa at Trancas Street to the River mouth because this tidal portion of the stream should be evaluated using estuarine-based sampling methods and numeric endpoints. Freshwater standards do not apply to this tidally-influenced reach.

The Water Board is currently developing an assessment framework to evaluate impairment due to nutrients in tidal areas of San Francisco Bay, and, when that process is complete, we expect to collect data to evaluate the tidal portion of the River.

1.3 Weight of Evidence Approach to Delisting Sonoma Creek

The datasets used to evaluate nutrient impairment in the Creek are both spatially representative of the watershed and span a decade. Nutrient chemistry data were collected from 2002 (fall), 2003 (winter, summer), 2004 (spring), 2009 (summer), 2011 (late summer) 2012 (summer, late summer). The benthic algae-based lines of evidence were developed using data collected most recently in late summer of 2011 and 2012 and represent current conditions in the watershed. Therefore, this dataset meets the spatial and temporal Listing Policy requirements (State Water Board 2004).

We used three lines of evidence (i.e., water column chlorophyll *a*, benthic chlorophyll *a*, and benthic percent macroalgae cover) to directly quantify the amount of algae in the stream, in order to determine if the narrative water quality objective for biostimulatory substances (i.e., eutrophication) is currently exceeded. However, because these algae-based metrics are not formally adopted numeric Water Quality Objectives or U.S. EPA Criteria, the binomial distribution approach used in Tables 4.1 or 4.2 of the Listing Policy does not apply (State Water Board 2004). In fact, the evaluation of eutrophic conditions requires the weight of evidence approach because the evaluation process examining a stream's trophic status requires measuring naturally occurring stream organisms (i.e., algae) and determining if the current amount of algae is affecting recreational beneficial uses or water quality parameters that influence aquatic life (e.g., pH and dissolved oxygen). Such an analysis requires the integration of secondary water quality indicators at sites with high algal biomass because the presence of algae alone does not demonstrate that aquatic impacts have occurred.

We developed a total of eight lines of evidence to evaluate the current listing for nutrients in the Creek (Table 13). We developed three direct lines of evidence (benthic chlorophyll *a*, benthic percent macroalgae cover, water column chlorophyll *a*) and an indirect line of evidence (pH) using evaluation guidelines provided by Tetra Tech (2006), which showed that the narrative biostimulatory water quality objective was not exceeded. For the eutrophication-based lines of evidence (i.e., chlorophyll *a* and percent macroalgae cover) we collected 18 benthic chlorophyll *a*, 18 macroalgae percent cover, and 25 water column samples. However, these measures are fairly consistent over time, so they take into account water quality conditions for weeks to months around the sample date. The temporally integrative nature of the algal biomass lines of evidence is supported by growth rates of algae, and the minor change in percent algae cover observed across the summer in 2012 at six sites. As a result, we are confident that the weight of evidence approach is appropriate for this analysis. For the four lines of evidence regarding nutrients with direct toxic effects (i.e., un-ionized ammonia, total ammonia, nitrite, and nitrate + nitrite), we used Listing Policy Table 4.1 criteria for toxicants to show that exceedances have been below the maximum number of exceedances allowed to remove a water segment and that municipal, agricultural, and aquatic life beneficial uses were not affected by nutrient toxicity.

The nuisance algae indicators showed that the Creek is not impaired for nutrients because they had a low rate of exceedance of the applicable guidelines, and for those instances, the secondary indicators were not consistently exceeded. Of the samples collected in 2011 and 2012, we observed one (5.5 percent) exceedance for chlorophyll *a* based on the Cold Freshwater Habitat beneficial use threshold of 150 mg/m^2, and no exceedances of the percent filamentous cover threshold of 30 percent. At the three sampling locations where we observed exceedances of these evaluation guidelines, the alternate algae indicator and secondary indicators (e.g., pH and dissolved oxygen) showed that potentially impacted beneficial uses were not affected by nutrients.

Following the guidance in 4.11 of the Listing Policy, we propose the following:

- Delist the Sonoma Creek water body segment from the Creek's headwaters to Hwy 121 for eutrophication related to nutrients.
- Do not change the original listing for the Creek from Hwy 121 to the Creek mouth because this tidal portion of the stream should be evaluated using estuarine-based sampling methods and numeric endpoints. Freshwater standards do not apply to this tidally-influenced reach.

The Water Board is currently developing an assessment framework to evaluate impairment due to nutrients in tidal areas of San Francisco Bay, and, when that process is complete, we expect to collect data to evaluate the tidal portion of the Creek.

2 Water Quality

2.1 Background on Water Quality Impairments Associated with Nutrients

Water quality impairment from nutrients is usually associated with excess concentrations of nitrogen and phosphorus, as these are usually growth-limiting in freshwaters. The primary consequence of excess nutrients is eutrophication, the stimulation of excessive algae or weedy plant growth. Algae blooms often occur in the form of large floating mats of filamentous algae, but excessive algae can also grow on the stream bottom. Algae blooms can cause severe changes in dissolved oxygen, significantly affecting aquatic life beneficial uses, and certain types of algae (e.g., cyanobacteria) can produce toxins that are harmful to wildlife, domestic animals, and humans. Additionally, nuisance algae levels can impair recreation-based beneficial uses by producing strong decaying odors or preventing suitable swimming or wading conditions. Therefore, understanding the levels and behavior of nitrogen and phosphorus in water bodies is an important step in preventing eutrophic conditions. Reductions in nutrients can be achieved through many actions depending on their sources.

Nitrogen and phosphorus are usually transported to a stream in dissolved and particulate forms. The dissolved inorganic form of phosphorus is orthophosphate, PO_4^{3-} (US Department of Agriculture, 1999), which is the form in which it is most bioavailable in streams. However, most of the phosphorus in the environment is in particulate forms consisting of either phosphate adsorbed on mineral surfaces, or iron, aluminum or calcium phosphate minerals that are relatively insoluble. In natural systems, the sources of orthophosphate are the decomposition of organic phosphorus-containing materials and the release of adsorbed orthophosphate. These two processes are slow compared to normal stream flow. Therefore, the loads of orthophosphate to a stream dictate the impact of this nutrient on algal growth.

Dissolved nitrogen forms include ammonium, nitrate, and nitrite (US Department of Agriculture, 1999). Nitrate is the stable form in streams, so nitrite concentrations are generally lower than nitrate. Nitrate and ammonium are the dissolved nitrogen species that are bioavailable for algal growth. In natural systems, the source of nitrate and ammonium is the decomposition of materials containing organic nitrogen. The decomposition process is slow compared to normal stream flow, and ammonium readily converts to nitrate in surface waters. Therefore, the loads of nitrate usually dictate the impact of nitrogen on algal growth.

Both nitrogen and phosphorus can also occur as dissolved organic ions, which may also be bioavailable. Overall, however, the loadings of nitrate and orthophosphate into a stream determine the potential for eutrophication Tetra Tech 2006).

While high nutrient loads often result in nuisance algae growth, a number of other variables, such as sunlight, water temperature, and stream velocity, also influence the levels of algae observed in water bodies. The complex causes and results of excessive algae growth are described in detail in *Conceptual Approach for Developing Nutrient TMDLs for San Francisco Bay Area Waterbodies* (Water Board 2003).

Many interacting factors determine algae growth rates (Gasith and Resh 1999, Biggs 2000, Dodds 2006). Some of the most important factors are listed below:

- External nutrient loading, which is nutrients entering the stream via surface runoff, groundwater seepage, or precipitation, is the primary source of nutrients for algal growth. The form of nutrients entering the water also affects algal growth rates. Dissolved inorganic nutrients are generally more available to algae and tend to have a greater stimulatory effect on algal growth than organic and particulate forms of nutrients.
- Internal loading can also be a source of nutrients. Internal loading is the release of nutrients stored in the sediment or in decaying biomass back into the water column, where they are again available for algal uptake. However, the rate of biomass decomposition is usually slow compared to surface or ground water inflows carrying nitrate.
- Light is essential for photosynthesis. The shade provided by riparian vegetation can be a major limiting factor on algae growth in streams.
- Stream flow can also influence algal growth. Low flows provide an environment conducive to rising stream water temperature, which can result in increased rates of algal growth. Conversely, extremely high flows inhibit biomass accumulation by detaching algae and transporting it downstream.
- Grazing of algae by benthic macroinvertebrates is important in controlling the accumulation of algal biomass and under some circumstances can prevent excessive algal growth even when nutrient and light conditions are optimal for growth.

All of these factors vary a great deal from location to location, which complicates efforts to predict algae growth and underscores the need to collect site-specific data. Note that the environmental factors that promote algal growth can occur downstream from the source of nutrients, and therefore, the presence of algae does not necessarily indicate a source of nutrients at the area the algae is observed.

Conditions that tend to support eutrophication, such as sufficient light, low flows, and higher temperatures, occur during the dry spring and summer months and act together with dry weather loads of nitrate and orthophosphate to effect algae growth. Loads of nitrate and orthophosphate during the wet winter months rapidly flow out of the watershed to the Bay and do not contribute, or contribute only minimally, to algal growth observed in the spring and summer.

Oxygen depletion is an important effect of excessive algal growth due to its direct negative impact on aquatic life. Most native aquatic organisms found in streams are adapted to high levels of dissolved oxygen, and, when oxygen levels fall, these organisms must either leave the system or die. Factors that consume oxygen in aquatic systems include decomposition, biological oxidation of ammonia to nitrate (nitrification), and respiration. In pristine streams these processes are fairly slow relative to reoxygenation from the atmosphere, and dissolved oxygen levels remain near equilibrium with the atmosphere – that is, near 100 percent saturation. By contrast, excessive nutrient loading can drastically accelerate algal-related oxygen-consuming processes, respiration by living algal cells, and decomposition of dead algal material, causing severe oxygen depletion.

Periphyton (benthic algae) growth in Bay Area streams occurs primarily from late spring though early autumn (Water Board 2012), the period when temperatures and light levels are optimal for algal growth and when scouring high flow conditions are absent. However, this is also often the period of lowest external nutrient loads (Boyer et al. 2006). Loading through surface runoff is low or completely absent in low-rainfall summer months, so external loading occurs almost exclusively through groundwater seepage. Limited loading combined with rapid uptake by the growing mass of algae tends to result in declining nutrient concentrations throughout the summer months. Eventually, nutrient concentrations may become so low that they limit further algal growth. The exact nutrient levels at which algal growth limitation begins to occur vary, but are generally less than 0.5 mg/L for total nitrogen or 0.1 mg/L for total phosphorus (Bowie et al. 1985). In the Napa River and Sonoma Creek watersheds, where nitrogen is typically limiting, nitrate is a significant component of total nitrogen and is one of the most bioavailable forms of nitrogen (SFEI 2005). If nutrient concentrations fall to limiting levels early in the season, only a modest standing crop of algae will be produced; if limiting concentrations do not occur until later, or if nutrient levels remain high all summer, large, problematic quantities of algal biomass may develop (Biggs 2000, Dodds and Welch 2000).

The question of "how much algae is too much" is complex. Numerous sources have proposed quantitative periphyton density targets for western streams based on densities of chlorophyll *a*, a common photosynthetic pigment in freshwater algae (Welch et al. 1988, Dodds et al. 1998, Sosiak 2002). Proposed targets range from 100 to 200 milligrams per square meter (mg/m^2) of benthic chlorophyll *a*. Benthic chlorophyll *a* measures the amount of living plant material growing along the stream bottom (benthos) and includes submerged or floating mats of filamentous algae, if present at the exact sample location. The values represent levels of benthic algae above which recreational or aquatic habitat uses are impaired. In its *Technical Approach to Developing Nutrient Numeric Endpoints for California*, Tetra Tech, Inc. proposed a seasonal maximum impairment threshold of 150 mg/m^2 chlorophyll *a* for Cold Freshwater Habitat California streams (Dodds et al. 1997, Dodds and Welch 2000, Dodds et al. 2002, Tetra Tech 2006). The development of nutrient numeric endpoints is a State Water Board-led effort to develop numeric criteria to evaluate nuisance algae conditions caused by eutrophication.

Even in the absence of consistent quantitative targets, it is still possible to characterize impairment through qualitative or semi-quantitative observation of periphyton densities. It has been reported that the range of quantitative targets mentioned above correlates with approximately 30 percent stream bottom coverage by filamentous algae (Welch et al. 1988, Biggs, 2000, Tetra Tech 2006). While 30 percent filamentous algae cover does not constitute impairment in all situations, coverage levels far in excess clearly represent significant impairment.

The causal relationship between nutrient concentrations and periphyton growth is complex and site-specific. For this reason, definitive nutrient concentration targets have not been developed. However, Tetra Tech has developed modeling tools, calibrated to California data, that can be used to provide provisional screening-level nutrient targets under conditions of slow flow, shallow water depth, adequate sunlight and warmer weather (Tetra Tech, 2006). Based on these modeling tools, screening-level concentrations of 0.150 mg/L nitrogen or 0.0064 mg/L phosphate are predicted to result in less than 150 mg/m^2 chlorophyll *a* under favorable summer conditions (Tetra Tech, 2006).

These nutrient screening levels are generally consistent with proposed benthic algae targets below 150 mg/m^2 (Biggs 2000, Dodds et al. 2002). Note, however, that these screening levels represent the nutrient concentrations supplied for algal growth and not necessarily the stream's water column concentration over time. That is, the most limiting nutrient will be depleted to the maximum extent possible by growing biomass, while other nutrients will only be used until the most limiting nutrient is depleted. In the River and Creek, where nitrogen is typically the limiting nutrient, low nitrate concentrations in summer months can be indicative of either low supply or ongoing algal growth (SFEI 2005).

2.2 Nutrient Sources

Nutrient sources for nitrogen and phosphorus include a variety of anthropogenic activities and natural sources. The Water Board and U.S. EPA classify sources as point or non-point sources, using different regulatory tools to address each source type.

Point sources are those where the discharge to a water body is at a discrete physical location, or point. In contrast, non-point sources are spatially distributed in a catchment or watershed. As an example of a non-point source, pesticides are applied to agricultural fields in a distributed fashion but can then migrate to surface water or groundwater.

The main *non-point sources* of nutrients (especially nitrate) are: onsite wastewater treatment systems (septic systems), grazing lands, confined animal facilities, agriculture/vineyards, wildlife, direct wet and dry atmospheric deposition, and groundwater discharges (Figures 2, 4). The contribution that these sources make to nutrient-related water quality impacts depends heavily on the timing of their delivery to streams and rivers as well as physical conditions such as stream flow, shading, and temperature.

The important *point sources* of nitrate are: municipal wastewater treatment facilities, failing sanitary sewer collection systems, and municipal runoff. These three point source categories discharge little nitrate during the dry season; wastewater treatment plants in these watersheds, for example, recycle their effluent for agricultural use and only discharge to surface waters on the few days when rainfall exceeds recycling capacity. Municipal runoff is similarly low during dry weather. During the wet season when point sources do discharge nitrate, algal growth is minimal due to low temperature and solar radiation as well as the depth and rapidity of flows. As a result, these nutrients are washed out to the Bay and do not contribute significantly to dry weather impairment in freshwater reaches of the River and Creek. Impacts due to elevated nutrients in the Bay, however, are being analyzed as part of the San Francisco Bay Nutrient Numeric Endpoint Development http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/planningtmdls/amendments/estuarynne.shtml.

2.3 Changes in Nutrient Sources

Since the original listings, the relative contributions of these sources have changed. A detailed description of the key changes is provided in Sections 3.1.4 (Napa River) and 4.1.4 (Sonoma Creek).

2.4 Water Quality Criteria

Under the authority of the federal Clean Water Act, the Water Board has established water quality standards for the River and its tributaries. Water quality standards consist of: a) beneficial uses[1] for the water body, b) Water Quality Objectives[2] (numeric or narrative) to protect those beneficial uses, and c) the Antidegradation Policy, which requires the continued maintenance of existing high-quality waters. The Basin Plan specifies beneficial uses for water bodies in the San Francisco Bay Region as well as Water Quality Objectives and implementation measures necessary to protect those uses (Water Board 2013). Beneficial uses designated for the River and its tributaries are listed in Table 1. Table 2 specifically lists the beneficial uses that could be affected by nutrients for which the Water Board has established Water Quality Objectives or for which there are evaluation guidelines to interpret existing objectives. It is important to note that evaluation guidelines are not established Water Quality Objectives, but, rather, are used as guidance to inform consideration as to whether the relevant narrative objectives are being achieved.

A number of nutrient analytes (i.e., total phosphorus, total nitrogen, and orthophosphate) were collected during these various studies but were not analyzed as lines of evidence due to the absence of numeric guidance, or because existing numeric guidance, is unsuitable for this Region. U.S. EPA provided guidance on eutrophication thresholds by setting benchmarks for total nitrogen and total phosphorus for the western United States using the 25^{th} percentile method of available data (US Environmental Protection Agency, 2000a). The numeric guidance for subregion 6, which covers the Napa River watershed, was 0.518 mg/L for total nitrogen (TN) and 0.03 mg/L for total phosphorus (TP). However, nutrient data collected from reference streams (streams with minimal anthropogenic stress in the watershed) within the San Francisco

[1] Synonymous with “designated uses” as used in the CWA.

[2] Synonymous with “water quality criteria” as used in the CWA.

Bay Area showed frequent exceedances of these benchmarks, demonstrating that these may not be suitable criteria for reference conditions in the Bay Area (Water Board 2012). Therefore, in the absence of vetted numeric guidance, TP and TN were not analyzed as lines of evidence for this delisting. The Basin Plan (Water Board 2013) does not provide guidelines for TP, TN, or phosphate (PO_4^{3-}) nor does the California Toxics Rule (US Environmental Protection Agency, 2000b), so this analyte was also not used as a line of evidence.

The State Water Board is initiating the process to develop a nutrient policy for inland surface waters, excluding inland bays and estuaries in California (http://www.waterboards.ca.gov/plans_policies/nutrients.shtml). The State Water Board intends to develop narrative nutrient objectives, with numeric guidance to translate the narrative objectives. This numeric guidance could include the Nutrient Numeric Endpoint (NNE) framework which establishes numeric endpoints based on the response of a water body to nutrient overenrichment (e.g., algal biomass, dissolved oxygen, etc.). Until a statewide policy is in place, regions must analyze eutrophication problems on a case by case basis.

Table 1. Designated Beneficial Uses for the Napa River and Sonoma Creek and potential impairment by nutrients for which there are numeric evaluation guidelines or objectives.

Beneficial uses	Potentially impaired
Agricultural supply (AGR)	X
Cold freshwater habitat (COLD)	X
Fish migration (MIGR)	
Fish spawning (SPWN)	
Municipal and domestic supply (MUN)	X
Navigation (NAV)	
Non-contact water recreation (REC-2)	X
Preservation of rare or endangered species (RARE)	
Warm freshwater habitat (WARM)	X
Water contact recreation (REC-1)	X
Wildlife habitat (WILD)	

In terms of toxicity for drinking water sources, the Basin Plan (Water Board 2013) provides threshold criteria for nitrate plus nitrite ($NO_2^- + NO_3^-$) of 10 mg/L for municipal supply and 5 mg/L for agricultural supply, and 1 mg/L for nitrite (NO_2^-) (Table 2). The national primary drinking water standard for nitrite (NO_2^-) is 1 mg/L and for nitrate (NO_3^-) is 10 mg/L. The Basin Plan specifies an annual median numeric water quality objective for un-ionized ammonia (NH_3), the form of ammonia that is toxic to aquatic life (Water Board 2013). This objective is 0.025 mg/L. No annual measures exceeded this objective. Additionally, the U.S. EPA Office of Water released final guidelines for total ammonia for freshwater to protect aquatic life beneficial uses to address toxicity due to un-ionized ammonia (U.S. Environmental Protection Agency, 2013). U.S. EPA put forward both an acute and a chronic criterion which requires an assessment of total ammonia concentrations along with water pH and temperature because the toxic form of ammonia, the un-ionized fraction, depends on those parameters. Therefore, we compared every observed total ammonia value to the instantaneous total ammonia nitrogen criterion according to the chronic (Criterion Continuous Concentration) formula (U.S. Environmental Protection Agency, 2013, p. 46). Some pH and temperature values were missing from the older datasets, so we used the average pH and temperature values from the current data to fill in missing data. On average, the chronic toxicity criterion was 0.769 mg/L total ammonia and was never exceeded. The acute toxicity criterion is, by definition, higher than the chronic criterion, so it was also never exceeded. The instantaneous chronic criterion was not calculated in this analysis since no sample exceeded the chronic threshold (Table 2).

The Basin Plan's (Water Board 2013) narrative water quality objective for biostimulatory substances states that water bodies "shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses." This objective applies to nutrients, since eutrophication is synonymous with nutrient-induced biostimulation. Nutrient-induced biostimulation, or eutrophication, impairs aquatic habitat uses through broad impacts on the entire biological community. This objective also applies to impairment of recreational uses (primarily through the negative aesthetic effects of excessive algal growth), or aquatic life uses (though the impacts of algae on habitat quality). Three numeric evaluation guidelines were used to evaluate this narrative objective (Table 2).

The biostimulatory substances narrative water quality objective was evaluated using three lines of evidence based on numeric targets related to algal biomass. Tetra Tech modeled the relationships between nutrients and benthic algae cover as described in section 2.1. This effort resulted in statewide numeric guidance, called beneficial use risk category (BURC) thresholds. The first line of evidence is based on chlorophyll *a* for the Cold Freshwater Habitat beneficial use, which is the more protective than the Warm Freshwater Habitat beneficial use. Levels of benthic algae above 150 mg/m^2 are presumed to be impaired for Cold Freshwater Habitat, so this number became the guidance threshold (Table 2). This threshold is supported by regional reference site monitoring in perennial and non-perennial streams, which found high values of up to 100 and 169 mg/m^2 in late summer (Water Board 2012).

The second direct line of evidence related to the biostimulatory narrative objective was based on percent cover of filamentous algae. There is not a clearly established percent cover threshold described by Tetra Tech (2006), but the report references two papers that discussed such thresholds (Appendix 2-4). Biggs (2000) recommended a 30 percent cover by filamentous green or brown algae, which was associated with chlorophyll *a* readings of approximately 120 mg/m^2 in order to protect recreation and fisheries. Additionally, Quinn (1991) used a 40 percent cover threshold to protect recreation and aesthetics. Tetra Tech used 20 percent filamentous cover to set the chlorophyll *a* threshold (Tetra Tech 2006). The method of sampling percent cover according to the SWAMP bioassessment protocol (Fetscher et al. 2009) slightly overestimates the true percent cover because crews often record filamentous algae as present when only a few strands of algae are located at each of the 105 sample points that comprise this metric. The average over-estimate for this method when compared to an area-based visual cover estimate was 7.3 percentage points (SWAMP unpublished data). Therefore, the evaluation guideline based on the SWAMP protocol was set at 30 percent filamentous algae cover (Table 2). The

SWAMP bioassessment protocol involves a visual estimate of percent filamentous algae cover at 11 sections along the stream, but these data were not used in this report. According to this method, the visual percent cover estimates are placed into binned categories of 0, 1-10%, 10-40%, 40-70% and >70% cover, and these bins are averaged over all 11 observations to determine the mean percent cover for the 150 m section of stream. Therefore, the 105 point observations is the most accurate metric collected by SWAMP because the percent visual cover algae binned metric result in reduced data accuracy compared to a numeric observation.

The third direct line of evidence related to the biostimulatory narrative objective the water column chlorophyll *a* metric. Water column chlorophyll *a* measures the amount of algae growing in the water column, which are called phytoplankton. There are no formal criteria for evaluating this indicator, so we relied on an evaluation guideline proposed by the Central Coast Water Board (Central Coast Water Board 2013) of 15 µg/L, which is also the same threshold used by North Carolina to protect trout-supporting (coldwater) water bodies and by Oregon to determine nuisance levels. This concentration was derived by the Central Coast Water Board by investigating sites known to be impacted by nutrients and reference conditions that did not have excessive levels of nutrients.

Table 2. Applicable Water Quality Objectives or Evaluation Guidelines and Associated Beneficial Uses

Beneficial use	Analyte	Water Quality Objective[1]	Evaluation Guideline*	Application of WQO
AG	Nitrate+ Nitrite	5 mg/L		Instantaneous
MUN	Nitrite	1 mg/L		Instantaneous
MUN	Nitrate+ Nitrite	10 mg/L		Instantaneous
WARM, COLD, WILD, RARE	Ammonia, un-ionized	0.025 mg/L		Annual median
WARM, COLD, WILD, RARE	Ammonia, total		0.1-2.8 mg/L [2]	Instantaneous (chronic)
REC-1, REC-2, WARM, COLD	Percent algae cover	Biostimulatory substances narrative	30% filamentous cover [3]	Instantaneous
COLD	Benthic biomass chlorophyll *a*	Biostimulatory substances narrative	BURC II/III boundary < 150 mg/m^2 [4]	Instantaneous
WARM	Benthic biomass chlorophyll *a*	Biostimulatory substances narrative	BURC II/III boundary < 200 mg/m^2 [4]	Instantaneous
WARM	Dissolved Oxygen	5.0 mg/L		Instantaneous
WARM	Dissolved Oxygen		4.0 mg/L [4]	7 day avg of min values
COLD	Dissolved Oxygen	7.0 mg/L		Instantaneous
COLD	Dissolved Oxygen		5.0 mg/L [4]	7 day avg of min values
Generally applicable	pH	6.5 -8.5		Instantaneous
WARM, COLD, WILD, RARE	Water column chlorophyll *a*		15 µg/L [5]	Instantaneous

[1] *The San Francisco Bay Basin (Region 2) Water Quality Control Plan* (Water Board 2013)
[2] *2013 Aquatic Life Ambient Water Quality Criteria For Ammonia* – Freshwater EPA-822-R-13-001 (U.S. Environmental Protection Agency 2013)
[3] *New Zealand periphyton guideline: Detecting, monitoring and managing enrichment of stream.* (Biggs 2000)
[4] *Technical Approach to Develop Nutrient Numeric Endpoints for California*. (Tetra Tech 2006) BURC stands for beneficial use risk categories. These chlorophyll *a* values correspond to the BURC II/III boundary, which represents a threshold above which the risk of beneficial use impairment by nutrients is probable.
[5] Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters (Central Coast Water Board 2010)

*Note: Evaluation Guidelines are used as numeric thresholds when numeric Water Quality Objectives are lacking.

3 Napa River

3.1 Project Definition

3.1.1 Background

In 1976, the Napa River (River) main stem was identified on California's Clean Water Act Section 303(d) List as impaired by excessive levels of nutrients resulting in eutrophication (excessive algal growth). The listing encompassed 57 miles[3] of stream as measured by the National Hydrography Dataset (US Geological Survey 2013) between the River mouth and the top of the watershed (Figure 1). The River lies within the jurisdiction of the Water Board and drains to San Francisco Bay. The original listing largely stemmed from concerns over wastewater treatment plant discharges to the River, particularly during periods of low flow, and from observations of excessive algal growth (Water Board 1975).

The primary effect of excess nutrients on the River is eutrophication (Carpenter et al. 1998); that is, the stimulation of excessive algal growth. Phosphorus and nitrogen are the nutrients usually responsible for eutrophication, as these are usually growth-limiting in uncontaminated surface waters. Eutrophication in Bay Area streams, including the River and neighboring Sonoma Creek, usually takes the form of algae that grow attached to the bottom substrate (periphyton), as opposed to suspended in the water column (phytoplankton). Excessive periphyton growth can smother bottom habitat and depress dissolved oxygen concentrations in bottom gravels and in the water column. Dissolved oxygen is a critical water quality condition that can affect survival of protected salmonids, such as steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*), in these waters. Because the Bay Area has a Mediterranean climate, excessive algal growth is typically a dry season phenomenon that occurs during the summer and early fall months prior to the rainy season.

3.1.2 Proposed Delisting

We are proposing to delist the non-tidal River main stem for nutrient impairment upstream of Trancas Street in the City of Napa (US Army Corps of Engineers 1988), which is 36 miles of stream according to the National Hydrography Dataset (US Geological Survey 2013). The Water Board has observed improvement in water quality conditions in the 30 years since the River was listed as impaired for nutrients. Additionally, in 2006, the State Water Board released draft numeric endpoints for nutrients and other tools to predict acceptable nutrient concentrations (Tetra Tech 2006). These tools allow for numeric review of whether narrative Water Quality Objectives are being met and beneficial uses supported.

This project:

1) Compiled all known existing data related to nutrients and algae growth in the watershed;

[3] The current listing description at the State Water Board website (http://www.waterboards.ca.gov/water_issues/programs/#wqassessment) is for 65 miles but the current stream length measured using the National Hydrography Dataset is 57 miles.

2) Collected additional data on benthic algae in a manner consistent with the State Water Board's nutrient numeric endpoint guidance (Tetra Tech 2006);
3) Created eight lines of evidence to evaluate all relevant available data; and
4) Proposes to refine the nature and scope of the beneficial use impairment in the River based on its findings.

This delisting report does not include a proposal to modify the nutrient listing for the tidal portion of the River because guidelines and standards for such an evaluation do not yet exist. The Water Board is developing a model to understand nutrients in tidal areas of the Bay, and when that process is complete, we plan to evaluate the tidal portion of the River.

3.1.3 Analysis Supporting Delisting

Data allowing us to consider delisting the River for nutrients were collected between 2002 and 2012. This assessment included examination of nuisance algae levels caused by excess nutrients resulting in eutrophication and toxicity resulting from ammonia, nitrate, and nitrite. Eight lines of evidence were produced using the following analytes: ammonia, nitrate, nitrite, benthic chlorophyll *a*, percent macroalgae cover, pH, and water column chlorophyll *a*. Data used to create these lines of evidence were collected by the San Francisco Estuary Institute (SFEI) (2002-2004), Water Board staff (2009), and the Water Board's Surface Water Ambient Monitoring Program (SWAMP) staff (2011-2012). Additionally, continuous monitoring dissolved oxygen data were collected at a subset of sites during the 2011-2012 sampling effort.

New water quality policy and tools to measure and evaluate excess algae levels have allowed staff to conduct a rigorous and standardized analysis of algae levels and water quality conditions in the River. The analysis presented in this report relied on guidance set forth in 2004 by the State Water Board's 303(d) Listing Policy (Listing Policy) in regards to sample size, analysis approach, and data quality assurance (State Water Board 2004). SWAMP recently created standardized sampling methods to quantify algal biomass (Fetscher et al. 2009) and quality assurance and quality control procedures for field crews and laboratories collecting these data (SWAMP 2008). Subsequently, SWAMP staff collected algal biomass and nutrient data from 2011-2012 using these standardized sampling techniques. Algal biomass data were reviewed against the available guidance thresholds (Tetra Tech 2006). Therefore, the current evaluation of water quality standard attainment is more sophisticated and relies on a better dataset compared to analyses that were possible during the original 1976 listing.

Current water quality conditions in the River (2002-2012) show that nutrient-related numeric and narrative Water Quality Objectives are being met and potentially impacted beneficial uses are not negatively affected by nutrients in this water body. The eight lines of evidence did not show exceedances beyond what is specified in the Listing Policy (State Water Board 2004). Therefore, we conclude that water quality conditions have improved since the original listing in 1976. No algae cover data were available from the time of the listing, so a direct comparison between current and past conditions was not possible. However, limited historical nutrient data were available. Nitrate concentrations along River averaged 6.2 mg/L between 1968-1972, yet are now 10 times lower on average in the watershed (mean = 0.6 mg/L).

3.1.4 Rationale for Reduced Algae Growth

The reduction in nuisance algae levels was probably a cumulative effect of NPDES permit restrictions on wastewater discharges, changes in land use in the River's watershed over the past 30 years, and improved agricultural best management practices (BMPs). Few water quality controls were in place before the federal Clean Water Act or the 1975 San Francisco Bay Basin Water Quality Control Plan (Basin Plan) (Water Board 1975). Historical conditions could generally be described as having higher levels of cattle grazing (probably with direct access to streams and tributaries), more dairies and confined animal feeding operations (i.e., milking cows) with limited BMPs, and limited requirements on the 3 non-tidal and 2 tidal wastewater treatment plants. Nutrient loads from these sources have been reduced through activities described below.

The River was identified as having poor water quality conditions and designated as Water Quality Limited in the 1975 Basin Plan (Water Board 1975). The Basin Plan's narrative description of past conditions and sources focused on contributions of biological oxygen demanding substances from agricultural lands and municipal wastewater treatment facilities. This 1975 designation was restated in 1976, when the River was placed on the section 303(d) list of impaired water bodies for nutrients causing eutrophic conditions (State Water Board 1976). Although point source and non-point sources of nutrients were identified in the original listing (Table 3), wastewater treatment plants were considered to be a major contributor of nutrients at the time. However, over the past 30 years, improvements to and changed practices at wastewater treatment plants have significantly reduced discharges and nutrient impacts in discharges to the River.

By the 1980s, NPDES permits issued by the Water Board to municipal wastewater treatment plants included specific language prohibiting discharge during the "dry season," when the minimum 10:1 river water to discharge dilution ratio could not be achieved as dictated by the 1982 Basin Plan (Water Board 1982).[4] This discharge prohibition significantly reduced nutrient loading into the River at a time when flows are naturally low because of the summer drought occurring in this Region's Mediterranean climate. With the prohibition, wastewater treatment plants in these watersheds generally store or recycle 100 percent of their discharge during the dry season, and employ those same techniques during the wet season when the 10:1 ratio cannot be achieved. This has resulted in no dry season discharges to the River, and only occasional discharges during the rainy season, when the impacts of nutrient discharges are limited because environmental conditions result in very limited algal growth and rapid flushing of nutrients into the Bay. Current NPDES permits require dilution ratios of up to 50:1, so treatment plants are discharging even less frequently into the River during the winter season. Additionally, over the past 30 years, the three plants that discharge to the non-tidal River reach (Calistoga, St. Helena, and Yountville) have improved treatment BMPs or added treatment technologies to reduce nitrogen inputs.

Shifts in agriculture practices likely have also played a role in reducing nutrient loads to the River. Guidance provided by the U.S. Department of Agriculture National Resources

[4] The exact dates of the dry season varied slightly in each permit, but it was generally from May 1 – October 31.

Conservation Service and by local Resource Conservation Districts has improved agricultural BMPs for grazing animals and confined animal facilities. Examples include the development of Farm Conservation Plans, Nutrient Management Plans, Waste Management Systems, and Ranch Water Quality Control Plans (reviewed in Lewis et al. 2011). The implementation of such plans in the San Francisco Bay Region has resulted in fewer nutrient inputs and less sediment erosion into water bodies (Larson et al. 2005, Lewis et al. 2011). Additionally, crop reports produced by the Napa County Agricultural Commissioner show that cattle and calf production decreased tenfold from 247,000 centum weight (CWT) in 1970 to 27,188 CWT in 2011 (http://www.countyofnapa.org/AgCommissioner/CropReport/). CWT is a measure of weight in 100-lb units. Decreased production of cattle occurred because of reductions in cattle on rangelands and a reduction in number of confined animal facilities. In fact, no dairy confined animal facilities were identified in this watershed under actions of the 2003 waiver of waste discharge requirements for confined animal facilities (Resolution No. R2-2003-0094).

Since the 1970s, vineyard acreage has increased in the Napa Valley to 43,581 from 14,597 acres (http://www.countyofnapa.org/AgCommissioner/CropReport/), an increase of about 45 square miles. However, nutrient addition to vineyards is low (Rosenstock et al. 2013), and a portion of the vineyard acreage increase was conversion from other agricultural land uses with greater potential to contribute nutrients to the River. Additionally, there are active watershed programs to reduce the water quality impacts from vineyards. In 2002, the Napa Valley Vintners Association, the Napa County Grapegrowers Association, and the Napa County Farm Bureau brought the Fish Friendly Farming program to Napa County (http://www.fishfriendlyfarming.org/). This program teaches the use of sediment control and bank stabilization BMPs, efforts that will also reduce sediment bound nutrients from entering the streams. About a third of acreage currently planted in vineyards has been certified under the Fish Friendly Farming program.

We did not find evidence of significant changes to physical conditions in the watershed that were likely to facilitate algae blooms. For example, increases in water temperature, decreases in water depth, decreases in riparian shade, and decreases in stream flow can increase algae growth. An analysis of annual steam flow between 1960 and 2010 from two U.S. Geological Survey stations along the River showed no consistent change over time. The U.S. Geological Survey did not collect temperature data over the same time period, so a historical temperature analysis could not be performed. A historical ecology analysis of the Napa Valley found that from the 1940s to now, riparian shade has increased significantly (Grossinger 2012).

Table 3. 1976 EPA 303(d) listing information for the Napa River related to nutrients and eutrophic conditions.

Segment name & description	Beneficial uses evaluated*	Objective violated	Source
Napa River main stem	WARM, COLD, MUN, AG, REC-1, REC-2	Nutrients resulting in eutrophication	Point and non-point sources

*The original 1976 listing included WARM, SPWN, MIGR, and REC-1 as the beneficial uses affected. The beneficial uses noted in this table are for uses currently applied to this water body with numeric Water Quality Objectives or evaluation guidelines. Beneficial Use designations are described in Table 1.

3.2 Watershed Description

The Napa River watershed is located in the California Coast Ranges north of San Pablo Bay (Figure 1) and covers an area of approximately 426 square miles (1,103 square kilometers). The main stem of the River flows approximately 57 miles in a southeasterly direction though the Napa Valley before discharging to San Pablo Bay. Although the original listing only focused on the River main stem, numerous tributaries enter the main stem from the mountains that rise abruptly on both sides of the valley. In this report, the terms "Napa River" and "River" refer to the main stem of the River as well as its tributaries within the Napa River watershed. Combined, the River main stem and tributaries are over 464 miles long. We conducted a watershed-based water quality assessment, examining conditions in both the tributaries and the main stem. The results of this assessment and subsequent lines of evidence are discussed in Section 3.3.

This watershed has a Mediterranean climate with warm, dry summers and cool, wet winters (Gasith and Resh, 1999). Average annual rainfall ranges from 25 to 38 inches in the Napa Valley, and the large majority of rainfall occurs from November through April, with the heaviest rainfall occurring from December through February (Gilliam 2002). This rainfall regime results in two distinct seasons in the watershed. During the winter wet season, stream flow and pollutant loading are dominated by precipitation-driven surface runoff. In contrast, during the dry summer months, groundwater inflow and minor runoff from watershed activities are dominant. Major land cover types in the watershed are forest (38 percent), grassland/rangeland (18 percent), and agriculture (20 percent). Approximately two-thirds of agricultural land is in vineyards (16 percent of total area). Developed land (e.g., residential, industrial, and commercial) accounts for approximately 16.5 percent of the watershed (Association of Bay Area Governments 2006, Table 4). The population of the Napa River watershed is 238,660.

Table 4. Land use in the Napa River watershed.

Land use*	Percentage of watershed
Forest / Open Space	38.2%
Rangeland	18.1%
Agriculture-vineyard*	16.2%
Agriculture other	3.4%
Urban-Residential	7.7%
Urban-Commercial & Industrial	2.9%
Urban-Open	2.0%
Urban-Other	3.8%
Water & Wetlands	7.6%

*Land use from Association of Bay Area Governments (2006) except vineyard area from Napa County Agriculture layer from 2007 (http://gis.napa.ca.gov/giscatalog/catalog.asp).

3.3 Water Quality Data

3.3.1 Data quality

Data to support this delisting were collected over multiple years (2002-2012) by different sampling crews and analyzed by multiple laboratories (Table 5). All data used as lines of evidence are considered to be high quality. Data collected from 2011-2012 are either SWAMP-compliant or qualified as determined by the SWAMP Quality Assurance Program Plan (2008). Data collected from 2009 were analyzed by a U.S. EPA lab, so these samples underwent the QC testing required of U.S. EPA labs. Nutrient data collected from 2002-2004 were analyzed for precision and accuracy. Laboratory duplicate samples showed a precision range of < 30 percent, which we consider to be of acceptable quality because it is just above SWAMP guidance of a relative percent difference of 25 percent (SWAMP 2008, 2013). One chlorophyll *a* result was removed from the analysis due to a spurious result. The result was over 500 mg/m^2, which was the second highest reading in the SWAMP databases for chlorophyll *a* when compared against 2000 samples throughout California, and was found at a stream with no filamentous algae. This reading cannot be accurate for a site that lacked filamentous algae and did not have high levels of microalgae (diatoms). Rejection of this data point was approved by the SWAMP Quality Assurance Team. For 2002-2004 pH data, SFEI did not produce a Sampling and Analysis Plan or Quality Assurance Project Plan that could confirm the reliability of the equipment used, pH standards, number of points used for calibration, adequate frequencies pre- and post-measurement calibrations, and established measurement quality objectives for drift. For these reasons, we determined these data to be unusable for the pH line of evidence analysis.

3.3.2 Lines of evidence

Four lines of evidence support removing the original listing for eutrophication and four lines of evidence show that nutrient toxicity is not present (Table 6).

3.3.2.a Eutrophication

Three direct lines of evidence for biostimulation of algae and a fourth indirect line of evidence demonstrate that Water Quality Objectives are not exceeded and designated beneficial uses are supported. The three direct lines of evidence are algal biomass indicators represented by benthic chlorophyll *a* and percent macroalgae cover (attached + unattached) collected using the SWAMP Bioassessment protocol (Ode 2007, Fetscher et al. 2009), and water column chlorophyll *a*.

The direct benthic chlorophyll *a* line of evidence showed two exceedances of evaluation guidelines out of 16 samples collected over two years. Likewise, we recorded only two exceedances for percent macroalgae cover out of 17 samples collected across two years. The proportion of exceedances in this study (≤12.5 percent) is within acceptable proportions discussed in the Listing Policy. Relatively fewer data points are available for the algae mass indicators compared to water column chemistry measures (e.g., ammonia, nitrate, and nitrite) because they are more expensive and time consuming to collect. However, fewer data points are necessary to evaluate overall water quality conditions because they are seasonally integrative measures. A single data point represents weeks to months of water quality conditions.

Table 5. Data summary for delisting.

Year	Seasons	Sampling crew	Laboratory	Analytes
2002	October	SFEI	Romberg Tiburon Center	ammonia, nitrite, nitrate+nitrite, total dissolved nitrogen, total dissolved phosphorus, & orthophosphate.
2003	January, July	SFEI	Romberg Tiburon Center	ammonia, nitrite, nitrate+nitrite, total dissolved nitrogen, total dissolved phosphorus, & orthophosphate.
2004	May	SFEI	Romberg Tiburon Center	ammonia, nitrite, nitrate+nitrite, total dissolved nitrogen, total dissolved phosphorus, andorthophosphate.
2009	July	Water Board Staff	EPA Region 9 Lab	ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphorus, & orthophosphate.
2011	August-September	Water Board Staff	Delta Environmental Laboratories, DFW Water Pollution Control Laboratory	ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphorus, orthophosphate, benthic Chl-a, & percent macroalgae cover (field).
2012	June, August-September	Water Board Staff	Delta Environmental Laboratories, DFW Water Pollution Control Laboratory	ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphorus, orthophosphate, benthic Chl-a, & percent macroalgae cover (field).

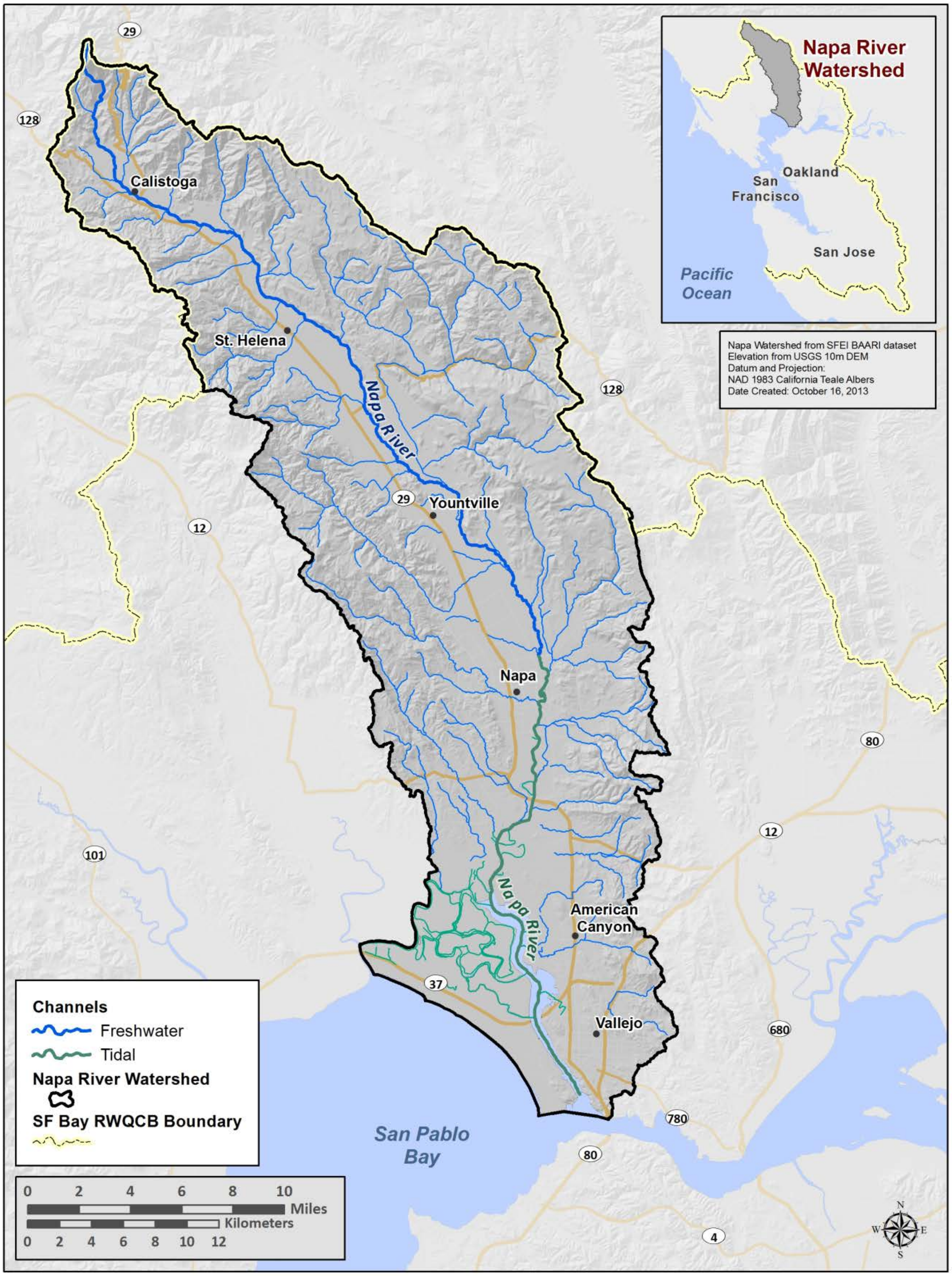

Figure 1. Map of the Napa River watershed.

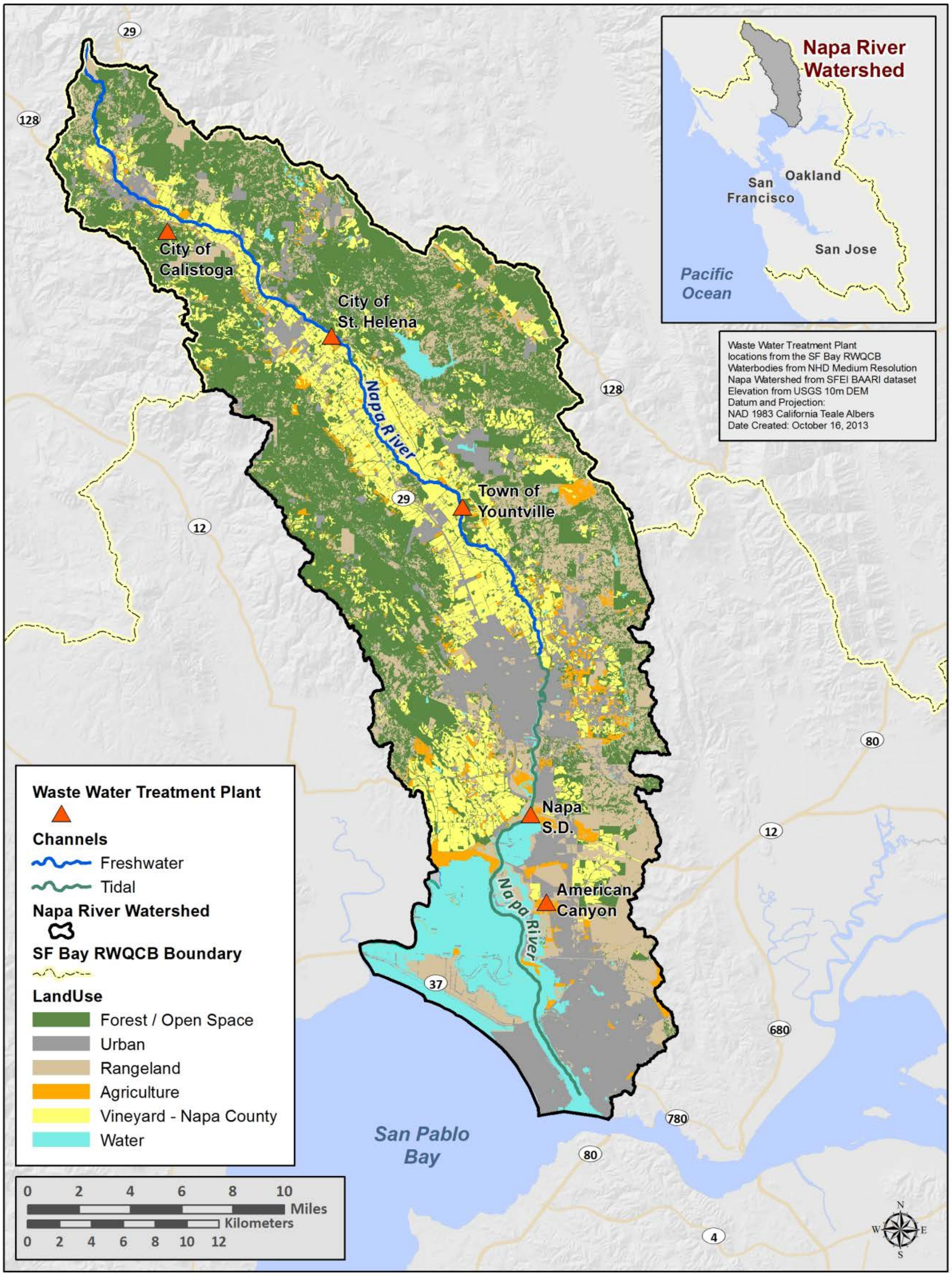

Figure 2. Map of land use and potential nutrient sources in the Napa River watershed.

Table 6. Napa River Summary of Lines of Evidence and exceedances of Evaluation Guidelines

LOE	Analyte	Numeric Evaluation Guideline	Number of exceedances	Numeric metric	Listing factor
1	Benthic biomass chlorophyll *a*	< 150 mg/m^2	2/16	Evaluation Guideline	4.11 weight of evidence
2	Percent macroalgae cover [a]	30%	2/17	Evaluation Guideline	4.11 weight of evidence
3	Nitrite	1 mg/L	0/120	Water Quality Objective	4.1 toxicant
4	Nitrate+ Nitrite	10 mg/L	0/120	Water Quality Objective	4.1 toxicant
5	Ammonia, un-ionized	0.025 mg/L	0/6 [b]	Water Quality Objective	4.1 toxicant
6	Ammonia, total	0.1-2.8 mg/L	0/120	U.S. EPA Criterion	4.1 toxicant
7	pH [c]	6.5-8.5 units	0/27	Water Quality Objective	4.1 toxicant
8	Water column chlorophyll *a*	15 µg/L	1/40	Evaluation Guideline	4.11 weight of evidence

[a] metric calculated from the SWAMP bioassessment protocol from 105 observations along a 150 m section of stream.
[b]120 unique samples analyzed by year.
[c] Only pH data collected using the SWAMP QAPrP were incorporated into this assessment.

Table 7. Napa River water quality parameters at the two sites with chlorophyll *a* algae exceedances listed in LOE 1 in Table 6

Sample site	Year	Season	Benthic chlorophyll *a*	% Macroalgae cover	% Riparian cover	Dissolved oxygen median (mg/L)
N-09	2011	Late summer	162 mg/m^2	58.1	74	7.33
N-09	2012	Late summer	42 mg/m^2	45.7	65	6.40
N-55	2012	Late summer	161 mg/m^2	6.7	41	2.87

Chlorophyll *a* in the water column was collected by SFEI in 2002 and 2003 and showed few exceedances. A total of 1 of 40 samples exceeded the 15 µg/L evaluation guideline. Therefore, this line of evidence does not support impairment according to the biostimulatory objective.

At the two sites with exceedances of the chlorophyll *a* evaluation guideline (N-09 and N-55), other algal biomass or eutrophication indicators did not demonstrate a consistent problem (Table 7). For example, in 2011 the N-09 benthic chlorophyll *a* level of 162 mg/m^2 was slightly above the 150 mg/m^2 guideline for the Cold Freshwater Habitat beneficial use (although still below the 200 mg/m^2 guideline for Warm Freshwater Habitat), yet chlorophyll *a* data from the following year (2012) was well below the threshold. However, the percent macroalgae cover (based on 105 sample points along a 150 m section of stream) was consistently high in both years. Secondary indicators at N-09, such as continuously monitored dissolved oxygen, showed that water quality conditions were adequate for aquatic life uses (both cold water and warm water uses) based on guidance from Tetra Tech (2006). Also the strong daily (diel) swing of dissolved oxygen, which occurs in severely eutrophic waters, was not observed, nor were highly oxygenated water above 13 mg/L observed. Fisheries population data from the Napa Resource Conservation District shows that populations of steelhead trout and Chinook salmon continue to be supported by this watershed (Koehler and Blank 2013). Recent surveys identify steelhead redds and surviving smolts, which provides support that the overall watershed supports conditions necessary for multiple life stages (Koehler and Blank 2013). This reach continues to support both Human Contact and Non-contact beneficial uses as it is accessible to the public and frequently visited. The geomorphology of the stream reach is a wide, braided channel, so there is less shading from tall upland trees compared to other portions of the River where the stream is incised or has been partially channelized. In sum, the weight of evidence at this site does not indicate an exceedance of the narrative biostimulatory objective at this location.

The second site with a chlorophyll *a* exceedance was N-55. Similar to the other site, the chlorophyll *a* value was just above the 150 mg/m^2 threshold for Cold Freshwater Habitat, but was below the 200 mg/m^2 threshold for Warm Freshwater Habitat. This site was only sampled once, so it is not possible to compare this parameter over time. However, the percent macroalgae cover (7 percent) observed at the same time as chlorophyll *a* sampling was well below the evaluation guideline of 30 percent. Dissolved oxygen concentrations at this site were far below the minimum thresholds listed in the Tetra Tech guidance (2006), but daily variation in dissolved oxygen levels were generally 4-5 mg/L, which is within the range observed in non-eutrophic reference streams (Water Board 2012, raw data). The River at this location was deep and wide (1-2 m depth by 9 m width) with very little flow (< 1 cubic feet per second). Under such conditions, the stream water did not mix, so it resembled conditions from a pond (lentic) rather than a stream (lotic). A restoration project at this site removed the riparian vegetation on the right bank in order to lower the floodplain and increase flood protection, which might have temporarily allowed more light to reach the stream. Over time the restored riparian community will provide more shade for this reach, reducing temperatures and decreasing the potential for nuisance algae conditions. In sum, the weight of evidence at this site does not indicate an exceedance of the narrative biostimulatory objective at this site.

3.3.2.b Toxicity

Four lines of evidence show the River water quality is not toxic to human or wildlife and that beneficial uses are supported. Although the River is not listed for nutrient-related toxicity, we compiled existing data and collected new data to confirm that waters were not toxic to wildlife or humans. The water quality data were below appropriate drinking water quality standards for nitrate and nitrite (Table 6), so municipal drinking water beneficial uses were supported. In addition, the waters were not toxic to wildlife as indicated by new criteria for total ammonia recently published by U.S. EPA (2013) so aquatic life beneficial uses were supported (Table 6). The number of samples for nitrite, nitrate and ammonia meet the minimum sample sizes (n > 28) from Table 4.1 in the Listing Policy (State Water Board 2004).

3.3.3 Spatial variation

The nutrient data to support this analysis were collected throughout the River's watershed (Figure 3). The sample locations were along the main stem and in tributaries of varying stream orders. Perennial streams compose the majority of the sample locations because they have water during the summer when algae growth peaks, but a handful of non-perennial streams were monitored as well. Collections of algae cover and benthic chlorophyll *a* from 2011-2012 could be completed only from the wadeable sections of the main stem where the depth was 1m or less during the summer. This prohibited measurements on the main stem below Yountville, preventing quantification of algal biomass in the lower 9 miles of the non-tidal main stem.

Although the lowest 21 miles of the main stem were included in the original 303(d) listing as being impaired by nutrients, this section is tidally influenced and was not assessed in this report because freshwater Water Quality Objectives and numeric guidance do not apply to this segment. At present the Water Board could not identify any relevant data or appropriate guidelines to evaluate the biostimulatory substances narrative in the tidal portion of the River. Therefore, this segment was excluded from analysis in this delisting (Figure 1). The Water Board plans to reassess this listing in the tidal Napa River subsequent to the conclusion of the San Francisco Bay numeric nutrient endpoint project. That work is expected to generate guidelines/standards for identifying nutrient impairment in brackish and salt waters.

3.3.4 Temporal variation

Neither inter-annual (between years) nor intra-annual (across seasons) variability strongly affected the nutrient results. A previous analysis of water chemistry in the Napa watershed showed small differences in nutrient concentrations across seasons (SFEI 2005). The River met applicable toxicity Water Quality Objectives and evaluation guidelines for nutrients in all seasons and across all years. Nutrient concentrations did not substantially differ across the dry season. For example, in 2012 nutrient concentrations collected in June were only slightly higher than samples from August and September.

Similarly, Napa River benthic algal biomass did not exhibit significant temporal variation during the study period. In 2011 and 2012 algal biomass was collected only once in the late dry season (August – September), when maximum algal biomass was expected based on the Mediterranean climate and previously collected data in our Region. Increasing summer temperatures and decreased stream flow generally lead to maximal algae growth during that time frame before temperatures cool and early winter rains in October and November scour the stream bed, reducing the standing crop of benthic algae. Reference stream monitoring by SWAMP demonstrated that algal biomass can change substantially throughout a season and was greatest during in August and September (Water Board 2012). For example, benthic algal biomass measured using chlorophyll *a* at 3 perennial streams with minimal human disturbance increased from an average of 25 mg/m^2 in April/May to 37 mg/m^2 in June/July to 51 mg/m^2 in August/September. Maximum benthic algae chlorophyll *a* results from that study were 100 mg/m^2 for a perennial stream and 169 mg/m^2 in a non-perennial stream, which generally reinforce Tetra Tech's 150 and 200 mg/m^2 chlorophyll *a* thresholds for COLD and WARM, respectively (Tetra Tech 2006).

Benthic algal biomass indicators from the current monitoring effort did not change significantly between 2011 and 2012. Although chlorophyll *a* was nearly the same (Figure 4), and benthic algae measured using percent macroalgae cover was just slightly significantly higher in 2011 (Figure 5). However, some intra-annual variation was observed in percent cover measurements that were collected by estimating algae cover approximately once a month for three months in 2012. Two stream reaches showed some changes in observed percent cover. N-09 increased from 31 percent to 46 percent to 61 percent, showing increased growth throughout the dry season. N-55 in contrast showed a slight decrease in percent cover over time from 7 percent to 0 percent a month later.

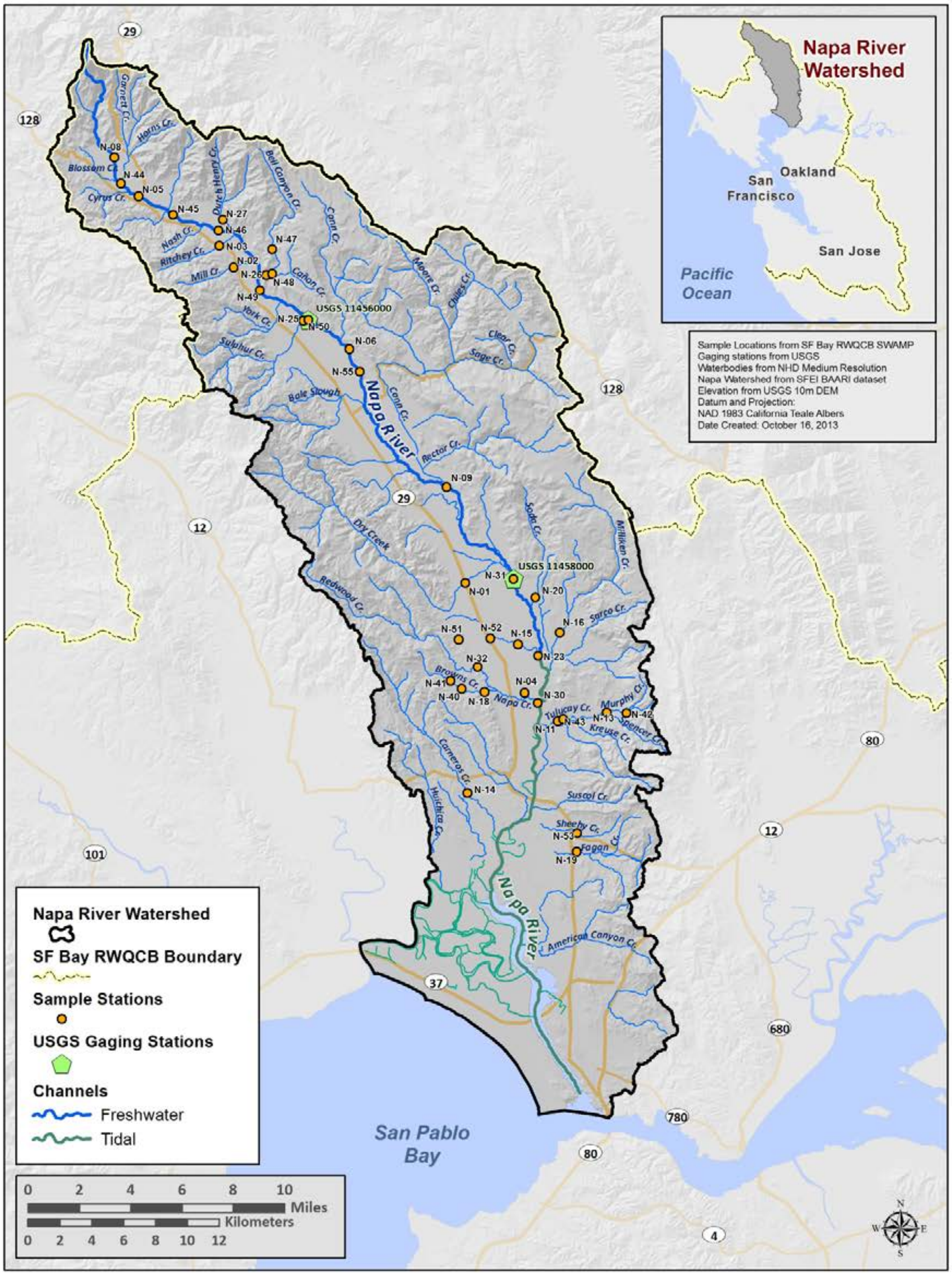

Figure 3. Map of all sample stations within the Napa River watershed. Precise sample locations can be seen in Table 9.

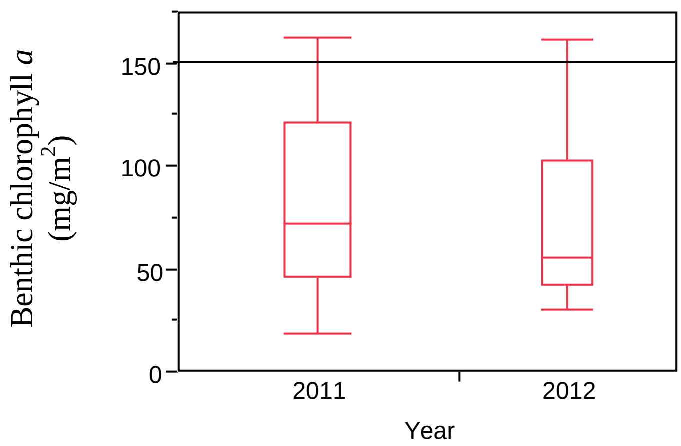

Figure 4. Box plot of benthic algae chlorophyll *a* levels in Napa River for 2011 and 2012. The evaluation guideline is 150 mg/m^2. The box plots represent the 25^{th} to 75^{th} percentiles and the whiskers represent the 10^{th} and 90^{th} percentiles. The line in the middle of the box shows the median observed value.

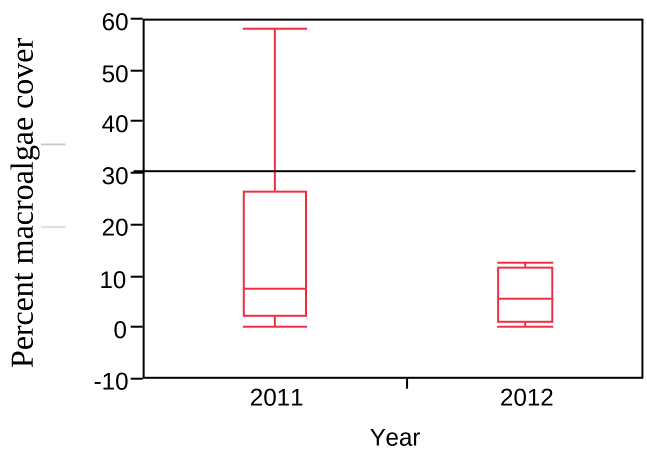

Figure 5. Box plot of benthic algae percent macroalgae cover levels in Napa River for 2011 and 2012. The evaluation guideline is 30 percent cover. Box plots represent the 25^{th} to 75^{th} percentiles and the whiskers represent the 10^{th} and 90^{th} percentiles. The line in the middle of the box shows the median observed value.

3.4 Flow Data

This report does not rely on flow data to evaluate the eight lines of evidence. However, two U.S. Geological Survey stations are present in the watershed, and data from 1960 – 2012 were analyzed to examine long-term flow trends (http://waterdata.usgs.gov/usa/nwis/rt; Table 8). Between 1960 and 2010, the average annual flow in cubic feet per second (cfs) did not show a consistent increase or decrease in flow over time (linear regression, slope < 1 cfs/year). Stream gage data confirmed the River's strong seasonality, with winter base flows ranging from 50-100 cfs and decreasing to 0-10 cfs in summer. Storm flows were 10-100 times winter base flows and surpassed 10,000 cfs. Flow (instantaneous) was measured at all sample locations during the late dry season in 2011 and 2012 (Table 9). These August and September flows were generally low (mean = 1.37 cfs) and ranged from 0.02 to 6.56 cfs. In general, tributaries carried less flow than the main stem.

Table 8. US Geological Survey flow monitoring information in Napa River.

Station information	GPS location	Period of record	Sampling frequency*
USGS 11458000 NAPA R NR NAPA CA	38.368333 -122.302222	1960-2012	Annual average
USGS 11456000 NAPA R NR ST HELENA CA	38.511389 -122.454722	1930-2012	Annual average

*Sampling frequency currently every 15 minutes, but annual flow average was used to determine potential flow changes over time.

3.5 Habitat Quality Data

Water Board staff collected physical habitat conditions in 2011 and 2012 according to the bioassessment protocol. The environmental variables most related to eutrophication are shade, stream temperature, and depth. In general, Napa streams are well shaded; the mean densiometer reading of canopy cover over the stream was 71 percent. Temperature readings during the late morning hours between 9 and 11 AM averaged 16.8°C (they ranged from 14.4 - 21.8°C). The average reach-wide depth at all sampling locations was 0.25 m. Overall, streams within Napa are well-shaded, but locations with open canopy, warmer temperatures, and shallow waters are more likely to produce algae blooms.

3.6 Data Analysis Summary

The three direct lines of evidence based on algal biomass (benthic chlorophyll *a*, water column chlorophyll *a*, and percent macroalgae cover) show the narrative water quality objective in the Basin Plan for biostimulatory substances was not exceeded (Table 6, 10, Water Board 2013). At the two sites with high algae levels (N-09 and N-55), secondary indicators of eutrophication (i.e., pH and dissolved oxygen) were not symptomatic of eutrophication. Most portions of the Napa River are well shaded (mean densiometer readings = 71 percent), and current levels of shade are important for preventing algae blooms. Four lines of evidence show that waters are not toxic to humans or wildlife, thus nutrients are not having a direct environmental impact on beneficial uses. No significant seasonal or inter-annual changes in water quality were observed that would affect this recommendation for delisting. This analysis supports delisting the Napa River non-tidal reach.

Table 9. Inventory of water quality monitoring stations in Napa River watershed

Station	Description	Latitude	Longitude	Sampling events							
				Oct 2002	Jan 2003	July 2003	May 2004	July 2009	Aug/Sept 2011	June 2012	Aug/Sept 2012
N-01	Dry Ck. @ Railroad Bridge	38.36500	-122.33813		x	x					
N-02	Mill Ck. @ the old Bale Mill	38.53992	-122.51067	x	x	x			x	x	x
N-03	Ritchey Ck. nr. Ranger Station	38.55175	-122.52124	x	x	x		x	x	x	x
N-04	Napa Ck. @ Jefferson	38.30054	-122.29339	x	x	x	x	x			
N-05	Napa R. @ Calistoga Community Center	38.57876	-122.58044	x	x	x	x	x			
N-06	Napa R. @ Zinfandel Lane	38.49549	-122.42560	x	x	x	x	x	x	x	x
N-08	Napa R. @ Tubbs Lane	38.60040	-122.59892		x	x					
N-09	Napa R. @ Yountville Ecopreserve	38.41890	-122.35326	x	x	x		x	x	x	x
N-11	Tulukay Ck. @ Terrace Court (close to N 44)	38.28852	-122.26935		x	x	x		x	x	x
N-13	Murphy Ck. @ "Stone Bridge" on Coombsville Road	38.29389	-122.23418	x	x	x	x	x			
N-14	Carneros Ck. @ Withers	38.24648	-122.33288		x	x					
N-15	Salvadore channel @ Garfield Park	38.33119	-122.29916	x	x	x	x				
N-16	Milliken Ck. @ Hedgeside Avenue	38.33827	-122.26945	x	x	x					
N-18	Brown Valley Ck. @ "Little Stone Bridge"	38.30389	-122.32224	x	x	x	x	x			
N-19	Fagan Ck. @ Kelly Rd.	38.21495	-122.25325	x	x	x					
N-20	Soda Ck. @ Silverado Trail	38.35792	-122.28727		x						
N-23	Napa R. @ Trancas St.	38.32508	-122.28435	x	x	x					
N-25	Sulphur Ck. @ Lower Bridge near Trailer Park	38.51083	-122.45929	x	x	x					
N-26	Bell Canyon Ck. @ Silverado	38.53617	-122.48703	x	x	x	x	x			
N-27	Dutch Henry Ck. @ Larkmead Lane Bridge	38.56665	-122.51919		x						
N-30	Napa R. @ 3rd St.	38.29818	-122.28370	x	x	x					
N-31	Napa R. @ Oak Knoll Ave.	38.36795	-122.30347	x	x	x				x	
N-32	Redwood Ck. @ Redwood Road	38.31785	-122.32750		x	x			x	x	
N-40	Browns Valley Ck. @ Buhman Ave.	38.30528	-122.33877				x	x			
N-41	Browns Valley Ck. @ Morningside Dr.	38.30957	-122.34670				x				
N-42	Murphy Ck. @ Shadybrook Ln.	38.29388	-122.21987				x	x			
N-43	Tulukay Ck. @ Shurtleff Ave. (close to N11)	38.28970	-122.26532				x				
N-44	Napa R. @ Heather Oaks Park	38.58567	-122.59333				x				
N-45	Napa R. @ Dunaweal Ln.	38.56873	-122.55527				x		x	x	x
N-46	Napa R. @ Larkmead Ln.	38.56057	-122.52203				x				

Station	Description	Latitude	Longitude	Sampling events							
				Oct 2002	Jan 2003	July 2003	May 2004	July 2009	Aug/Sept 2011	June 2012	Aug/Sept 2012
N-47	Bell Canyon Ck. @ Crystal Springs Rd.	38.55053	-122.48308				x				
N-48	Canon Ck. @322 Glass Mountain Rd.	38.53702	-122.48267				x				
N-49	Napa R. @ Lodi Ln.	38.52727	-122.49108				x				
N-50	Napa R. @ Pope St. Saint Helena	38.51137	-122.45567				x		x	x	
N-51	Salvadore Channel @ 2280 Dry Ck. Rd.	38.33307	-122.34195				x				
N-52	Salvadore Channel @ 121 near school	38.33423	-122.31901				x	x	x	x	x
N-53	Shehey Creek @ N Kelly Road & Executive way (Sh-1)	38.22540	-122.25320					x			
N-55	Napa River at Frogs Leap	38.48287	-122.41758								x
	Total number of samples			16	23	21	21	12	9	10	8

Table 10. Napa River water quality summary

	Years of collection	Seasons	No. of samples	Bench-mark	Units	Mean	25th	Median	75th	Number of exceedances
Chlorophyll *a*	2011, 2012	Summer/ early fall	16	150	mg/m^2	77	43	62	107	**2/16**
Percent macroalgae cover	2011, 2012	Summer/ early fall	17	30	%	13	2	7	18	**2/17**
Ammonia, total	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	120	0.26	mg/L	0.028	0.007	0.013	0.041	**0/120**
Ammonia, unionized	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	6	0.025	mg/L	0.0012	0.0004	0.0009	0.0019	**0/6**
Nitrate	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	120	n/a	mg/L	0.600	0.095	0.348	0.859	**0/120**
Nitrite	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	120	1	mg/L	0.008	0.001	0.002	0.006	**0/120**
Nitrite+ nitrate	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	120	10	mg/L	0.608	0.098	0.349	0.884	**0/120**
Total nitrogen	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	120	n/a	mg/L	0.97	0.40	0.68	1.24	**n/a**
Ortho-phosphate	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	120	n/a	mg/L	0.072	0.022	0.049	0.086	**n/a**
Total phosphorus	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	116	n/a	mg/L	0.07	0.04	0.07	0.09	**n/a**

4 Sonoma Creek

4.1 Project Definition

4.1.1 Background

In 1986, the Sonoma Creek (Creek) main stem was identified on California's Clean Water Act Section 303(d) List as impaired by excessive levels of nutrients, resulting in eutrophication (excessive algal growth). In this report, the terms "Sonoma Creek" and "Creek" refer to the main stem of the Creek as well as to its tributaries within the Sonoma watershed. The listing encompassed 33 miles[5] of stream length as measured by the National Hydrography Dataset (U.S. Geological Survey 2013) between the Creek mouth and the top of the watershed (Figure 6). The Creek lies within the jurisdiction of the Water Board and drains to San Pablo Bay, a portion of the San Francisco Bay. The original listing largely stemmed from concerns over domestic wastewater treatment plant discharges to the creek, particularly during periods of low flow, and from observations of excessive algal growth.

The primary effect of excess nutrients on the Creek is eutrophication (Carpenter et al. 1998); that is, the stimulation of excessive algal growth. Phosphorus and nitrogen are the nutrients usually responsible for eutrophication, as these are usually growth-limiting in uncontaminated surface waters. Eutrophication in Bay Area streams, including the Creek and neighboring Napa River, usually takes the form of algae that grow attached to the bottom substrate (periphyton), as opposed to suspended in the water column (phytoplankton). Excessive periphyton growth can smother bottom habitat and depress dissolved oxygen concentrations in bottom gravels and in the water column. Dissolved oxygen is a critical water quality condition that can affect survival of protected salmonids, such as steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*), in these waters. Because the Bay Area has a Mediterranean climate, excessive algal growth is typically a dry season phenomenon that occurs during the summer and early fall months prior to the rainy season.

4.1.2 Proposed Delisting

We are proposing to delist the non-tidal Creek main stem for nutrient impairment upstream from Hwy 121 (SFEI), which totals 23 miles of stream length according to the National Hydrography Dataset (U.S. Geological Survey 2013). The Water Board has observed general improvement in water quality conditions in the 30 years since the Creek was listed as impaired for nutrients. Additionally, in 2006, the State Water Board released draft numeric endpoints for nutrients and other tools to predict acceptable nutrient concentrations (Tetra Tech 2006). These tools allow for numeric review of whether narrative Water Quality Objectives are being met and beneficial uses supported.

[5] The most recent (2010) Integrated Report (http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml) lists the entire Sonoma Creek main stem which encompasses 30 miles, but the current stream length measured using the National Hydrography Dataset is 33 miles.

This project:

1) compiled all known existing data related to nutrients and algae growth in the watershed;
2) collected additional data on benthic algae in a manner consistent with the State Water Board's nutrient numeric endpoint guidance (Tetra Tech 2006);
3) created eight lines of evidence to evaluate all relevant available data; and
4) proposes to refine the nature and scope of the beneficial use impairment in Sonoma Creek based on its findings.

This delisting report does not include a proposal to modify the nutrient listing for the tidal portion of the Creek (10 miles) because guidelines and standards for such an evaluation do not yet exist. The Water Board is developing a model to understand nutrients in tidal areas of the Bay, and when that process is complete, we plan to evaluate the tidal portion of the River.

4.1.3 Analysis Supporting Delisting

Data allowing us to consider delisting the Creek for nutrients were collected between 2002 and 2012. This assessment included examination of nuisance algae levels caused by excess nutrients resulting in eutrophication, and toxicity resulting from ammonia, nitrate, and nitrite. Eight lines of evidence were produced using the following analytes: ammonia, nitrate, nitrite, benthic chlorophyll *a*, percent macroalgae cover, and pH. Data used to create these lines of evidence were collected by the San Francisco Estuary Institute (SFEI) (2002-2004), Water Board staff (2009), and SWAMP staff (2011-2012). Additionally, continuous monitoring dissolved oxygen data were collected at a subset of sites during the 2011-2012 sampling effort.

New water quality policy, along with tools to measure and evaluate excess algae levels, have allowed staff to conduct a rigorous and standardized analysis of algae levels and water quality conditions in the Creek. The analysis presented in this report relied on guidance set forth in 2004 by the State Water Board's 303(d) Listing Policy (Listing Policy) in regards to sample size, analysis approach, and data quality assurance (State Water Board 2004). SWAMP recently created standardized sampling methods to quantify algal biomass (Fetscher et al. 2009), and quality assurance and quality control procedures for field crews and laboratories collecting these data (SWAMP 2008). Subsequently, the Water Board collected algal biomass and nutrient data from 2011-2012 using these novel sampling techniques. Algal biomass data were reviewed against the State Water Board's guidance thresholds (Tetra Tech 2006). Therefore, the current evaluation of water quality standard attainment is more sophisticated and relies on a better dataset compared to analyses that were possible during the original 1986 listing.

Current water quality conditions in the Creek (2002-2012) show that nutrient-related numeric and narrative Water Quality Objectives are being met and potentially impacted beneficial uses are supported in this water body. The eight lines of evidence did not show exceedances beyond what is specified in the Listing Policy (State Water Board 2004). Therefore, we conclude that water quality conditions have improved since the original listing in 1986. No algae cover data were available from the time of the listing, so a direct comparison between current and past conditions was not possible. Additionally, no historical nutrient data could be identified for comparison.

4.1.4 Rationale for Reduced Algae Growth

The reduction in nuisance algae levels was probably a cumulative effect of NPDES permit restrictions on wastewater discharges, changes in land use in the Creek's watershed over the past 30 years, and improved agricultural best management practices (BMPs). Few water quality controls were in place before the federal Clean Water Act or the 1975 San Francisco Bay Basin Water Quality Control Plan (Basin Plan) (Water Board 1975). Historical conditions could generally be described as having included higher levels of cattle grazing (probably with direct access to streams and tributaries), more dairies and confined animal feeding operations (i.e., milking cows) with limited best management practices, and limited requirements on the wastewater treatment plant discharging into the non-tidal portion of the Creek. Nutrient loads from these sources have been reduced through activities described below.

The Creek was identified as having poor water quality conditions and was designated as Water Quality Limited in the 1975 Basin Plan (Water Board 1975). The Basin Plan's narrative description of past conditions and sources focused on contributions of biological oxygen-demanding substances from agricultural lands and municipal wastewater treatment facilities. The Creek was initially designated as an Effluent Limited Segment in the 1976 Clean Water Act 305(b) report for coliforms but not until 1986 was the Creek placed on the 303(d) list of impaired water bodies for nutrients causing eutrophic conditions (State Water Board 1976, 1986). Although point source and non-point sources of nutrients were identified in the original listing (Table 11), the wastewater treatment plant was considered to be a major contributor of nutrients at the time. However, over the past 30 years, improvements to and changed practices at the wastewater treatment plant has significantly reduced discharges and nutrient impacts in discharges to the Creek.

By the 1980s, NPDES permits issued by the Water Board to the wastewater treatment plant has included specific language prohibiting discharge during the "dry season," when the minimum 10:1 river water to discharge dilution ratio could not be achieved as dictated by the 1982 Basin Plan (Water Board 1982).[6] This discharge prohibition significantly reduced nutrient loading into receiving waters at a time when flows are naturally low because of the summer drought occurring in this region's Mediterranean climate. Wastewater treatment plants in the Sonoma and Napa watersheds that discharged to shallow waters stored or recycled 100 percent of their discharge during the dry season and also employed those same techniques during the wet season when the 10:1 ratio could not be achieved. This resulted in no dry season discharges, and only occasional discharges during the rainy season, when the impacts of nutrient discharges are limited because environmental conditions result in very limited algal growth and rapid flushing of nutrients into the Bay. Current NPDES permits require dilution ratios of up to 50:1, so treatment plants are currently discharging even less frequently into the Creek during the winter season. Additionally, over the past 30 years, the one plant that has continued discharging to a slough within the non-tidal Creek sections (Sonoma Valley County Sanitary District's plant) has improved treatment BMPs and added treatment technologies to reduce nitrogen inputs.

[6] The exact dates of the dry season varied slightly in each permit, but it was generally from May 1 – October 31.

Shifts in agriculture practices have likely also played a role in reducing nutrient loads to the River. Guidance provided by the U.S. Department of Agriculture National Resources Conservation Service and by local Resource Conservation Districts has improved agricultural BMPs for grazing animals and confined animal facilities. Examples include the development of Farm Conservation Plans, Nutrient Management Plans, Waste Management Systems, and Ranch Water Quality Control Plans (reviewed in Lewis et al. 2011). The implementation of such plans in the San Francisco Bay Region resulted in fewer nutrient inputs and less sediment erosion into water bodies (Larson et al. 2005; Lewis et al. 2011). Additionally, crop reports produced by the Sonoma County Agricultural Commissioner show that cattle and calf production decreased substantially from 237,865 centum weight (CWT) in 1970 to 157, 634 CWT in 2011. (http://www.countyofSonoma.org/AgCommissioner/CropReport/). CWT is a measure of weight in 100-lb units. Decreased production of cattle occurred because of reductions in cattle on rangelands and a reduction in the number of confined animal facilities.

Since the 1970s, vineyard acreage has increased in all of Sonoma County from 12,597 to 60,184 acres (http://www.countyofSonoma.org/AgCommissioner/CropReport/), an increase of about 67 square miles. However, nutrient runoff from vineyards is low (Rosenstock et al. 2013), and a portion of the increase in vineyard acreage was conversion from other agricultural land uses with greater potential to contribute nutrients to the Creek. Additionally, there are active watershed programs that reduce the water quality impacts from vineyards. In 2002, the Napa Valley Vintners Association, the Napa County Grapegrowers Association and the Napa County Farm Bureau brought the Fish-Friendly Farming program to Napa County, and since then implementation has expanded to the Sonoma Creek watershed (http://www.fishfriendlyfarming.org/). Although the program is new to Sonoma County, vintners have expressed interest in the program and have started to enroll. This program teaches the use of sediment control and bank stabilization BMPs - efforts that will also reduce sediment-bound nutrient discharges to streams.

We did not find evidence of significant changes to physical conditions in the watershed that were likely to lead to algae blooms. For example, increases in water temperature, decreases in water depth, decreases in riparian shade cover, and decreases in stream flow can all increase algae growth. An analysis of annual steam flow between 1955 and 2012 from the one U.S. Geological Survey station along the Creek showed no consistent change over time. The U.S. Geological Survey did not collect temperature data over the same time period, so a historical temperature analysis could not be performed.

Table 11. 1986 U.S. EPA 303(d) listing information for Sonoma Creek related to nutrients and eutrophic conditions.

Segment name & description	Beneficial uses evaluated*	Objective violated	Source
Sonoma Creek main stem	WARM COLD MUN AG REC-1 REC-2*	Nutrients resulting in eutrophication	Point and non-point sources

* The original 1986 listing included WARM, SPWN, and MIGR as the beneficial uses affected. The beneficial uses noted in this table are for uses currently applied to this water body with numeric Water Quality Objectives or evaluation guidelines. Beneficial Use designations are described in Table 1.

4.2. Watershed Description

The Sonoma Creek watershed is located in the California Coast Ranges north of San Pablo Bay (Figure 6) and covers an area of approximately 165 square miles. The main stem of the Creek flows approximately 33 miles in a southeasterly direction through the Sonoma Valley before discharging to San Pablo Bay. Although the original listing only focused on the Creek main stem, numerous tributaries enter the main stem from the mountains that rise abruptly on both sides of the valley. The combined length of the Creek main stem and its tributaries is over 247 miles. We conducted a watershed-based water quality assessment, examining conditions in both the tributaries and the non-tidal main stem. The results of this assessment and the subsequent lines of evidence are discussed in Section 4.3.2.

Table 12. Land use in the Sonoma Creek watershed.

Land use*	Percentage of watershed
Forest / Open Space	3.1%
Rangeland	11.3%
Agriculture-vineyard*	27.0%
Agriculture-other	24.1%
Urban-Commercial & Industrial	7.2%
Urban-Open	6.5%
Urban-Other	1.6%
Urban-Residential	17.1%
Water & Wetlands	2.2%

*Land use from Association of Bay Area Governments (2006) except vineyard area from Heaton 2007 (http://knowledge.sonomacreek.net/node/110).

This watershed has a Mediterranean climate with warm, dry summers and cool, wet winters (Gasith and Resh 1999). Average annual rainfall ranges from approximately 25 to 38 inches in the Sonoma Valley, and the large majority of rainfall occurs from November through April, with the heaviest rainfall occurring from December through February (Gilliam 2002). This rainfall regime results in two distinct seasons in the watershed. During the winter wet season, stream flow and pollutant loading are dominated by precipitation-driven surface runoff. In contrast, during the dry summer months, groundwater inflow and minor runoff from watershed activities are dominant. Major land cover types in the watershed are agriculture, which is largely composed of vineyard use (27%), and grassland/rangeland (11 percent). Developed land (e.g., residential, industrial, and commercial) accounts for approximately 32 percent of the watershed (Association of Bay Area Governments, 2006; Table 12). The population of the Sonoma Creek watershed is about 42,877.

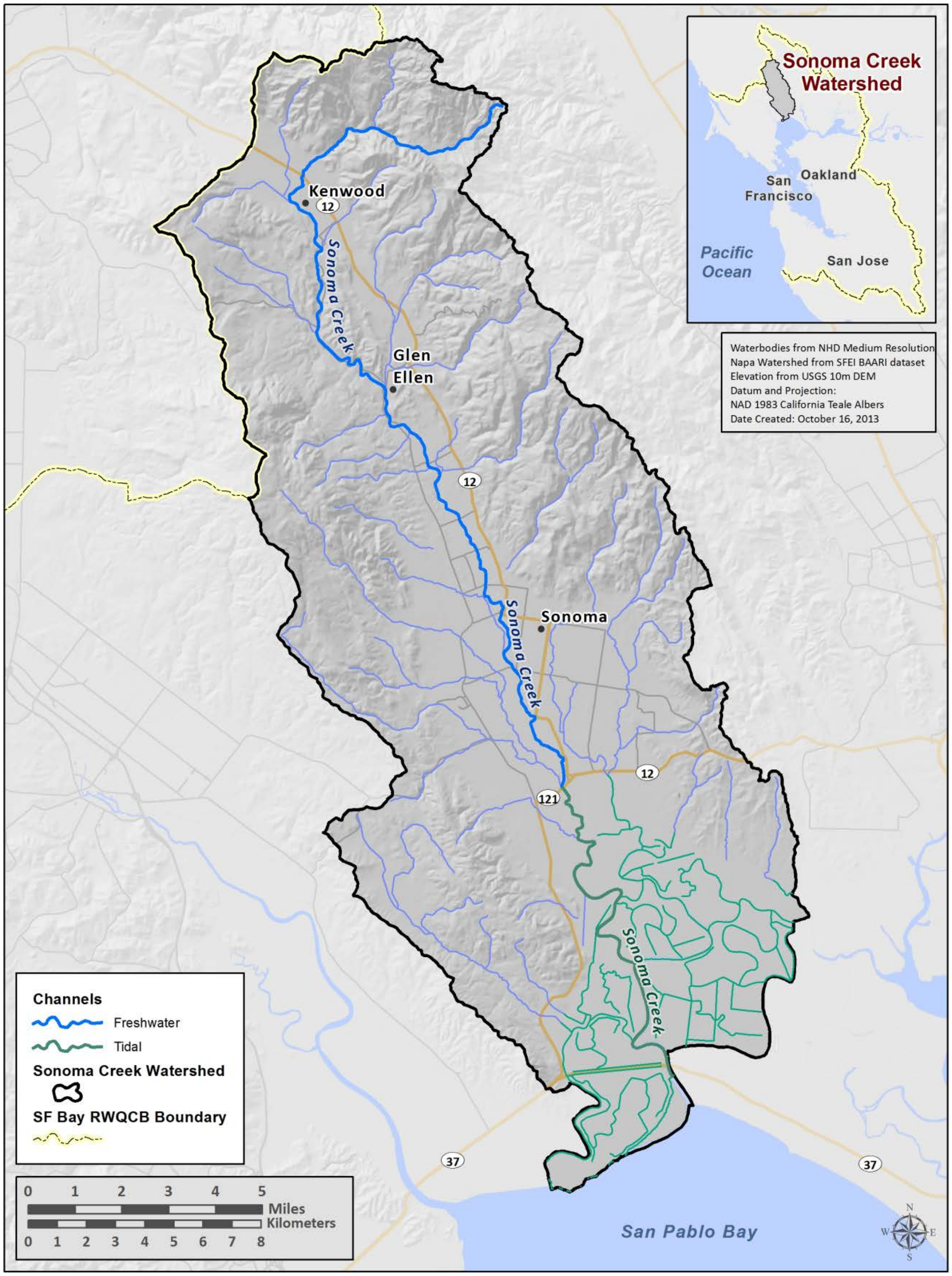

Figure 6. Map of the Sonoma Creek watershed

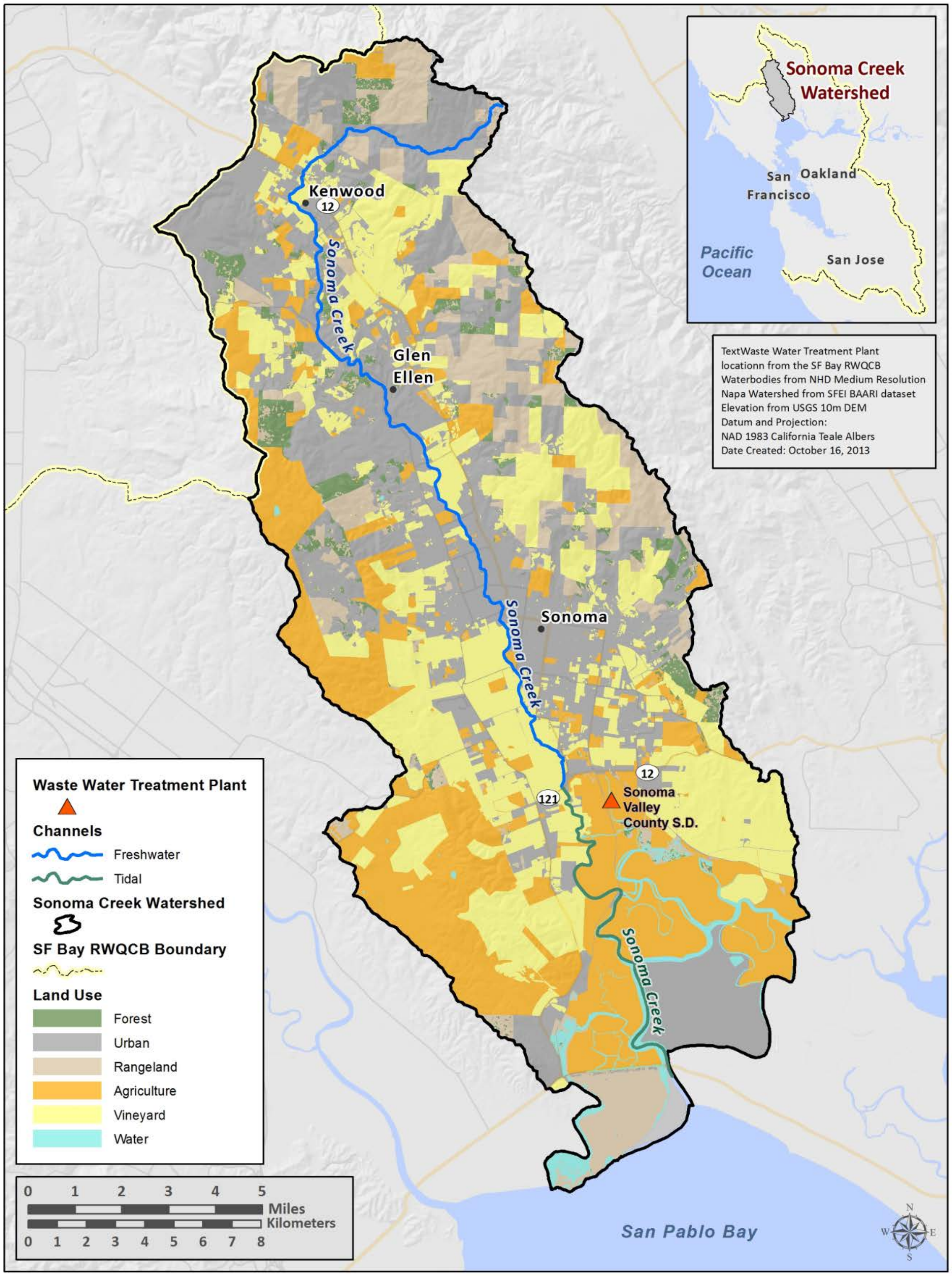

Figure 7. Map of land use and potential nutrient sources in the Sonoma Creek watershed.

4.3 *Water Quality Data*

4.3.1 Data quality

Data to support this delisting were collected over multiple years (2002-2012) by different sampling crews and analyzed by multiple laboratories (Table 5). All data used as lines of evidence are considered to be of high quality. Data collected from 2011-2012 are either SWAMP-compliant, or qualified as determined by the SWAMP Quality Assurance Program Plan (2008). Data collected from 2009 were analyzed by a U.S. EPA lab, so these samples underwent the QC testing required by U.S. EPA labs. Nutrient data collected from 2002-2004 were analyzed for precision and accuracy. Laboratory duplicate samples showed a precision range of < 30 percent, which we consider to be of acceptable quality because it is just above SWAMP guidance of a relative percent difference of 25 percent (SWAMP 2008, 2013). For 2002-2004 pH data, SFEI did not produce a Sampling and Analysis Plan or Quality Assurance Project Plan that could confirm the reliability of the equipment used, pH standards, number of points used for calibration, adequate frequencies pre- and post-measurement calibrations, and established measurement quality objectives for drift. For these reasons, we determined these data to be unusable for the pH line of evidence analysis.

4.3.2 Lines of evidence

Four lines of evidence support removing the original listing for eutrophication and four lines of evidence show that nutrient toxicity is not present (Table 13).

4.3.2.a Eutrophication

Three direct lines of evidence for biostimulation of algae and a fourth indirect line of evidence demonstrate that Water Quality Objectives are not exceeded and designated beneficial uses are supported. The three direct lines of evidence are algal biomass indicators represented by benthic chlorophyll *a* and percent macroalgae cover (attached + unattached) collected using the SWAMP Bioassessment protocol (Ode 2007, Fetscher et al. 2009) and water column chlorophyll *a*.

The direct benthic chlorophyll *a* line of evidence showed only one exceedance of evaluation guidelines out of 18 samples collected over two years. We recorded no exceedances for percent macroalgae cover out of 17 samples collected across two years. Relatively fewer data points are available for the algae mass indicators compared to water column chemistry measures (e.g., ammonia, nitrate, and nitrite) because they are more expensive and time consuming to collect. However, fewer data points are necessary to evaluate overall water quality conditions because they are seasonally integrative measures, which represent weeks to months of water quality conditions coalesced into a single data point.

Chlorophyll *a* in the water column was collected by SFEI in 2002 and 2003 and showed no exceedances against the evaluation guideline. Zero of 25 samples exceeded the 15 µg/L evaluation guideline. Therefore, this line of evidence does not support impairment according to the biostimulatory narrative objective.

Table 13. Sonoma Creek Summary of lines of evidence and exceedances of numeric evaluation guidelines.

LOE	Analyte	Numeric evaluation guideline	Number of exceedances	Evaluation metric	Listing factor
1	Benthic biomass chlorophyll *a*	< 150 mg/m^2	1/18	Evaluation Guideline	4.11 weight of evidence
2	Percent macroalgae cover [a]	30%	0/18	Evaluation Guideline	4.11 weight of evidence
3	Nitrite	1 mg/L	0/86	Water Quality Objective	4.1 toxicant
4	Nitrate+ Nitrite	10 mg/L	0/86	Water Quality Objective	4.1 toxicant
5	Ammonia, un-ionized	0.025 mg/L	0/6 [b]	Water Quality Objective	4.1 toxicant
6	Ammonia, Total	0.1-1.6 mg/L	0/86	U.S. EPA Criterion	4.1 toxicant
7	pH[c]	6.5-8.5 units	0/27	Water Quality Objective	4.1 toxicant
8	Water column chlorophyll *a*	15 µg/L	0/25	Evaluation Guideline	4.11 weight of evidence

[a] metric calculated from the SWAMP bioassessment protocol from 105 observations along a 150m section of stream.
[b] 86 unique samples analyzed by year.
[c] Only pH data collected using the SWAMP QAPrP were incorporated into this assessment.

Table 14. Sonoma Creek Water quality parameters at the one site with chlorophyll *a* algae exceedances listed in LOE 1 of Table 13.

Sample site	Year	Season	Benthic chlorophyll *a*	% Macroalgae cover	% Riparian cover	Dissolved oxygen median (mg/L)
S-36	2011	Late summer	259 mg/m^2	29.5	44	7.54
S-36	2012	Late summer	27 mg/m^2	13.3	54	6.02

At the one site with an exceedance of the chlorophyll *a* evaluation guideline (S-36) other algal biomass or eutrophication indicators did not demonstrate a consistent problem over time (Table 14). For example, in 2011 the benthic chlorophyll *a* level was well above the 150 mg/m^2 guideline for COLD and above the 200 mg/m^2 guideline for WARM, yet the chlorophyll *a* level from the following year (2012) was well below both thresholds. Additionally, the percent macroalgae cover (based on 105 sample points along a 150 m section of stream) was below the 30 percent evaluation guideline in both years. Secondary indicators, such as continuously monitored dissolved oxygen, showed that water quality conditions were adequate for aquatic life uses WARM and COLD based on guidance from Tetra Tech (2006). Also the strong daily (diel) swing of dissolved oxygen, which occurs in severely eutrophic waters, was not observed, nor was highly oxygenated water above 13 mg/L observed, a eutrophication indicator proposed by the Central Coast Water Board (2010). Fisheries data from the Sonoma RCD show that fish conditions for spawning and migration are supported in this watershed, but there is not enough information to determine population trends (CEMAR 2013). This reach is not publicly accessible, so it was not possible to evaluate whether REC-1 and REC-2 beneficial uses were affected by algae blooms. The geomorphology of the stream reach is a wide channel, so there is less shading from tall upland trees compared to other portions of the Creek where the stream is incised or has been partially channelized. In sum, the weight of evidence at this site does not indicate an exceedance of the narrative biostimulatory objective at this location.

4.3.2.b Toxicity

Four lines of evidence show that Creek water quality is not toxic to human or wildlife and that beneficial uses are supported. Although the Creek is not listed for nutrient-related toxicity, we compiled existing data and collected new data to confirm that waters were not toxic to wildlife or humans. The water quality data were below appropriate drinking water quality standards for nitrate and nitrite (Table 13), so municipal beneficial uses were supported. In addition, the waters were not toxic to wildlife as indicated by the evaluation guideline for total ammonia recently proposed by U.S. EPA (2013), so aquatic life beneficial uses were supported (Table 13). The number of samples for nitrite, nitrate and ammonia meet the minimum sample sizes ($n > 28$) from Table 4.1 in the Listing Policy (State Water Board 2004).

4.3.3 Spatial variation

The nutrient data to support this analysis were collected throughout the Creek's watershed (Figure 8). The sample locations were along the main stem and in tributaries of varying stream orders. Perennial streams compose the majority of the sample locations because they have water during the summer when algae growth peaks, but a handful of non-perennial streams were monitored, as well. Collections of algae cover and benthic chlorophyll *a* from 2011-2012 could be completed only from the wadeable sections of the main stem where the depth was 1m or less during the summer. The lowest sample point was approximately 1.5 miles upstream of the tidal boundary at State Highway 121, so we were effectively able to sample the entire length of the main stem.

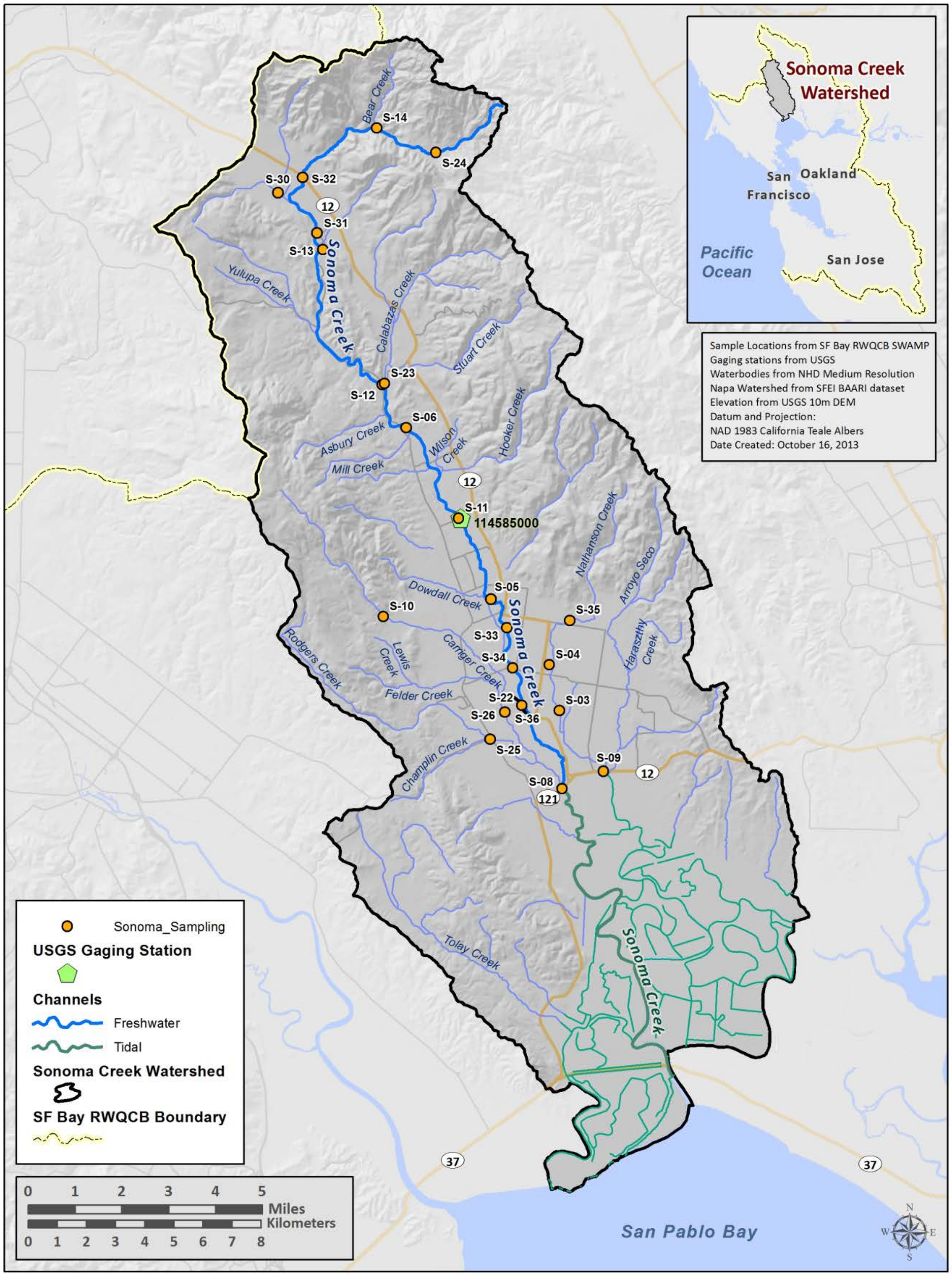

Figure 8. Map of all sample stations within the Sonoma Creek watershed

Although the lowest ten miles of the main stem were included in the original 303(d) listing as being impaired by nutrients, this section is tidally influenced and was not assessed in this report because freshwater Water Quality Objectives and numeric guidance do not apply to this segment. At present, we could not identify any relevant data or appropriate guidelines to evaluate the biostimulatory substances narrative objective in the tidal portion of the Creek. Therefore, this segment was excluded from analysis in this delisting (Figure 6). We plan to reassess this listing in the tidal reach of the Creek subsequent to the conclusion of the San Francisco Bay numeric nutrient endpoint project. That work is expected to generate guidelines/standards for identifying nutrient impairment in brackish and salt waters.

4.3.4 Temporal variation

Neither inter-annual (between years) nor intra-annual (across seasons) variability strongly affected the nutrient results. A previous analysis of water chemistry in the Sonoma Creek main stem and tributaries showed small differences in nutrient concentrations across seasons (SFEI). The Creek met applicable toxicity Water Quality Objectives and evaluation guidelines for nutrients in all seasons and across all years. Nutrient concentrations did not substantially differ across the dry season. For example, in 2012 nutrient concentrations collected in June were only slightly higher than samples from August and September.

Similarly, Creek benthic algal biomass did not exhibit significant temporal variation during the study period. In 2011 and 2012, algal biomass was collected only once in the late dry season (August – September) when maximum algal biomass was expected based on the Mediterranean climate and previously collected data in our Region. Increasing summer temperatures and decreased stream flow generally lead to maximal algae growth during that time frame before temperatures cool and early winter rains in October and November scour the stream bed, reducing the standing crop of benthic algae. Reference stream monitoring by SWAMP found that algal biomass can change substantially throughout a season and was greatest during August and September (Water Board 2012). For example, benthic algal biomass measured using chlorophyll *a* at three perennial streams with minimal human disturbance increased from an average of 25 mg/m^2 in April/May to 37 mg/m^2 in June/July to 51 mg/m^2 in August/September. Maximum benthic algae chlorophyll *a* results from that study were 100 mg/m^2 for a perennial stream and 169 mg/m^2 in a non-perennial stream, which generally reinforce Tetra Tech's 150 and 200 mg/m^2 chlorophyll *a* thresholds for Cold Freshwater Habitat and Warm Freshwater Habitat, respectively (Tetra Tech 2006).

Benthic algal biomass indicators from the current monitoring effort did show minor differences between 2011 and 2012. Although chlorophyll *a* was nearly the same (Figure 9), benthic algae measured by percent macroalgae cover slightly lower in 2012 although this difference was not statistically significant (Figure 10). However, some intra-annual variation was observed in percent cover measurements that were collected by estimating algae cover approximately once per month for three months in 2012. Three stream reaches showed little change in observed percent cover (mean change 4 percent). However, one site that also happened to be the only site with an exceedance of this metric (S-36), showed a substantial decrease from 46 percent in early summer to 0 percent macroalgae cover in fall, which resulted because the shallow portions of the Creek dried out during that time period so the filamentous algae was no longer counted as being in the stream.

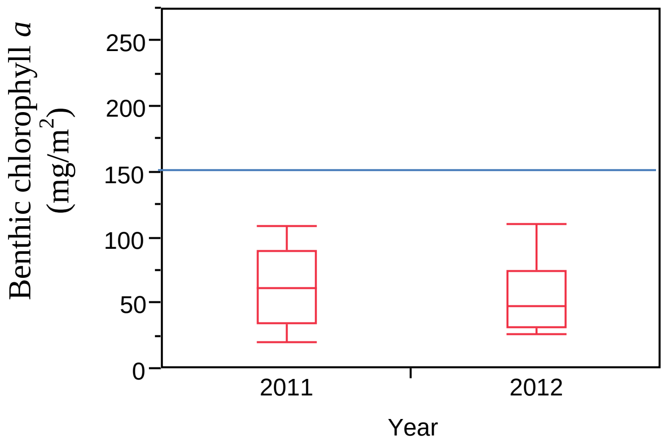

Figure 9. Box plot of chlorophyll *a* levels for 2011 and 2012. The evaluation guideline is 150mg/m^2. The box plots represent the 25th to 75th percentiles and the whiskers represent the 10th and 90th percentiles. The line in the middle of the box shows the median observed value.

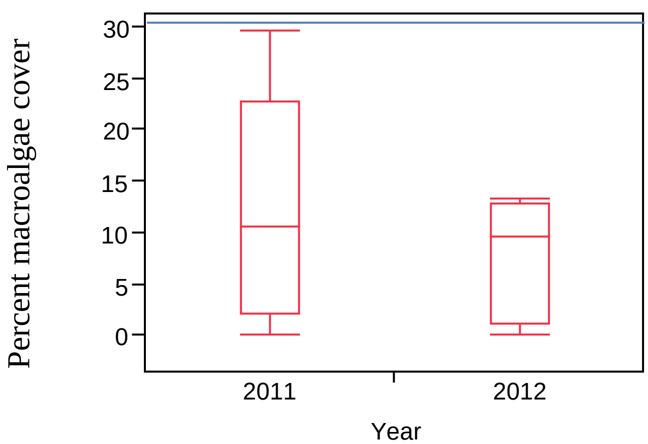

Figure 10. Box plot of percent macroalgae cover levels for 2011 and 2012. The evaluation guideline is 30 percent cover. The box plots represent the 25th to 75th percentiles and the whiskers represent the 10th and 90th percentiles. The line in the middle of the box shows the median observed value.

Table 15. Inventory of water quality monitoring stations in Sonoma Creek.

Station	Description	Latitude	Longitude	Sampling events							
				Oct 2002	Jan 2003	July 2003	May 2004	July 2009	Aug/Sep 2011	June 2012	Aug/Sep 2012
S-03	Nathanson Ck. @ Watmaugh just west of 5th Street	38.26457	-122.45307		x	x	x	x			
S-04	Nathanson Ck. @ Nathanson Park Napa Rd. to Larkin To Fine	38.27860	-122.45748		x	x	x				
S-05	Sonoma Ck. @ Maxwell Park near access from Riverside Drive	38.29840	-122.48120	x	x	x	x	x	x	x	x
S-06	Sonoma Ck. near Sonoma Developmental Center	38.35070	-122.51627	x	x	x		x	x	x	x
S-08	Sonoma Ck. @ Hwy 121	38.24047	-122.45130	x	x	x					
S-09	Schell Ck. @ Hwy 121	38.24625	-122.43508		x	x		x			
S-10	Carriger Ck. @ Marilyn Goode's property	38.29211	-122.52320	x	x						
S-11	Sonoma Ck. @ Agua Caliente	38.32318	-122.49470	x	x	x					
S-12	Sonoma Ck. @ Glen Allen (above confluence with Calabazas)	38.36376	-122.52617	x	x	x		x	x	x	x
S-13	Sonoma Ck. @ 986 Warm Springs Rd. 986 Warm Springs Road	38.40492	-122.55097	x	x	x	x	x	x	x	x
S-14	Sonoma Ck. @ Goodspeed Bridge (above Bear Creek confluence)	38.44295	-122.53110	x	x	x	x	x	x	x	x
S-22	Sonoma Ck. @ Watmaugh	38.26580	-122.46783		x	x	x	x			
S-23	Calabazas Ck. @ Glen Allen (from Henno Road)	38.36411	-122.52526		x	x					
S-24	Sonoma Ck. Sugarloaf State Park near Robert Ferguson Observatory	38.43593	-122.50738		x	x		x	x	x	x
S-25	Rogers Ck. @ Arnold Drive	38.25515	-122.48002		x						
S-26	Carriger Ck. @ Watmaugh	38.26358	-122.47450		x	x					
S-30	Unnamed Ck. @ Lawndale Ave.	38.42220	-122.56925				x		x	x	x
S-31	Sonoma Ck. @ Mound Ave	38.41010	-122.55352				x				
S-32	Sonoma Ck. @ Hwy 12 near Hoff St	38.42703	-122.55968				x		x	x	x
S-33	Sonoma Ck. @ Andrieux St.	38.28970	-122.47463				x				
S-34	Sonoma Ck. @ Leveroni Rd.	38.27732	-122.47178				x				
S-35	Nathanson Ck. @ 4th St.	38.29248	-122.44993				x				
S-36	Sonoma Ck. @ Watmaugh	38.26580	-122.46783						x	x	x
	Total number of samples			8	16	14	12	9	9	9	9

4.4 Flow Data

This report does not rely on flow data for its major analyses. However, one U.S. Geological Survey station is present in the watershed, and data from 1955– 2012 were analyzed to examine long-term flow trends (http://waterdata.usgs.gov/usa/nwis/rt; Table 16). Between 1955 and 2012, the average annual flow in cubic feet per second (cfs) did not show a consistent increase or decrease in flow over time (linear regression, slope < 1 cfs/year). Stream gage data confirmed the Creek's strong seasonality, with winter base flows ranging from 40-400 cfs and decreasing to <1-5 cfs in summer. Storm flows were 100 times winter base flows and surpassed 10,000 cfs. Flow (instantaneous) was measured at all sample locations during the late dry season in 2011 and 2012 (Table 15). These August and September flows were low (mean = 1.55 cfs) and ranged from 0.03 to 5.5cfs. In general tributaries carried less flow than the main stem.

Table 16. USGS flow monitoring information.

Station information	GPS location	Period of record	Sampling frequency*
USGS 11458500 SONOMA C A AGUA CALIENTE CA	38.323333 -122.493333	1955-2012	Annual average, daily average

*Sampling frequency currently every 15 minutes, but annual flow average was used to determine potential flow changes over time.

4.5 Habitat Quality Data

Water Board staff collected physical habitat conditions in 2011 and 2012 according to the SWAMP bioassessment protocol. The environmental variables most related to eutrophication are shade, stream temperature, and depth. In general, Sonoma Creek watershed streams are well shaded; the mean densiometer reading of canopy cover over the stream was 79 percent. Temperature readings during the late morning hours between 9 and 11 AM averaged 16.4°C (ranging from 13.6-20.9°C). The average reach-wide depth at all sampling locations was 0.21 m. Overall the Creek is well shaded, but locations with open canopy, warmer temperatures, and shallow waters are more likely to produce algae blooms.

4.6 Data Analysis Summary

The three direct lines of evidence based on algal biomass (benthic chlorophyll *a*, water column chlorophyll *a*, and percent macroalgae cover) show the narrative water quality objective in the Basin Plan for biostimulatory substances was not exceeded (Table 13, 15; Water Board 2013). At the site with high algae levels (S-36), secondary indicators of eutrophication (i.e., pH and dissolved oxygen) were not symptomatic of eutrophication. Most portions of the Creek are well-shaded (mean densiometer readings were 79 percent), and current levels of shade are important for preventing algae blooms. Four lines of evidence show that the waters are not toxic to humans or wildlife, thus nutrients are not having a direct environmental impact on beneficial uses. No significant seasonal or inter-annual changes in water quality were observed that would affect this recommendation for delisting. This analysis supports delisting the Creek's non-tidal reach.

Table 17. Sonoma Creek water quality summary

	Years of collection	Seasons	No. of samples	Bench-mark	Units	Mean	25th	Median	75th	Number of exceedances
Chlorophyll *a*	2011, 2012	Summer/ early fall	18	150	mg/m^2	65	33	49	77	**1/18**
Percent macroalgae cover	2011, 2012	Summer/ early fall	18	30	%	10	2	10	14	**0/18**
Ammonia, total	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	86	0.26	mg/L	0.032	0.041	0.014	0.008	**0/86**
Ammonia, unionized	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	6	0.025	mg/L	0.0013	0.0005	0.0012	0.0022	**0/6**
Nitrate	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	86	n/a	mg/L	0.726	1.377	0.413	0.175	**0/86**
Nitrite	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	86	1	mg/L	0.008	0.009	0.001	0.001	**0/86**
Nitrite+ nitrate	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	86	10	mg/L	0.734	1.378	0.441	0.178	**0/86**
Total nitrogen	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	86	n/a	mg/L	1.09	1.57	0.89	0.48	**n/a**
Ortho-phosphate	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	86	n/a	mg/L	0.079	0.094	0.057	0.037	**n/a**
Total phosphorus	2002, 2003, 2004, 2009, 2011, 2012	Winter, summer, fall	82	n/a	mg/L	0.08	0.09	0.08	0.05	**n/a**

5 Expectation of Long-term Beneficial Use Attainment – Napa River and Sonoma Creek

While the Napa River and Sonoma Creek are currently meeting standards and supporting beneficial uses associated with nutrients, the many implementation measures being taken under multiple Water Board programs are likely to further decrease controllable sources of nutrients and ensure that nutrients do not cause future impairments.

The actions below address point sources:

- **NPDES permits for municipal wastewater treatment facilities.** These facilities are regulated via individual National Pollutant Discharge Elimination System (NPDES) permits. A discharge prohibition in effect since 1982 forbids discharge of effluent to surface wasters during the dry season (May 1 - Oct 31). Consequently many facilities in the North Bay only discharge for a few days during the winter and reuse or recycle all of their effluent nearly all the time.
- **General Waste Discharge Requirement and Waiver of Waste Discharge Requirements for confined animal facilities.** Confined animal facilities (CAFs) may be a nutrient source in localized parts of the watersheds. Four diary CAFs in the Sonoma Creek watershed and no dairy CAFs in the Napa River watershed were identified to enroll in the Water Board's general waste discharge requirement (WDR) for confined animal facilities (Order No. R2-2003-0093) or waiver of waste discharge requirements (WDRs) for confined animal facilities (Resolution No. R2-2003-0094), which were both initiated in 2003. However, other CAFs (e.g., horse facilities, goat dairies) may still be identified in the watersheds and may be subject to future regulation. The 2003 WDR specified BMPs for manure pond siting, size and construction, management of stormwater across the facilities, and BMPs for discharging waste to land. In addition, CAFs were required to develop a waste management plan and operation and management plan. The wavier of WDRs required similar BMPs for manure ponds and discharge to the general WDR. Both the CAF waiver of WDRs and CAF WDR are in the process of being updated and reissued by the Water Board.
- **NPDES permit for municipal/urban runoff.** The following dischargers to the freshwater reach of the Napa River or Sonoma Creek are permitted under the Phase II NPDES municipal stormwater permit (State Water Board Order No. 2013-0001-DWQ): Napa and Sonoma counties and the cities of Calistoga, Napa, St. Helena, Yountville, and Sonoma. The Phase II permit requires implementation of management practices to reduce the adverse effects of stormwater runoff and includes requirements for continuous improvement. It includes requirements to address nutrients, including requirements to address illicit discharges and pollution prevention, for example, via reductions of landscape overwatering and requirements for erosion and sediment control.

The actions below address non-point sources:

- **The State Water Board approved a Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy).** The OWTS Policy addresses pathogen and nutrient impacts from septic systems through multiple actions. The OWTS Policy sets standards for OWTS that are constructed or replaced, that are subject to a major repair, and that have affected, or will affect, groundwater or surface water to a degree that makes it unfit for drinking water or other uses or cause a health or other public nuisance condition. The OWTS Policy also includes minimum operating requirements for OWTS that may include siting, construction, and performance requirements; requirements for OWTS near certain waters on the section 303(d) list; requirements authorizing local agency implementation of the requirements; corrective action requirements; minimum monitoring requirements; exemption criteria; requirements for determining when an existing OWTS is subject to major repair; and a conditional waiver of waste discharge requirements. Because OWTS Policy requirements are broadly consistent with the Water Board's existing requirements for septic systems, we would expect control of discharges from such systems to be maintained consistent with current standards.
- **Waiver of waste discharge requirements (WDRs) for grazing operations.** In 2011, the Water Board approved the Conditional Waiver of Waste Discharge Requirements for Grazing Operations in the Napa River and Sonoma Creek watersheds (Order No. R2-2011-0060) to reduce pathogen, sediment, and nutrient inputs into these water bodies. This waiver of WDRs requires evaluation of operating practices; development of comprehensive site-specific pathogen and sediment control measures; an implementation schedule for installation of identified management measures; and, submittal of annual progress reports documenting actions undertaken to reduce or eliminate animal waste and sediment runoff. This waiver of WDRs also contains conditions that include basic visual monitoring and compliance monitoring reporting. It contains the requirement to submit an annual certification of compliance. Additionally, landowners/operators of the ranch facility are required to develop and implement a Ranch Water Quality Plan that includes an assessment of facility conditions, an inventory of resources and management practices, and a schedule for implementation of new management practices that reduce nonpoint source pollution due to grazing.
- **General waste discharge requirement for vineyards.** Although vineyards in this region use low levels of nitrogen and often apply this via drip irrigation so surface runoff of fertilizer is low (Rosenstock et al. 2013), efforts to reduce sediment erosion into streams will also result in reduced nutrient loading from these sources. Water Board staff is in the process of developing a general WDR for vineyards in the Napa and Sonoma watersheds to control sediment erosion.

References

Association of Bay Area Governments. 2006. Existing land use in 2005: Data for San Bay Area Counties (GIS layer) Publication Number: P06001EQK. Oakland, CA.

Biggs, B. J. 2000. New Zealand periphyton guideline: Detecting, monitoring and managing enrichment of streams. Ministry of Environment. http://www.mfe.govt.nz/new/periphyton.pdf

Bowie, G.L., W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W.H. Chan, S.A. Gherini, and C.E. Chamberlin. 1985. Rates, Constants, and Kinetic Formulations in Surface Water Quality Modeling (Second Edition). EPA/600/3/-85/040. Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, GA.

Boyer, T.V., M.R. David, and L.E. Gentry. 2006. Timing of Riverine Export of Nitrate and Phosphorus from Agricultural Watersheds in Illinois: Implications for Reducing Nutrient Loading to the Mississippi River. Environmental Sciences and Technology 40: 4126-4131.

Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Non-point pollution of surface waters with phosphorus and nitrogen. Ecological Applications 8: 559-568.

CEMAR (Center for Ecosystem Management and Restoration). 2013. Sonoma Creek Watershed Outmigrant Study Project Report, Spring 2013. Prepared by CEMAR (Oakland, CA) in association with Hagar Environmental Science, the Sonoma Ecology Center and the Sonoma Resource Conservation District.

Central Coast Water Board (Central Coast Regional Water Quality Control Board). 2010. Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters. California Regional Water Quality Control Board, Central Coast Region. Assessed online at http://www.ccamp.org/ccamp/documents/R3_NNE_Tech_Report_Final_July2010.pdf.

Dodds, W.K. 2006. Eutrophication and trophic state in rivers and streams. Limnology and Oceanography 51: 671-680.

Dodds, W.K. and E.B. Welch. 2000. Establishing nutrient criteria in streams. Journal of the North American Benthological Society 19(1): 186-196.

Dodds, W.K., J.R. Jones, and E.B. Welch. 1998. Suggested classification of stream trophic state: distributions of temperate stream types by chlorophyll, total nitrogen, and phosphorus. Water Research 32(5): 1455-1462.

Dodds, W. K., V.H. Smith, and B. Zander. 1997. Developing nutrient targets to control benthic chlorophyll-a levels in streams: a case study of the Clark Fork River. Water Research 31(7): 1738-1750.

Dodds, W.K., V.H. Smith, and K. Lohman. 2002. Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 59: 865-874.

Fetscher, A.E., L. Busse, and P. R. Ode. 2009. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 002.

Gasith A, and V.H. Resh. 1999. Streams in Mediterranean climate regions: Abiotic influences and biotic responses to predictable seasonal events. Annual Review of Ecology and Systematics 30: 51-81.

Gilliam, H. 2002. Weather of the San Francisco Bay Region. 2nd edn. University of California Press, Berkeley, CA, USA

Grossinger, R. 2012. *Napa Valley Historical Ecology Atlas*. University of California Press. p. 240.

Koehler, J., and P. Blank. 2013. Napa River Steelhead and Salmon Monitoring Program 2012-2013 Season. Napa County Resource Conservation District. http://www.naparcd.org/fishresources.html

Larson, S., K Smith, D Lewis, J. Harper, M George. 2005. Evaluation of California's Rangeland Water Quality Education Program. Rangeland Ecology and Management 58(5): 514-522.

Lewis, D., M. Lennox, N. Scolari, L. Prunuske, C. Epifanio. 2011. A Half Century of Stewardship: a programmatic review of conservation by Marin RCD & partner organizations (1959-2009). Prepared for Marin Resource Conservation District by U.C. Cooperative Extension, Novato CA. 99 p.

SFEI (San Francisco Estuary Institute). 2005. Human influences on nitrogen and phosphorus concentrations in creek and river waters of the Napa and Sonoma watersheds, northern San Francisco Bay, California. SFEI contribution 421.

Ode, P.R.. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

Quinn, J.M. 1991. Guidelines for the control of undesired biological growths in water, New Zealand National Institute of Water and Atmospheric Research, Consultancy Report No. 6213/2. *In*: Pollutant Effects in Freshwater; Applied Limnology, Third Edition. E.B. Welch and J.M. Jacoby 2004. Spon Press, London & New York.

Rosenstock, T.S., D Liptzin, J. Six, and T.P. Tomich. 2013. Nitrogen fertilizer use in California: Assessing the data, trends and a way forward California Agriculture 67(1):68-79. DOI: 10.3733/ca.E.v067n01p68. http://ucce.ucdavis.edu/files/repositoryfiles/ca.E.6701p68-100244.pdf

Sosiak, A. 2002. Long-Term Response of Periphyton and Macrophytes to Reduced Municipal Nutrient Loading to the Bow River (Alberta, Canada). Canadian Journal of Fisheries and Aquatic Sciences 59: 987-1001.

State Water Board (State Water Resources Control Board). 1976. Annual Water Quality Inventory, Water Year 1975: A report on water quality conditions, problems, and water quality control programs prepared in fulfillment of the requirements of Section 305(b) of PL 92-500.

State Water Board (State Water Resources Control Board). 1986. Annual Water Quality Inventory for Water Years 1984&1985: Section 305(b) Report Water Quality Monitoring Report Number 86 5WQ.

State Water Board (State Water Resources Control Board). 2004. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List. State Water Resources Control Board. Resolution No. 2004-0063.

SWAMP (Surface Water Ambient Monitoring Program). 2008. Quality Assurance Program Plan (QAPrP) Version 1.0. Surface Water Ambient Monitoring Program, Sacramento, CA.

SWAMP (Surface Water Ambient Monitoring Program). 2013. Quality Assurance Program Plan (QAPrP) Version 1.0. Quality Control and Sample Handling Guidelines. Surface Water Ambient Monitoring Program, Sacramento, CA. http://www.waterboards.ca.gov/water_issues/programs/swamp/mqo.shtml

Tetra Tech. 2006. Technical Approach to Develop Nutrient Numeric Endpoints for California. Prepared for USEPA Region 9. State Water Resources Control Board. 68-C-02-108-To-111 Tetra Tech, Inc., Lafayette, CA.

US Army Corps of Engineers. 1998. Napa River, California - Napa River/Napa Creek Flood Protection Project Volume I Final Supplemental General Design Memorandum. U.S. Army Corps of Engineers Sacramento District and Napa County Flood Control and Water Conservation District. Available at http://www.countyofnapa.org/.

US Department of Agriculture. 1999. A Procedure to Estimate the Response of Aquatic Systems to Changes in Phosphorus and Nitrogen Inputs. Prepared by B.J. Newton and W.M. Jarrell, National Water and Climate Center.

US Environmental Protection Agency. 2000a. Nutrient Criteria Technical Guidance Manual: Rivers and Streams EPA-822-B-00-002. United States Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

US Environmental Protection Agency. 2000b. Water Quality Standards; Establishment of Numeric Criteria for Priority Pollutants for the State of California. 40 CFR Part 131. Environmental Protection Agency.

US Environmental Protection Agency. 2013. Draft 2009 Aquatic Life Ambient Water Quality Criteria For Ammonia – Freshwater 2013. EPA-822-R-13-001. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

US Geological Survey. 2013. National Hydrography Dataset - 100K resolution. US Geological Survey, Reston, Virginia. Accessed online at http://nhd.usgs.gov/data.html

Water Board (San Francisco Bay Regional Water Quality Control Board). 1975. San Francisco Bay Basin (Region 2) Water Quality Control Plan. California Regional Water Quality Control Board, San Francisco Bay Region.

Water Board (San Francisco Bay Regional Water Quality Control Board). 1982. San Francisco Bay Basin (Region 2) Water Quality Control Plan. California Regional Water Quality Control Board, San Francisco Bay Region.

Water Board (San Francisco Bay Regional Water Quality Control Board). 2003. Conceptual Approach for Developing Nutrient TMDLs for San Francisco Bay Area Waterbodies (June 18, 2003). Accessed online at http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sonomacrknutrients/scnutrientsstaffrept0603.pdf

Water Board (San Francisco Bay Regional Water Quality Control Board). 2012. The Reference Site Study and the Urban Gradient Study Conducted in Selected San Francisco Bay Region Watersheds in 2008-2010 (Years 8 to 10). Surface Water Ambient Monitoring Program (SWAMP), San Francisco Bay Regional Water Quality Control Board, Oakland, CA. Accessed online at http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/reglrpts/r2refsitestdy.pdf

Water Board (San Francisco Bay Regional Water Quality Control Board). 2013. San Francisco Bay Basin (Region 2) Water Quality Control Plan. California Regional Water Quality Control Board, San Francisco Bay Region. Accessed online at http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

Welch, E.B., J.M. Jacoby, R.R. Horner, and M.R. Seeley. 1988. Nuisance biomass levels of periphytic algae in streams. Hydrobiologia 157: 161-168.

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Staff Report
Appendix A

Water Quality Data

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Napa River Nutrient Delisting Water Quality Data

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
N-01	1/7/2003	16:30	0.498	0.002	0.500		0.017	0.024	0.307	9.1	**	0.004	0.156	0.001	0
N-01	7/8/2003	14:26	0.332	0.001	0.333		0.009	0.028	0.484	8.5	**	0.007	0.370	0.001	
N-02	10/3/2002	12:00	0.003	0.000	0.003		0.081	0.089	0.065	8.2	**	0.004	0.672	0.000	0
N-02	1/8/2003	10:30	0.300	0.000	0.300		0.031	0.022	0.629	9.2	**	0.004	0.133	0.001	0
N-02	7/8/2003	19:50	0.071	0.000	0.071		0.074	0.088	0.138	9.0	**	0.003	0.167	0.001	
N-02	8/23/2011	11:35	0.110	*0.001*	0.111	0.334	0.060	0.078	0.445	7.90	15.92	0.0877	1.162	0.002	
N-02	6/14/2012	9:15	0.240	*0.001*	0.241	0.325	0.105	0.079	0.566	7.93	14.97	0.0840	1.186	0.002	
N-02	9/13/2012	10:45	0.033	*0.001*	0.034	0.368	0.081	0.085	0.402	8.15	14.65	0.0430	0.875	0.002	
N-03	10/3/2002	11:37	0.005	0.000	0.005		0.068	0.088	0.129	8.1	**	0.005	0.773	0.000	0
N-03	1/8/2003	10:53	0.023	0.000	0.023		0.040	0.038	0.059	9.2	**	0.004	0.138	0.001	0
N-03	7/8/2003	19:30	0.016	0.000	0.016		0.072	0.084	0.136	9.0	**	0.005	0.169	0.001	
N-03	7/9/2009	11:24	0.060	*0.025*	0.085	1.80	*0.250*	0.090	1.885	*	**	0.021	0.884	0.001	
N-03	8/2/2011	10:42	0.020	*0.001*	0.021	0.295	0.070	0.082	0.316	7.94	14.45	0.0462	1.210	0.001	
N-03	6/14/2012	8:40	0.193	*0.001*	0.194	0.327	0.087	0.079	0.521	7.82	15.41	0.0740	1.333	0.001	
N-03	8/15/2012	10:10	0.046	*0.001*	0.047	0.321	0.095	0.091	0.368	7.99	17.57	0.0430	0.922	0.001	
N-04	10/2/2002	11:50	0.249	0.005	0.254		0.019	0.049	0.424	8.4	**	0.017	0.493	0.001	1
N-04	1/7/2003	12:22	0.921	0.000	0.921		0.022	0.045	1.008	9.3	**	0.005	0.116	0.002	0
N-04	7/8/2003	13:08	0.433	0.004	0.436		0.010	0.025	0.641	8.0	**	0.012	0.884	0.000	
N-04	5/5/2004	15:39	0.887	0.008	0.895		0.024	0.033	1.055	*	**	0.022	0.884	0.001	
N-04	7/9/2009	9:10	0.480	*0.025*	0.505	1.40	*0.250*	0.050	1.905	*	**	*0.008*	0.884	0.000	
N-05	10/3/2002	10:55	0.008	0.000	0.008		0.073	0.075	0.180	7.7	**	0.018	1.285	0.000	1
N-05	1/8/2003	11:13	1.378	0.009	1.387		0.050	0.061	1.406	9.0	**	0.013	0.179	0.003	0
N-05	7/8/2003	19:00	0.092	0.001	0.093		0.044	0.081	0.305	8.6	**	0.020	0.334	0.002	
N-05	5/6/2004	10:05	0.322	0.001	0.324		0.038	0.038	0.485	*	**	0.013	0.884	0.000	
N-05	7/9/2009	11:40	0.370	*0.025*	0.395	0.82	*0.250*	0.090	1.215	*	**	*0.008*	0.884	0.000	
N-06	10/2/2002	16:50	0.027	0.001	0.028		0.031	0.073	0.286	8.4	**	0.029	0.485	0.002	2
N-06	1/8/2003	8:54	2.071	0.013	2.084		0.045	0.059	2.098	9.2	**	0.013	0.136	0.005	0
N-06	7/8/2003	17:00	1.206	0.009	1.215		0.017	0.035	1.578	8.6	**	0.016	0.312	0.002	
N-06	5/6/2004	13:40	1.246	0.003	1.249		0.027	0.041	2.379	*	**	0.011	0.884	0.000	
N-06	7/9/2009	10:43	0.860	*0.025*	0.885	0.19	*0.250*	0.030	1.075	*	**	*0.008*	0.884	0.000	
N-06	8/24/2011	11:40	0.870	0.010	0.880	0.359	0.030	0.069	1.239	7.06	19.12	0.0781	1.949	0.000	
N-06	6/14/2012	10:45	0.836	0.102	0.938	0.321	0.071	0.046	1.259	7.08	18.61	0.1260	1.997	0.001	
N-06	8/14/2012	10:06	0.970	*0.001*	0.971	0.201	0.023	0.039	1.172	7.24	20.04	0.1630	1.678	0.001	
N-08	1/8/2003	11:35	0.610	0.004	0.614		0.017	0.042	0.751	9.0	**	0.006	0.167	0.002	1
N-08	7/8/2003	18:35	0.025	0.000	0.025		0.023	0.033	0.193	8.9	**	0.005	0.212	0.001	
N-09	10/2/2002	16:00	0.000	0.000	0.000		0.018	0.046	0.323	8.7	**	0.007	0.302	0.001	2
N-09	1/8/2003	12:50	2.199	0.009	2.208		0.046	0.071	2.414	8.9	**	0.018	0.212	0.004	0

Napa River Nutrient Delisting Water Quality Data

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
N-09	7/8/2003	20:45	0.936	0.005	0.941		0.024	0.046	1.125	8.9	**	0.019	0.208	0.004	
N-09	7/9/2009	10:18	0.060	*0.025*	0.085	1.30	*0.250*	0.050	1.385	*	**	0.027	0.884	0.001	
N-09	8/25/2011	10:25	0.470	0.009	0.479	0.284	0.050	0.074	0.763	7.68	19.27	0.0438	1.224	0.001	
N-09	6/14/2012	11:30	0.506	0.099	0.605	0.261	0.089	0.058	0.866	7.63	19.24	0.1230	1.293	0.002	
N-09	9/11/2012	10:05	*0.001*	*0.001*	0.002	0.432	*0.004*	0.071	0.434	7.82	16.59	*0.0200*	1.235	0.000	
N-11	1/7/2003	11:27	3.159	0.003	3.162		0.110	0.130	3.273	9.0	**	0.010	0.187	0.002	0
N-11	7/8/2003	11:10	1.919	0.001	1.921		0.075	0.086	2.133	8.8	**	0.003	0.225	0.001	
N-11	5/5/2004	18:50	2.900	0.043	2.943		0.072	0.081	3.362	*	**	0.004	0.884	0.000	
N-11	8/15/2011	10:25	0.440	*0.001*	0.441	0.387	0.070	0.072	0.828	6.60	15.46	*0.0030*	2.809	0.000	
N-11	6/14/2012	15:00	0.645	0.099	0.744	0.285	0.072	0.089	1.029	7.00	16.90	0.0820	2.304	0.000	
N-11	8/21/2012	9:49	0.264	*0.001*	0.265	0.402	0.115	0.088	0.667	6.61	15.94	0.0820	2.719	0.000	
N-13	10/2/2002	10:20	0.104	0.000	0.104		0.198	0.174	0.300	8.5	**	0.007	0.376	0.001	0
N-13	1/7/2003	10:48	0.609	0.007	0.616		0.085	0.090	0.720	9.0	**	0.004	0.167	0.001	0
N-13	7/8/2003	10:42	0.185	0.001	0.186		0.181	0.164	0.323	8.1	**	0.003	0.750	0.000	
N-13	5/5/2004	18:05	0.348	0.000	0.348		0.156		0.481	*	**	0.007	0.884	0.000	
N-13	7/9/2009	9:35	0.090	*0.025*	0.115	0.73	*0.250*	0.160	0.845	*	**	*0.008*	0.884	0.000	
N-14	1/7/2003	9:47	0.706	0.000	0.706		0.070	0.097	1.195	9.3	**	0.005	0.121	0.002	0
N-14	7/8/2003	10:00	0.001	0.001	0.000		0.026	0.087	0.320	7.9	**	0.010	1.030	0.000	
N-15	10/2/2002	13:50	0.097	0.000	0.097		0.014	0.026	0.333	8.5	**	0.008	0.379	0.001	1
N-15	1/7/2003	13:39	2.308	0.004	2.312		0.027	0.050	2.767	9.2	**	0.011	0.131	0.004	0
N-15	7/8/2003	14:14	0.781	0.004	0.785		0.014	0.025	1.072	8.7	**	0.014	0.292	0.002	
N-15	5/6/2004	14:48	1.731	0.006	1.737		0.006	0.014	2.519	*	**	0.028	0.884	0.001	
N-16	10/3/2002	12:30	0.018	0.000	0.018		0.022	0.033	0.249	7.9	**	0.004	0.962	0.000	0
N-16	1/7/2003	14:59	0.845	0.002	0.846		0.013	0.028	1.011	9.1	**	0.010	0.156	0.003	0
N-16	7/8/2003	15:30	0.092	0.002	0.093		0.029	0.051	0.339	8.9	**	0.017	0.193	0.004	
N-18	10/2/2002	13:15	0.029	0.000	0.029		0.012	0.044	0.280	8.3	**	0.003	0.582	0.000	9
N-18	1/7/2003	12:49	0.674	0.000	0.674		0.019	0.041	1.002	9.2	**	0.002	0.144	0.001	0
N-18	7/8/2003	13:24	0.348	0.002	0.349		0.010	0.030	0.586	8.9	**	0.007	0.193	0.002	
N-18	5/5/2004	16:02	0.848	0.003	0.850		0.017	0.037	1.083	*	**	0.014	0.884	0.000	
N-18	7/9/2009	13:08	0.115	*0.025*	0.140	1.25	*0.250*	0.040	1.390	*	**	*0.008*	0.884	0.000	
N-19	10/2/2002	8:50	0.152	0.005	0.156		0.055	0.093	0.604	8.1	**	0.040	0.750	0.002	0
N-19	1/7/2003	17:08	1.595	0.007	1.602		0.037	0.092	2.025	8.6	**	0.020	0.334	0.002	0
N-19	7/8/2003	9:10	0.163	0.003	0.166		0.007	0.051	0.488	8.4	**	0.026	0.509	0.002	
N-20	1/7/2003	15:26	0.599	0.004	0.603		0.023	0.022	0.973	9.2	**	0.002	0.130	0.001	0
N-23	10/2/2002		0.008	0.000	0.008		0.031	0.097	0.332	8	**	0.004	1.300	0.000	18
N-23	1/7/2003	14:20	1.835	0.006	1.841		0.058	0.092	2.129	9.0	**	0.028	0.187	0.007	0
N-23	7/8/2003	15:00	0.393	0.006	0.399		0.019	0.042	0.608	8.9	**	0.010	0.212	0.002	

Napa River Nutrient Delisting Water Quality Data

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
N-25	10/2/2002	17:30	0.001	0.001	0.002		0.065	0.099	0.303	8.3	**	0.043	0.536	0.003	3
N-25	1/8/2003	9:55	0.706	0.005	0.711		0.035	0.058	1.080	9.1	**	0.076	0.158	0.022	0
N-25	7/8/2003	17:31	0.132	0.005	0.137		0.026	0.062	0.327	8.3	**	0.019	0.563	0.001	
N-26	10/3/2002	9:55	0.522	0.001	0.524		0.041	0.050	0.449	8.5	**	0.009	0.431	0.001	0
N-26	1/8/2003	12:20	1.586	0.002	1.588		0.040	0.037	1.882	8.7	**	0.009	0.269	0.001	0
N-26	7/8/2003	17:56	0.979	0.002	0.981		0.052	0.064	1.226	8.5	**	0.012	0.423	0.001	
N-26	5/6/2004	11:05	0.970	0.003	0.973		0.046		1.115	*	**	0.013	0.884	0.000	
N-26	7/9/2009	11:08	0.100	*0.025*	0.125	0.16	*0.250*	0.060	0.285	*	**	*0.008*	0.884	0.000	
N-27	1/8/2003	11:59	0.375	0.001	0.376		0.037	0.032	0.351	8.7	**	0.002	0.307	0.000	0
N-30	10/2/2002	11:20	0.096	0.007	0.103		0.087	0.104	0.730	7.6	**	0.086	1.487	0.001	7
N-30	1/7/2003	10:25	1.720	0.003	1.723		0.059	0.089	1.992	9.4	**	0.049	0.103	0.024	0
N-30	7/8/2003	11:48	0.185	0.004	0.190		0.028	0.131	0.538	9.4	**	0.058	0.110	0.026	9
N-31	10/2/2002	18:25	0.014	0.000	0.015		0.053	0.063	0.110	8.2	**	0.008	0.705	0.000	0
N-31	1/7/2003	15:50	1.341	0.004	1.344		0.055	0.074	1.778	9.4	**	0.028	0.104	0.013	0
N-31	7/8/2003	16:01	0.536	0.004	0.540		0.046	0.073	0.765	9.0	**	0.012	0.185	0.003	
N-31	6/21/2012	13:50	0.237	0.001	0.238	0.153	0.096	0.055	0.391	7.85	20.66	0.131	0.914	0.004	
N-32	1/7/2003	13:12	0.649	0.000	0.649		0.022	0.061	0.686	8.9	**	0.002	0.215	0.000	0
N-32	7/8/2003	13:47	0.095	0.003	0.098		0.007	0.012	0.192	8.6	**	0.005	0.351	0.001	
N-32	8/16/2011	11:15	0.120	*0.001*	0.121	0.470	*0.004*	0.015	0.591	7.98	16.85	0.0605	0.980	0.002	
N-32	6/14/2012	14:00	0.307	0.001	0.308	0.2380	0.004	0.020	0.546	8.31	19.82	0.0790	0.484	0.006	
N-40	5/5/2004	16:17	0.456	0.002	0.458		0.020	0.026	0.574	*	**	0.011	0.884	0.000	
N-40	7/9/2009	12:59	0.140	*0.025*	0.165	2.20	*0.250*	0.050	2.365	*	**	*0.008*	0.884	0.000	
N-41	5/5/2004	16:45	0.857	0.001	0.858		0.015	0.022	0.938	*	**	0.006	0.884	0.000	
N-42	5/5/2004	17:45	0.489	0.001	0.490		0.196		0.592	*	**	0.004	0.884	0.000	
N-42	7/9/2009	9:45	0.240	*0.025*	0.265	0.22	*0.250*	0.210	0.485	*	**	*0.008*	0.884	0.000	
N-43	5/5/2004	18:20	2.957	0.000	2.958		0.071	0.097	3.306	*	**	0.015	0.884	0.000	
N-44	5/6/2004	9:44	0.254	0.002	0.256		0.057	0.069	0.430	*	**	0.010	0.884	0.000	
N-45	5/6/2004	10:17	1.303	0.001	1.304		0.186	0.203	1.399	*	**	0.013	0.884	0.000	
N-45	8/31/2011	11:30	0.100	*0.001*	0.101	0.344	0.060	0.115	0.445	7.42	19.22	0.0707	1.565	0.001	
N-45	6/14/2012	7:50	0.258	*0.001*	0.259	0.246	0.011	0.106	0.505	7.47	18.13	0.1090	1.613	0.001	
N-45	8/27/2012	10:50	*0.001*	*0.003*	0.004	0.664	0.101	0.156	0.668	7.47	15.74	0.0418	1.882	0.000	
N-46	5/6/2004	10:43	1.000	0.003	1.003		0.131	0.315	1.183	*	**	0.016	0.884	0.001	
N-47	5/6/2004	11:30	0.040	0.001	0.041		0.020		0.338	*	**	0.016	0.884	0.001	
N-48	5/6/2004	11:55	0.773	0.001	0.775		0.073	0.156	1.273	*	**	0.012	0.884	0.000	
N-49	5/6/2004	12:12	0.490	0.002	0.492		0.056	0.071	0.505	*	**	0.011	0.884	0.000	
N-50	5/6/2004	12:30	0.423	0.003	0.425		0.047	0.050	1.222	*	**	0.016	0.884	0.001	
N-50	8/29/2011	10:40	0.100	*0.001*	0.101	0.820	0.090	0.111	0.921	7.47	21.08	0.0838	1.333	0.001	

Napa River Nutrient Delisting Water Quality Data

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
N-50	6/14/2012	10:00	0.184	0.001	0.185	0.310	0.095	0.079	0.495	7.44	20.97	0.113	1.376	0.001	
N-51	5/6/2004	14:10	0.002	0.006	0.008		0.007	0.024	0.410	*	**	0.014	0.884	0.000	
N-52	5/6/2004	14:30	1.565	0.000	1.565		0.016	0.031	2.499	*	**	0.040	0.884	0.001	
N-52	7/9/2009	12:44	2.600	*0.025*	2.625	*0.03*	*0.250*	0.090	2.650	*	**	*0.008*	0.884	0.000	
N-52	8/9/2011	10:50	1.410	*0.001*	1.411	0.586	0.040	0.074	1.997	7.38	18.17	0.0580	1.726	0.000	
N-52	6/14/2012	13:25	0.137	0.104	0.241	0.366	0.096	0.093	0.607	7.50	21.84	0.1000	1.238	0.001	
N-52	8/9/2012	9:50	1.450	*0.001*	1.451	0.541	0.062	0.094	1.992	7.63	18.79	0.0520	1.332	0.001	
N-53	7/9/2009	8:36	0.060	*0.025*	0.085	2.30	*0.250*	0.100	2.385	*	**	0.029	0.884	0.001	
N-55	9/4/2012	10:15	0.072	*0.001*	0.073	0.610	0.039	0.056	0.683	7.50	17.99	0.0431	1.586	0.000	

* Denotes missing data where a mean pH of 8.0 was used for ammonia criteria calculations

** Denotes missing data where a mean temperature of 17oC was used for ammonia criteria calculations

***pH data from 2002-2004 time range was collected with unknown equipment and without explicit quality assurance project protocol with defined measurement quality objective.
Therefore, these data were not used for the pH line of evidence.

Values in italics were non-detects and the value half way between 0 and the minimum detection limit (MDL) was used for all calculations

Napa River Nutrient Delisting Benthic Algal Biomass and Environmental Data

Site Code	Sample Time	Sample Time	Percent macroalgae cover	Benthic algae chlorophyll a (mg/m2)	Average water depth (m)	Flow Discharge (Q, m3/s)	Avergae velocity (m/s)	Average shade and canopy cover (%)
N-02	08/23/11	11:35	2.9	18	0.065	0.033	0.23	94
N-02	09/13/12	10:45	0.0	43	0.081	0.004	0.03	95
N-03	08/15/12	10:10	0.0	69	0.048	0.004	0.03	94
N-03	08/02/11	10:42	0.0	47	0.099	0.013	0.04	91
N-06	08/24/11	11:40	9.5	72	0.278	0.186	0.15	65
N-06	08/14/12	10:06	10.5	*	0.299	0.016	0.01	72
N-09	08/25/11	10:25	58.1	162	0.284	0.116	0.07	74
N-09	09/11/12	10:05	45.7	41	0.354	0.011	0.01	65
N-11	08/15/11	10:25	7.6	108	0.357	0.002	0.00	90
N-11	08/21/12	9:49	4.8	103	0.301	0.000	0.00	89
N-32	08/16/11	11:15	29.5	136	0.094	0.010	0.02	77
N-45	08/27/12	10:50	3.8	30	0.332	0.001	0.00	75
N-45	08/31/11	11:30	1.9	50	0.288	0.026	0.01	76
N-50	08/29/11	10:40	1.9	43	0.281	0.114	0.04	48
N-52	08/09/11	10:50	23.8	84	0.189	0.016	0.03	72
N-52	08/09/12	9:50	12.4	56	0.200	0.003	0.00	85
N-55	09/04/12	10:15	6.7	161	0.624	0.010	0.00	41
* Data point rejected based on quality control								

Sonoma Creek Nutrient Delisting Water Quality Data

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
S-03	1/6/2003	11:02	1.530	0.003	1.534		0.095	0.111	2.504	9.5	**	0.009	0.103	0.005	0
S-03	7/7/2003	10:35	0.887	0.008	0.895		0.024	0.033	1.055	8.9	**	0.022	0.943	0.001	
S-03	5/5/2004	14:40	0.773	0.001	0.775		0.073	0.156	1.273	*	**	0.012	0.943	0.000	
S-03	7/9/2009	9:17	*0.025*	*0.025*	0.050	0.64	*0.250*	0.240	0.690	*	**	0.036	0.943	0.001	
S-04	1/6/2003	11:50	1.375	0.001	1.376		0.072	0.090	1.761	8.7	**	0.008	0.297	0.001	0
S-04	7/7/2003	11:00	0.696	0.009	0.705		0.053	0.064	0.986	8.7	**	0.032	0.943	0.001	
S-04	5/5/2004	13:39	1.303	0.001	1.304		0.186	0.203	1.399	*	**	0.013	0.943	0.000	
S-05	10/1/2002	12:15	2.049	0.004	2.052		0.066	0.085	2.305	8.5	**	0.013	0.943	0.000	0
S-05	1/6/2003	12:40	1.454	0.001	1.455		0.054	0.068	1.619	9.1	**	0.005	0.166	0.001	0
S-05	7/7/2003	12:35	1.530	0.005	1.536		0.015	0.015	1.593	9.5	**	0.020	0.943	0.001	
S-05	5/5/2004	11:40	1.246	0.003	1.249		0.027	0.041	2.379	*	**	0.011	0.943	0.000	
S-05	7/9/2009	9:52	*0.025*	*0.025*	0.050	0.11	*0.250*	0.090	0.160	*	**	*0.008*	0.943	0.000	
S-05	9/12/2011	11:05	0.139	*0.001*	0.140	0.766	0.064	0.107	0.906	7.67	18.59	0.0103	1.293	0.000	
S-05	6/21/2012	12:05	0.198	*0.001*	0.199	0.230	0.109	0.076	0.429	7.97	20.11	0.0700	0.805	0.003	
S-05	8/29/2012	8:45	0.060	*0.001*	0.061	0.174	0.069	0.083	0.235	7.83	17.34	0.0327	1.162	0.001	
S-06	10/1/2002	15:40	1.561	0.006	1.568		0.077	0.095	1.792	8.6	**	0.025	0.943	0.001	0
S-06	1/6/2003	14:08	1.495	0.001	1.496		0.049	0.071	1.694	9.6	**	0.005	0.098	0.003	0
S-06	7/7/2003	14:05	0.589	0.008	0.597		0.056	0.066	0.885	9.1	**	0.045	0.943	0.001	
S-06	7/9/2009	10:11	*0.025*	*0.025*	0.050	0.22	*0.250*	0.080	0.270	*	**	*0.008*	0.943	0.000	
S-06	9/13/2011	11:55	0.175	*0.001*	0.176	0.718	0.060	0.103	0.894	8.01	17.73	0.0900	0.887	0.003	
S-06	6/21/2012	11:15	0.359	0.098	0.457	0.356	0.107	0.110	0.813	8.18	18.22	0.0820	0.663	0.004	
S-06	8/28/2012	10:20	0.044	*0.001*	0.045	0.567	0.075	0.081	0.612	8.08	18.32	0.0418	0.769	0.002	
S-08	10/1/2002	10:00	0.489	0.001	0.490		0.196		0.592	7.5	**	0.004	0.943	0.000	12
S-08	1/6/2003	9:58	1.521	0.001	1.522		0.059	0.113	1.976	9.3	**	0.011	0.135	0.004	0
S-08	7/7/2003	9:45	0.456	0.002	0.458		0.020	0.026	0.574	8.4	**	0.011	0.943	0.000	1
S-09	1/6/2003	10:30	2.154	0.009	2.163		0.168	0.206	4.076	9.1	**	0.064	0.175	0.017	0
S-09	7/7/2003	10:10	2.227	0.003	2.230		0.059	0.066	2.326	8.9	**	0.010	0.943	0.000	
S-09	7/9/2009	9:06	*0.025*	*0.025*	0.050	0.67	*0.250*	0.230	0.720	*	**	0.025	0.943	0.001	
S-10	10/1/2002	14:15	0.348	0.000	0.348		0.156		0.481	8.4	**	0.007	0.943	0.000	0
S-10	1/6/2003	13:12	0.093	0.000	0.093		0.044	0.060	0.288	9.2	**	0.004	0.140	0.001	0
S-11	10/1/2002	15:00	0.286	0.011	0.297		0.069	0.098	0.861	8.9	**	0.014	0.943	0.000	0
S-11	1/6/2003	13:40	1.442	0.001	1.443		0.048	0.063	1.467	9.4	**	0.006	0.110	0.003	0
S-11	7/7/2003	13:35	0.203	0.000	0.203		0.043	0.055	0.272	9.2	**	0.004	0.943	0.000	
S-12	10/1/2002	16:15	2.957	0.000	2.958		0.071	0.097	3.306	8.5	**	0.015	0.943	0.000	0
S-12	1/6/2003	14:46	1.611	0.001	1.613		0.050	0.076	1.897	9.4	**	0.006	0.117	0.003	0
S-12	7/7/2003	14:30	2.900	0.043	2.943		0.072	0.081	3.362	9.7	**	0.004	0.943	0.000	
S-12	7/9/2009	10:22	0.210	*0.025*	0.235	0.15	*0.250*	0.080	0.385	*	**	*0.008*	0.943	0.000	

Sonoma Creek Nutrient Delisting Water Quality Data

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
S-12	9/6/2011	11:30	0.170	0.009	0.179	0.573	0.060	0.094	0.752	8.14	16.49	0.0857	0.789	0.003	
S-12	6/21/2012	10:35	0.559	0.099	0.658	0.352	0.111	0.080	1.010	8.26	17.58	0.0780	0.607	0.004	
S-12	8/22/2012	9:55	0.229	*0.001*	0.230	0.193	*0.004*	0.085	0.423	8.09	17.03	0.0420	0.823	0.002	
S-13	10/1/2002	17:21	0.016	0.000	0.016		0.072	0.084	0.136	8.8	**	0.005	0.943	0.000	1
S-13	1/6/2003	15:48	1.616	0.004	1.619		0.045	0.072	1.780	9.3	**	0.003	0.123	0.001	0
S-13	7/7/2003	15:15	0.536	0.009	0.545		0.041	0.073	0.790	8.8	**	0.034	0.943	0.001	
S-13	5/5/2004	9:35	1.000	0.003	1.003		0.131	0.315	1.183	*	**	0.016	0.943	0.000	
S-13	9/7/2011	11:27	1.160	0.010	1.170	0.382	0.060	0.096	1.552	8.07	15.54	0.0581	0.934	0.002	
S-13	6/21/2012	10:00	1.200	*0.001*	1.201	0.209	0.111	0.088	1.410	8.08	15.20	0.1260	0.941	0.004	
S-13	8/8/2012	10:05	1.070	*0.001*	1.071	0.327	0.056	0.077	1.398	8.05	15.40	*0.0200*	0.971	0.001	
S-13	7/9/2009	10:39	1.600	*0.025*	1.625	*0.03*	*0.250*	0.085	1.650	*	**	*0.008*	0.943	0.000	
S-14	10/1/2002	18:00	1.105	0.019	1.124		0.062	0.094	1.399	8.6	**	0.041	0.943	0.001	0
S-14	1/6/2003	16:51	0.166	0.000	0.166		0.033	0.056	0.251	9.5	**	0.002	0.101	0.001	0
S-14	5/5/2004	10:40	0.254	0.002	0.256		0.057	0.069	0.430	*	**	0.010	0.943	0.000	
S-14	7/9/2009	11:15	0.110	*0.025*	0.135	*0.03*	*0.250*	0.080	0.160	*	**	*0.008*	0.943	0.000	
S-14	8/10/2011	10:15	0.250	*0.002*	0.252	0.396	0.040	0.065	0.648	8.22	14.45	0.0590	0.793	0.002	
S-14	6/21/2012	8:35	0.272	*0.001*	0.273	0.700	0.096	0.058	0.973	8.32	14.03	0.0700	0.692	0.004	
S-14	9/5/2012	10:15	0.112	*0.001*	0.113	0.377	0.062	0.066	0.490	8.16	13.57	0.0292	0.923	0.001	
S-14	7/7/2003	15:45	0.072	0.000	0.072		0.026	0.035	0.152	8.6	**	0.006	0.943	0.000	
S-22	1/6/2003	11:20	1.388	0.001	1.389		0.053	0.076	1.693	9.3	**	0.008	0.128	0.003	0
S-22	7/7/2003	11:15	0.586	0.009	0.595		0.038	0.151	0.836	8.7	**	0.009	0.943	0.000	
S-22	5/5/2004	14:19	1.565	0.000	1.565		0.016	0.031	2.499	*	**	0.040	0.943	0.001	
S-22	7/9/2009	9:28	*0.025*	*0.025*	0.050	0.23	*0.250*	0.080	0.280	*	**	*0.008*	0.943	0.000	
S-23	1/6/2003	15:07	1.381	0.001	1.382		0.042	0.050	1.558	9.2	**	0.006	0.146	0.002	0
S-23	7/7/2003	14:40	0.970	0.003	0.973		0.046		1.115	9.0	**	0.013	0.943	0.000	
S-24	1/6/2003	16:25	0.079	0.000	0.079		0.025	0.046	0.154	9.5	**	0.001	0.106	0.001	0
S-24	7/7/2003	16:35	0.857	0.001	0.858		0.015	0.022	0.938	8.9	**	0.006	0.943	0.000	
S-24	7/9/2009	11:01	*0.025*	*0.025*	0.050	0.06	*0.250*	0.050	0.110	*	**	*0.008*	0.943	0.000	
S-24	8/1/2011	11:20	0.200	*0.001*	0.201	0.622	0.030	0.037	0.823	7.94	14.78	0.0439	1.184	0.001	
S-24	6/21/2012	7:55	0.175	*0.001*	0.176	0.583	0.086	0.043	0.759	7.98	13.78	0.0870	1.194	0.002	
S-24	8/13/2012	9:10	0.223	*0.001*	0.224	0.461	0.049	0.046	0.685	7.70	15.91	0.0400	1.487	0.001	
S-25	1/6/2003	18:05	1.546	0.004	1.550		0.094	0.152	2.711	9.4	**	0.012	0.120	0.005	0
S-26	1/7/2003	8:50	1.498	0.002	1.500		0.075	0.117	1.729	9.6	**	0.010	0.098	0.005	0
S-26	7/7/2003	11:35	0.848	0.003	0.850		0.017	0.037	1.083	9.0	**	0.014	0.943	0.000	
S-30	5/5/2004	10:05	0.002	0.006	0.008		0.007	0.024	0.410	*	**	0.014	0.943	0.000	
S-30	8/8/2011	10:15	0.280	0.010	0.290	0.632	0.020	0.106	0.922	7.61	16.64	0.0644	1.561	0.001	
S-30	6/21/2012	9:00	0.404	*0.001*	0.405	0.565	*0.004*	0.050	0.970	7.60	16.08	0.1360	1.635	0.002	

Site Code	Sample Date	Sample Time	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate + Nitrite (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	OrthoPhosphate as P,Dissolved (mg/L)	Phosphorus as P,Total (mg/L)	Total Nitrogen (mg/L)	pH***	Temperature (°C)	Ammonia as N,Total (mg/L)	EPA Chronic Total Ammonia Nitrogen threshold (mg/L)	un-ionized ammonia NH3 Calc (mg/L)	Water Column Chl-a (mg/L)
S-30	8/16/2012	9:07	0.272	*0.001*	0.273	0.315	*0.004*	0.051	0.588	7.88	16.61	0.0400	1.142	0.001	
S-31	5/5/2004	11:02	0.322	0.001	0.324		0.038	0.038	0.485	*	**	0.013	0.943	0.000	
S-32	5/5/2004	10:18	1.731	0.006	1.737		0.006	0.014	2.519	*	**	0.028	0.943	0.001	
S-32	8/30/2011	10:25	0.190	*0.001*	0.191	0.701	0.030	0.074	0.892	7.70	15.30	0.0576	1.547	0.001	
S-32	6/21/2012	9:25	0.302	*0.001*	0.303	0.437	*0.004*	0.052	0.740	7.93	16.13	0.2580	1.101	0.006	
S-32	9/6/2012	10:25	0.021	*0.001*	0.022	0.322	0.027	0.058	0.344	7.97	14.03	0.0360	1.192	0.001	
S-33	5/5/2004	12:20	0.423	0.003	0.425		0.047	0.050	1.222	*	**	0.016	0.943	0.000	
S-34	5/5/2004	14:00	0.490	0.002	0.492		0.056	0.071	0.505	*	**	0.011	0.943	0.000	
S-35	5/5/2004	13:12	0.040	0.001	0.041		0.020		0.338	*	**	0.016	0.943	0.001	
S-36	9/14/2011	10:50	0.207	0.009	0.216	0.615	0.051	0.093	0.831	7.77	18.45	0.1100	1.165	0.002	
S-36	6/21/2012	13:00	0.232	*0.001*	0.233	0.341	0.107	0.072	0.574	8.06	20.88	0.1160	0.672	0.005	
S-36	8/23/2012	8:45	0.235	*0.001*	0.236	0.144	0.057	0.073	0.380	7.67	18.32	*0.0200*	1.316	0.000	

* Denotes missing data where a mean pH of 8.0 was used for ammonia criteria calculations

** Denotes missing data where a mean temperature of 17oC was used for ammonia criteria calculations

***pH data from 2002-2004 time range was collected with unknown equipment and without explicit quality assurance project protocol with defined measurement quality objective. Therefore, these data were not used for the pH line of evidence.

Values in italics were non-detects and the value half way between 0 and the minimum detection limit (MDL) was used for all calculations

Sonoma Creek Nutrient Delisting Benthic Algal Biomass and Environmental Data

Site Code	Sample Time	Sample Time	Percent macroalgae cover	Benthic algae chlorophyll a (mg/m2)	Average water depth (m)	Flow Discharge (Q, m3/s)	Avergae velocity (m/s)	Average shade and canopy cover (%)
S-05	08/29/12	8:45	9.5	31	0.459	0.014	0.00	73
S-05	09/12/11	11:05	16.2	45	0.293	0.155	0.05	60
S-06	09/13/11	11:55	28.6	108	0.312	0.120	0.05	59
S-06	08/28/12	10:20	13.3	37	0.365	0.010	0.00	72
S-12	09/06/11	11:30	10.5	34	0.159	0.107	0.09	87
S-12	08/22/12	9:55	12.4	48	0.167	0.015	0.01	90
S-13	09/07/11	11:27	4.8	71	0.195	0.090	0.10	90
S-13	08/08/12	10:05	0.0	110	0.195	0.030	0.03	91
S-14	08/10/11	10:15	1.9	35	0.098	0.046	0.15	95
S-14	09/05/12	10:15	1.9	96	0.105	0.001	0.00	98
S-24	08/13/12	9:10	9.5	30	0.143	0.001	0.00	93
S-24	08/01/11	11:20	1.9	20	0.125	0.010	0.03	94
S-30	08/08/11	10:15	17.1	62	0.200	0.015	0.03	71
S-30	08/16/12	9:07	1.0	50	0.181	0.001	0.00	70
S-32	09/06/12	10:25	1.0	53	0.184	0.002	0.00	86
S-32	08/30/11	10:25	0.0	61	0.198	0.007	0.01	85
S-36	09/14/11	10:50	29.5	259	0.206	0.157	0.11	44
S-36	08/23/12	8:45	13.3	27	0.216	0.007	0.00	54