Appendix B Nutrient Target Development

Contents

B.1 Preface

The purpose of this appendix is to develop and present nutrient numeric water quality criteria for eight different waterbody-type categories within the Pajaro River basin. As discussed previously in the TMDL report, in terms of biostimulation a single, uniform nutrient numeric water quality criterion is generally not appropriate to be applied universally in all surface waters of a given state, river basin or ecoregion. At the larger geographic scales, natural ambient nutrient concentrations and associated biostimulatory risks in surface waters are highly variable due to variations in vegetation, hydrology, climate, geology and other natural factors. As such, it is important to consider natural variability of nutrient concentrations locally at smaller and higher-resolution geographic scales.

B.2 Background

The Central Coast Basin Plan has narrative criteria regarding biostimulatory substances, which states: "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses." They do not however specify what levels of algal growth constitute a nuisance.

The Water Board is required to develop technically defensible numeric water quality targets that are protective of the Basin Plan's narrative objective for biostimulatory substances. Targets should be based on established methodologies or peer-reviewed numeric criteria. It is important to recognize that definitive and unequivocal scientific certainty is not necessary in a TMDL process with regard to development of nutrient water quality targets protective against biostimulation. Numeric targets should be scientifically defensible, but are not required to be definitive. Eutrophication is an ongoing and active area of research. If the water quality objectives and numeric targets for biostimulatory substances are changed in the future, then any TMDLs and allocations that are potentially adopted for biostimulatory substances pursuant to this project may sunset and be superseded by revised water quality objectives.

Recent research on biostimuation on inland surface waters from an agricultural watershed in the California central coast region indicates that existing nutrient numeric water quality objectives found in the Basin Plan (i.e., the 10 mg/L nitrate-nitrogen MUN objective) is unlikely to reduce benthic algal growth below even the highest water quality benchmarks[1]. Therefore, the 10 mg/L nitrate-nitrogen objective is insufficiently protective against biostimulatory impairments. Consequently, staff concludes that it is necessary to set nutrient numeric targets more stringent than the existing numeric objectives found for nitrate in the Basin Plan (i.e., the 10 mg/L MUN objective).

In USEPA (2000) nutrient criteria guidance for streams, three general approaches for criteria setting are recommended:

(1) Statistical analysis of data: identification of reference reaches for each stream class based on best professional judgment or percentile selections of data plotted as frequency distributions;

(2) use of predictive relationships (e.g., trophic state classifications, models, biocriteria); and

(3) application and/or modification of established nutrient/algal thresholds (e.g., nutrient concentration thresholds or algal limits from published literature).

USEPA (2000) states that a weight of evidence approach combining any or all of the three approaches above will produce criteria of greater scientific validity.

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[1] University of California, Santa Cruz. 2010. Final Report: Long-term, high resolution nutrient and sediment monitoring and characterizing in-stream primary production. Proposition 40 Agricultural Water Quality Grant Program. Dr. Marc Los Huertos, Ph.D., project director.

USEPA-recommended approaches for developing nutrient criteria.

USEPA-Recommended Approaches	Approach Assessed in this TMDL project?	Methodology	Notes
Use of **Predictive Relationships** (modeling; biocriteria)	☑	California NNE Approach	Staff used NNE benthic biomass model tool to supplement and corroborate targets based on USEPA-recognized statistical approaches
Statistical Analysis of Data	☑	USEPA-recommended statistical analysis: 25th percentile of nutrient data for stream population	Staff used USEPA recognized[h] statistical approach in development of nutrient numeric criteria.
Use of established concentration **thresholds from published literature**	☑	USEPA published nutrient criteria for Ecoregion III, Subecoregion 6	Staff evaluated USEPA ecoregional criteria. Staff finds subecoregion III-6 criteria are inappropriate, and over-protective for the TMDL project area . The ecoregional-scale approach lumps together streams of with significantly different characteristics: headwater streams, alluvial valley streams, coastal confluence streams, etc. USEPA itself recognizes ecoregional criteria may not sufficiently address local variation.

Staff followed USEPA guidance in developing draft target with the goal being to account for physical and hydrologic variation within the TMDL project area (see *Nutrient Criteria Technical Guidance Manual, River and Streams* - USEPA July 2000). Nutrient criteria need to be developed to account for natural variation existing at the regional and basin level. Different waterbody processes and responses dictate that nutrient criteria be specific to waterbody type. No single criterion will be sufficient for each waterbody type. USEPA recommends classifying and group streams by type or comparable characteristics (e.g., fluvial morphology, hydraulics, physical, biological or water quality attributes). Classification will allow criteria to be identified on a broader scale rather than a site-specific scale. The aforementioned stream classification recommendation by USEPA is supported by recent research published for California's central coast region, as illustrated below:

> "*Sections of the Pajaro River watershed have been listed by the State of California as impaired for nutrient and sediment violations under the Clean Water Act ……**The best evidence linking elevated nutrient concentrations to algae growth was shown when the stream physiography, geomorphology, and water chemistry were incorporated into the survey and analysis."****
>
> ***emphasis added*
>
> *From: University of California, Santa Cruz. Final Report: Long-Term, High Resolution Nutrient and Sediment Monitoring and Characterizing In-stream Primary Production. Proposition 40 Agricultural Water Quality Grant Program.*

Staff used USEPA's 25th percentile approach for developing nutrient targets. 25th percentile values are characterized by USEPA as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000)[2]. This is because the 25th percentile of the entire population has been shown by USEPA to represent a surrogate for an actual reference population.

An additional line of evidence for establishing nutrient water quality targets in the TMDL project area was provided by an application of the California Nutrient Numeric Endpoint (California NNE) approach (Tetra Tech 2006). Use of the USEPA 25th percentile approach in conjunction with the NNE spreadsheet provide an additional line of evidence, and also may help corroborate the reasonableness USEPA 25th percentile approach nutrient targets.

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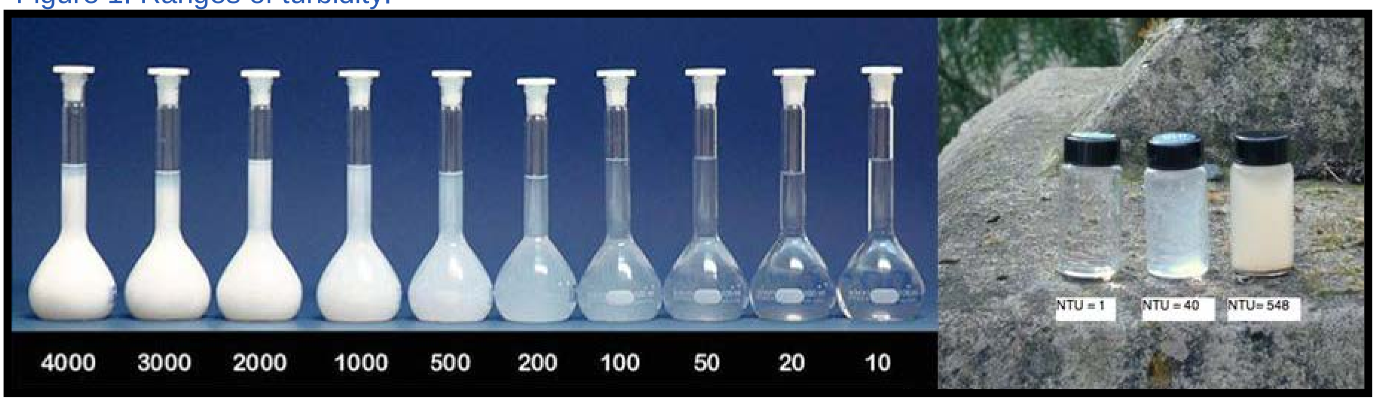
[2] U.S. Environmental Protection Agency. 2000. Nutrient Criteria Technical Guidance Manual, River and Streams. EPA-822-B-00-002.

It is important to recognize that the Calif. NNE spreadsheet tool is highly sensitive to user inputs for tree canopy shading and turbidity. Shading and turbidity have significant effects on light availability, and consequently photosynthesis and potential biostimulation. The light extinction coefficient is an important input parameter to the NNE spreadsheet tool. This coefficient is calculated in the spreadsheet as a function of turbidity. Higher levels of turbidity can preclude good sunlight penetration:

> *"...when nutrients are as high as they are in this system, talking about limiting nutrients probably isn't that relevant. In those cases,* ***light is probably what actually limits production*** *either* ***because of turbidity*** *which keeps overall biomass low or surface blooms which reduce light levels at depth."**
>
> **emphasis added*
>
> *— Dr. Jane Caffrey (University of West Florida), personal communication to Water Board staff, Sept. 12, 2011*

Nutrient target results provided by the NNE spreadsheet tool can vary substantially, based on even small changes in turbidity input. As such, it important it is to have plausible canopy and turbidity conditions that are reasonably representative of reach-scale conditions. The default value in the NNE spreadsheet tool is 0.6 NTU. The USEPA (2000) ecoregional criteria (Ecoregion III-6) for turbidity in reference conditions is 1.9 NTU. Both of these values (0.6 NTU and 1.9 NTU) represent ambient conditions in relatively undisturbed reference streams. It should be noted that relatively, undisturbed ambient turbidity conditions in some agricultural alluvial valley floor waterbodies may be closer to 20 or 30 NTU. For illustrative purposes, Figure 1 illustrates the appearance of water with various ranges of turbidity.

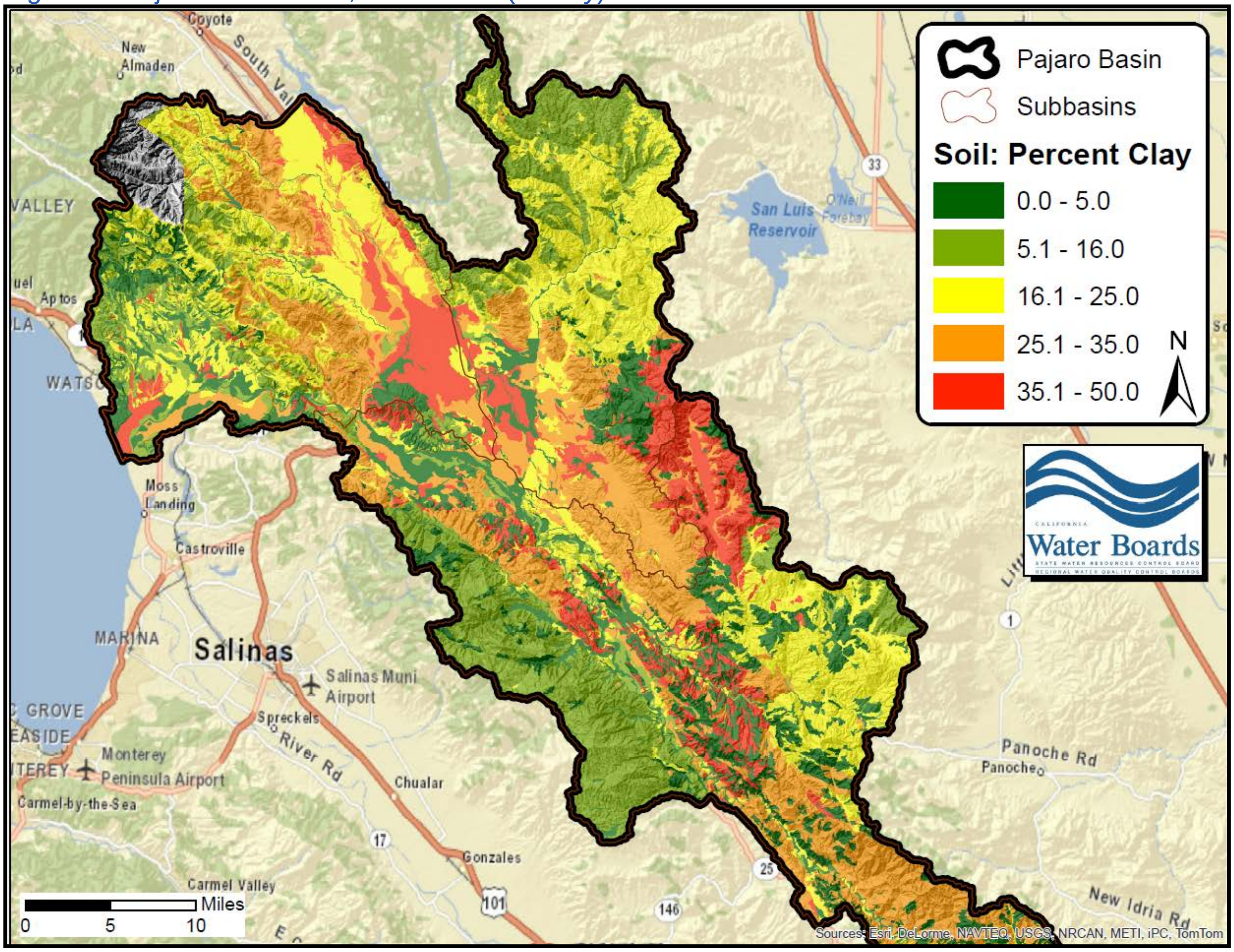
Figure 1. Ranges of turbidity.



Additionally, the benthic sediment composition of streams is an important factor to consider, because the physical characteristics of stream substrates may play a role in algal productivity; for example, by influencing the turbidity (and therefore, light availability) of the overlying water column.

A cursory evaluation of regional soil textures and regional geology illustrate the substantial variability in soil conditions even at the reach-scale or subwatershed-scale. Figure 2 illustrates soil textures in terms of percent clay in the Pajaro River basin. Turbidity conditions in agricultural alluvial valleys with clay-rich soils and substrates would often be expected to have substantially different ambient turbidity conditions relative to stream reaches in upland areas, or in areas underlain by consolidated bedrock and sandy soil and substrate conditions. It should be recognized that unlike sand, silt, or gravel, which are typically transported as bedload, clay is often transported in colloidal suspension in the water column even at very low stream velocities, thereby contributing to ambient turbidity.

Figure 2. Pajaro River basin, soil texture (% clay).



The basis for staff's previous comment about the expectation of higher ambient turbidity levels in agricultural drainages (up to 20 or 30 NTU) are summarized below:

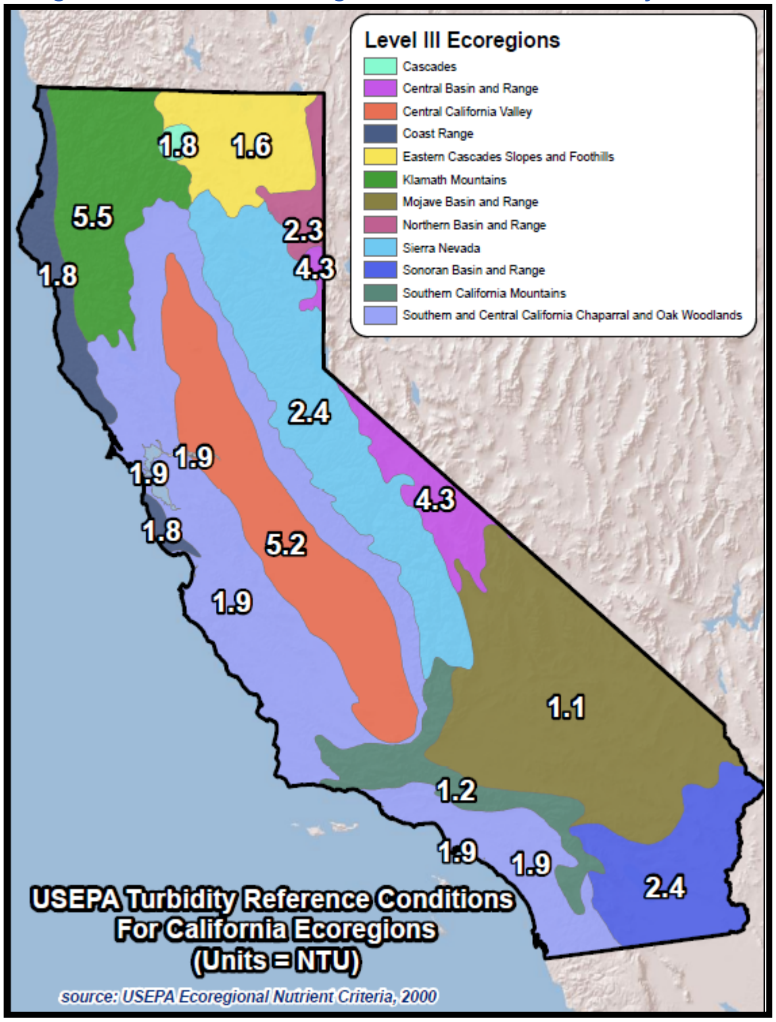
1) Peer-reviewed literature: It is recognized in the peer-reviewed literature that the hydraulics and substrates of agricultural water conveyance structures, such as canals and ditches, are often substantially different than natural streams, and can result in higher levels of turbidity under relatively undisturbed conditions.

> ***"The turbidity of irrigation water increases as it travels through delivery ditches, which are bare earth and add suspended solids via erosion"***
>
> *From: Research Article - "Monitoring helps reduce water-quality impacts in flood-irrigation pasture". Ken Tate, Donald Lancaster, Julie Morrison, David Lile, Yukako Sado, and Betsy Huang, in California Agriculture 59(3):168-175.*

2) Agricultural drain monitoring data: A large body of monitoring data from agricultural drains in the Central Valley, Salinas Valley, and the Pajaro Valley of California indicate that an average expected 25th percentile of turbidity data is 21 NTU (representing a relatively unimpacted condition) – see the figure below. This is consistent with staff's comment in the project report about the expectation of relatively higher levels and valley floor agricultural drainages.

Further, expected relatively undisturbed conditions in agricultural drainages could be around 20 NTU, which is far higher than natural streams. The USEPA ecoregional criteria for subecoregion 1.9 NTU (see Figure 3), which is unreasonably low for many agricultural valley floor drainages.

Figure 3. USEPA ecoregional criteria for turbidity.



As turbidity is a sensitive input value into the Calif. NNE spreadsheet tool, staff concluded that plausible reach-scale turbidity inputs should represent a range from relatively undisturbed (ambient-25th percentile of data population) conditions to lightly-to-moderately disturbed conditions at the high end. Higher turbidity conditions that may reflect substantial anthropogenic activities and impacts were not included in the NNE spreadsheet inputs.

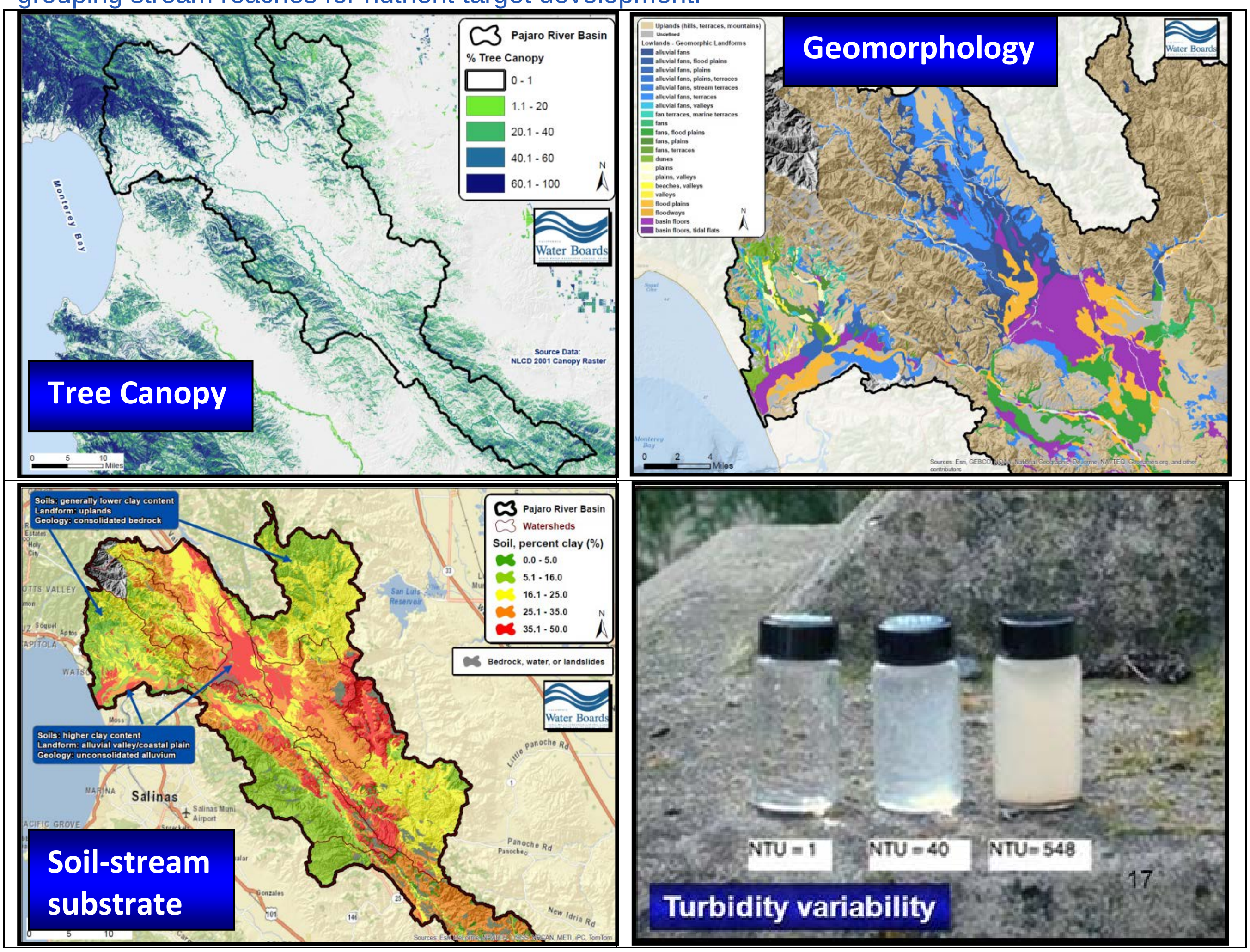
This approach conceptually is also consistent with the recommendations received from a scientific peer reviewer for this TMDL project:

> *"I would argue that the turbidity conditions that drive NNE modeling should be indicative of the* ***ambient or moderately disturbed conditions****."*
>
> - Dr. Marc Beutel, Washington State University, peer reviewer for this TMDL project (see Attachment 5 of Resolution No. R3-2013-0008)
>
> ***** emphasis added by Water Board staff

In fact, the upper, high-end NNE spreadsheet turbidity values staff used (dry season geomean – see sections B.5 through B.12) can plausibly be characterized as a lightly-to-moderately disturbed conditions. As our peer review referee Dr. Buetel, suggests above, it would be reasonable to use a range of ambient to *moderately disturbed turbidity* inputs in the NNE spreadsheet runs to represent reach conditions under which there are not substantial anthropogenic inputs. Turbidity values (dry season geomean) for each stream grouping in the TMDL project area are generally an order of magnitude lower than year-round averages (arithmetic mean) turbidity for each respective stream grouping. Therefore, staff maintains that the dry-season geomean turbidity value of each stream grouping can fairly be characterized as a lightly-to-moderately disturbed condition; e.g. they are substantially lower than the average or median measures of turbidity in each respective stream grouping.

Staff used field observations and digital datasets for tree canopy cover (source: National Land Cover Dataset, 2001) as presented in the Project Report, to estimate plausible canopy shading for stream categories. Additionally, as noted previously, stream geomorphology and stream physiography is important to consider with respect to establishing linkages between nutrient concentrations and algal growth (UC Santa Cruz, 2010)[3]. Consequently, staff used geomorphic classifications and soil properties data from the NRCS-SSURGO database (presented in the Project Report) to assist in classifying and grouping streams with comparable characteristics. Figure 4 conceptually illustrates some of the stream-reach and water column properties staff evaluated in grouping and classifying stream reaches with comparable characteristics, consistent with USEPA guidance.

Figure 4. Conceptual illustration of stream reach and water column characteristics used by staff in grouping stream reaches for nutrient target development.



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[3] University of California, Santa Cruz. 2010. Final Report: Long-term, high resolution nutrient and sediment monitoring and characterizing in-stream primary production. Proposition 40 Agricultural Water Quality Grant Program. Dr. Marc Los Huertos, Ph.D., project director.

B.3 California Nutrient Numeric Endpoints Approach

As noted previously, an additional line of evidence for establishing nutrient water quality targets in the TMDL project area was provided by an application of the California Nutrient Numeric Endpoint (California NNE) approach (Tetra Tech 2006). The California NNE approach is to use nutrient response indicators to develop potential nutrient water quality criteria. The California NNE approach also includes a set of relatively simple spreadsheet scoping tools for application in lake/reservoir or river systems to assist in evaluating the translation between response indicators (e.g. algal biomass) and nutrient concentrations. Accordingly, staff used the California NNE benthic biomass spreadsheet tool to develop potential water quality targets for the response indicator (e.g., benthic chlorophyll a density and corresponding estimated algal biomass density). These targets determine how much algae can be present without impairing designated beneficial uses. Numeric models (e.g., QUAL2K) are then used to convert the initial water quality targets for the response variables into numeric targets for nutrients.

The California NNE Approach Defines three risk categories for indicators (measures of algal growth and oxygen deficit): 1) Presumably unimpaired; 2) Potentially impaired; 3) Likely impaired. Additional detail on the three risk categories is provided by TetraTech, 2007, as reproduced below:

> The California NNE approach recognizes that there is no clear scientific consensus on precise levels of nutrient concentrations or response variables that result in impairment of a designated use. To address this problem, waterbodies are classified in three categories, termed Beneficial Use Risk Categories (BURCs). BURC I waterbodies are not expected to exhibit impairment due to nutrients, while BURC III waterbodies have a high probability of impairment due to nutrients. BURC II waterbodies are in an intermediate range, where additional information and analysis may be needed to determine if a use is supported, threatened, or impaired. Tetra Tech (2006) lists consensus targets for response indicators defining the boundaries between BURC I/II and BURC II/III.

The table below if from the published Tetra Tech, Inc. nutrient numeric endpoint guidance for the state of California and synthesizes the consensus BURC boundaries for various secondary indicators developed by TetraTech for the California NNE approach. The BURC II/III boundary provides an initial scoping point to establish minimum requirements for a TMDL.

Nutrient Numeric Endpoints for Secondary Indicators – Risk Classification Category Boundaries: I & II and II & III

Beneficial Use Risk-Category I. Presumptive unimpaired (use is supported).
Beneficial Use Risk Category II. Potentially impaired (may require an impairment assessment)
Beneficial Use Risk Category III. Presumptive impaired (use is not supported or highly threatened)

RESPONSE VARIABLE	RISK – CATEGORY BOUNDARY	BENEFICIAL USE						
		COLD	WARM	REC-1	REC-2	MUN[1]	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-a/m²) Maximum	I / II	100	150	C	C	100	100	B
	II / III	150	200	C	C	150	150	B
Planktonic Algal Biomass in Lakes and Reservoirs (as µg/L Chl-a)[2] – summer mean	I / II	5	10	10	10	5	A	B
	II / III	10	25	20	25	10	A	B
Clarity (Secchi depth, meters.)[3] – lakes summer mean	I / II	A	A	2	2	A	A	B
	II / III	A	A	1	1	A	A	B
Dissolved Oxygen (mg/l) Streams – the mean of the 7 daily minimums	I / II	9.5	6.0	A	A	A	8.0	C
	II / III	5.0	4.0	A	A	A	5.0	C
pH maximum – photosynthesis driven	I / II	9.0	9.0	A	A	A	C	C
	II / III	9.5	9.5	A	A	A	C	C
DOC (mg/l)	I / II	A	A	A	A	2	A	A
	II / III	A	A	A	A	5	A	A

A = No direct linkage
B = More research needed to quantify linkage
C = Addressed by Aquatic Life Criteria

[1] For application to zones within water bodies that include drinking water intakes.
[2] Reservoirs may be composed of zones or sections that will be assessed as individual water bodies
[3] Assumes that lake clarity is a function of algal concentrations, does not apply in waters of high non-algal turbidity

Staff developed nitrogen and phosphorus NNE nutrient targets in this appendix using existing NNE predictor run spreadsheet templates developed by the Water Board's Central Coast Ambient Monitoring Program staff available at http://www.ccamp.us/nne/nne_runs/

B.4 Nutrient Target Selection

In developing nutrient targets, it is important to recognize that

1) ambient nutrient concentrations in and of themselves, are not sufficient to predict the risk of biostimulation. because algal productivity depends on several additional factors such as stream morphology, hydraulics, light availability, etc., and
2) An important tenet of the California NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions.

Staff developed targets by using a combination of recognized methods to bracket and calibrate nutrient targets appropriate to local conditions, and that are credibly neither over-protective nor under-protective. The USEPA nutrient criteria technical guidance manual for rivers prescribes a combination of several approaches when developing water quality criteria for nutrients, including

1) the application of reference conditions;
2) predictive stressor-response relationships; and
3) values from existing literature.

Both USEPA and researchers (UC Santa Cruz, 2010-refer back to footnote 1) have recognized that combining these approaches help in the development of scientifically valid numeric objectives for nutrients. Staff used a range recognized nutrient target development methodologies, the USEPA recognized statistical-approaches, and the CA NNE approach. Additionally, staff identified a plausible range of ambient reach-scale stream conditions to account for local variation. This is consistent with USEPA guidance to group streams by type or comparable characteristics, thereby allowing nutrient criteria to be applied such that they account for spatial variations in stream characteristics.

The aforementioned approaches have different strengths. The CA NNE is a predictive modeling approach that helps establish concentrations at which nutrients can have detrimental effects on the biological health of a stream. The 25th percentile approach is a statistical approach, which can provide a plausible approximation of nutrient concentrations one might expect during a relatively undisturbed state and given local conditions. An important tenet of the California NNE approach (Tetra Tech 2006)[4] is that targets should not be set lower than the value expected under background or relatively undisturbed conditions. Therefore, the 25th percentile USEPA approach can help satisfy the caveat those targets should not be set lower than expected under local background, or relatively undisturbed conditions.

Further, staff received guidance from a researcher with expertise in central coast biostimulation problems that nutrient targets should not be more stringent than nutrient concentrations found in natural watershed systems. Staff used this guidance in the Pajaro River basin as well and applied the USEPA reference stream methodology (75th percentile approach) which ensures that biostimulation nutrient targets are no more stringent than nutrient concentrations found in natural or lightly-disturbed headwater and tributary reaches in the Pajaro River basin.

In summary, staff was able to evaluate a range of plausible nutrient targets for identified stream reaches using the strengths of various approaches. After establishing plausible ranges of potential nutrient targets using the aforementioned methodologies, the development and selection of final nutrient TMDL targets were determined using the following hierarchical approach, as illustrated below:

Summary of published technical guidance used by staff in nutrient target development:

- ✓ Using a combination of recognized approaches (i.e., literature values, statistical approaches, predictive modeling approaches) result in criteria of greater scientific validity (source: USEPA, 2000. Nutrient Criteria Manual).
- ✓ Classify and group streams needing nutrient targets, based on similar characteristics (source: USEPA, 2000. Nutrient Criteria Manual).
- ✓ Targets should not be lower than expected concentrations found in background/natural conditions (source: Calif. NNE guidance – TetraTech, 2006).

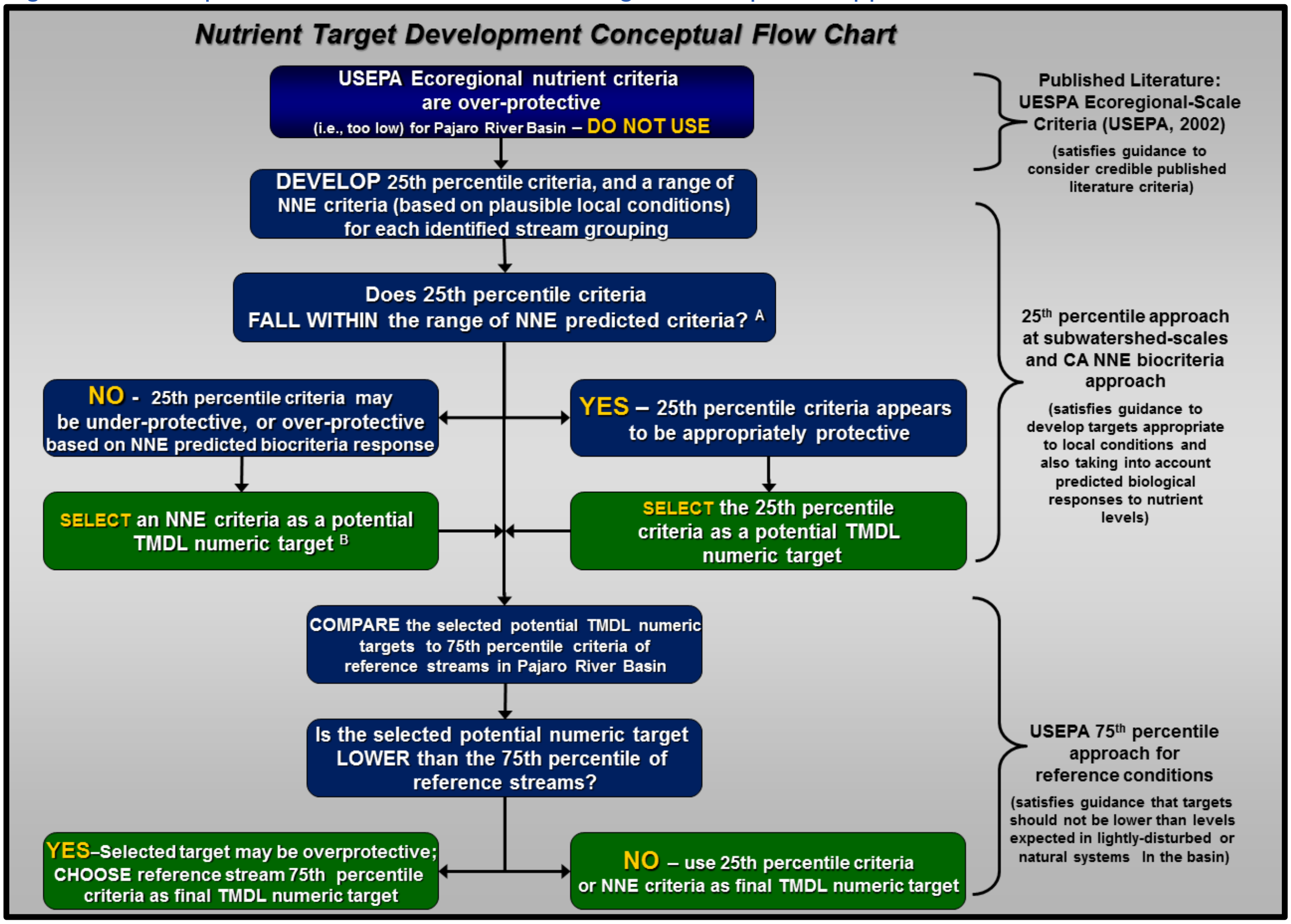
Also worth noting, USEPA recently stated that total nitrogen concentrations in streams which are protective against biostimulatory effects should generally be expected to be substantially lower than the 10 mg/L drinking water quality standard which has been applied to nitrate as N:

> *"(A)n excess amount of nitrogen in a waterway may lead to low levels of oxygen and negatively affect various plant life and organisms…An acceptable range of total nitrogen is **2 mg/L to 6 mg/L***, though it is recommended to check tribal, state, or federal standards…"*
>
> *From USEPA, 2013a, "Total Nitrogen" fact sheet, revised June 4, 2013*
>
> *******emphasis added by Central Coast Water Board staff*

See Figure 5 for a conceptual flow chart of the nutrient target development approach used in this TMDL project.

[4] TetraTech. 2006. Technical approach to develop nutrient numeric endpoints for California. Prepared for USEPA Region IX (Contract No. 68-C-02-108 to 111)

Figure 5. Conceptual flow chart of the nutrient target development approach



Notes:

A Orthophosphate targets developed with percentile-based approaches were not calibrated to NNE results. NNE only provides results for total phosphorus, which may not be a good measure of orthophosphate. In contract, nitrate typically comprises over 95% of water column total Nitrogen (TN) in project area streams; therefore, nitrate is a plausible surrogate for total nitrogen and can be compared to NNE TN target predictions.

B Where the 25th percentile numeric criteria is clearly under-protective, the marginally less stringent NNE numeric target is selected because central coast researchers have suggested that while it is reasonable to set lower nutrient numeric targets on stream reaches with limited anthropogenic sources, it may be prudent in areas with significant human disturbances to have less stringent targets until more information is available (source: Prop. 40 Nutrient Study–Pajaro River Watershed, 2011 – Project Lead: Dr. Marc Los Huertos). Where the 25th percentile numeric criteria is clearly over-protective, the next most stringent NNE numeric target was chosen, which is presumed to represent an intermediate end point between the most stringent and least stringent numeric criteria estimates developed for the stream category.

The CA NNE spreadsheet tool only calculates total phosphorus targets. In general, total phosphorus is not an adequate measurement of water column orthophosphate. Orthophosphate is only a fraction of total water column phosphorus. CA NNE calculations of total phosphorus generally appear to estimate targets that are lower than values expected under natural conditions in the Pajaro River basin. As such, in some cases NNE predictions for phosphorus water quality criteria could be reasonably considered over-protective. As such, staff followed guidance to develop targets that are not below (i.e., more stringent) than concentrations expected under natural conditions. Therefore, staff used 25th percentile levels of orthophosphate for stream group categories as potential TMDL numeric targets unless the 25th percentiles or NNE calculations fell below these background numbers. There were only two instances in which this occurred (South Santa Clara Valley and Soap Lake basin) and in these cases, staff chose the intermediate value as TMDL numeric targets.

The following sections of this Appendix present the information and methodologies pertaining to the development of nutrient targets for eight different types of waterbody categories within the Pajaro River basin.

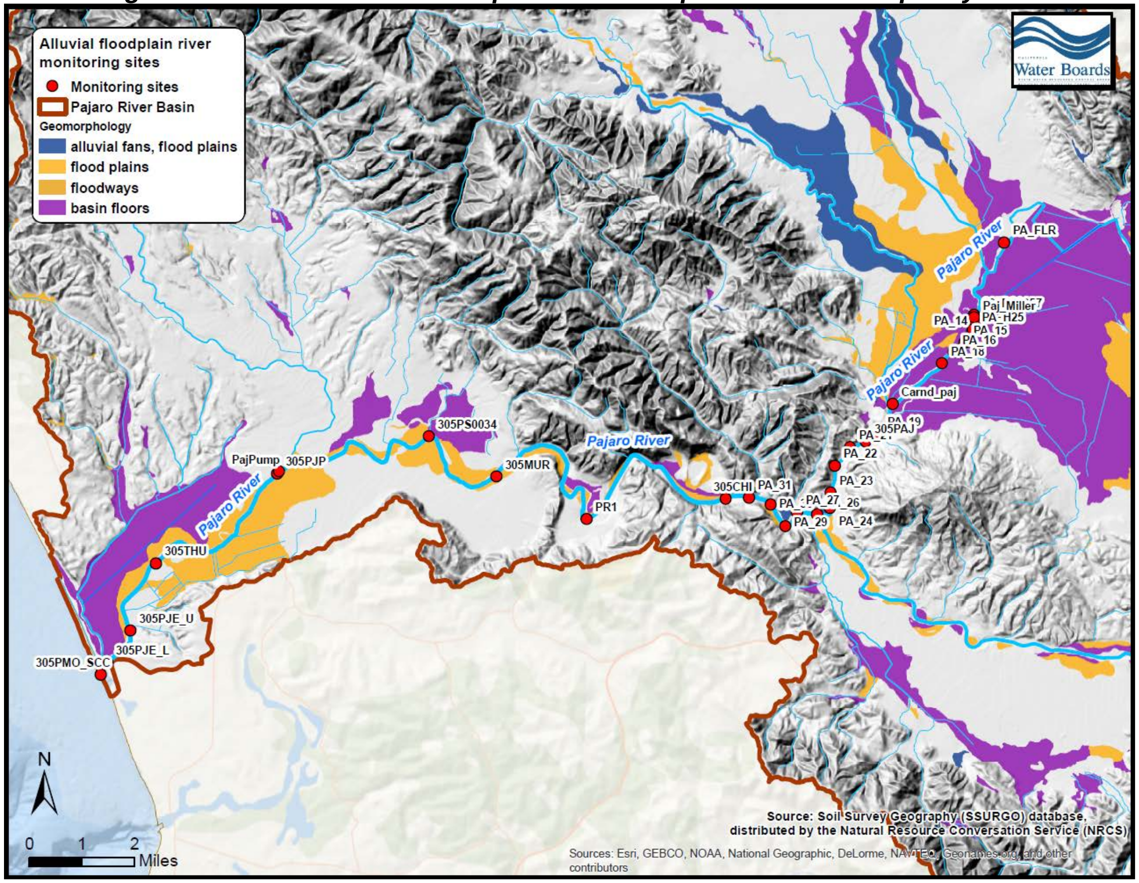
B.5 Pajaro River – Alluvial Floodplain River

B.5.1 Alluvial floodplain river - 25th Percentile Targets

Stream Conditions

- Geomorphic description: Alluvial floodplain. Low gradient, slopes less than 1 degree (source: NRCS-SSURGO)
- Waterbodies: Pajaro River
- Estimated riparian tree canopy: close to 20% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Quite variable, ranging from silty clay loam, gravelly coarse sand, gravelly sandy loam, clay (source: NRCS-SSURGO)
- Turbidity conditions: 21 NTU (geomean-dry season, May-Oct.); 9 NTU (25th percentile, dry season, May-Oct).

Monitoring sites used for alluvial floodplain river 25th percentile water quality data



Alluvial floodplain: Statistical summary	
Pajaro River **Statistical summary of nitrate as N (mg/L)**	
Temporal representation	May 1952 – Dec. 2013
Mean	6.97
Median	6.32
Minimum	0.00
Maximum	34.14
No. of samples	2,528
25th percentile	3.90

Alluvial floodplain: Statistical summary	
Pajaro River **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	April 1972 - Dec. 2013
Mean	0.12
Median	0.09
Minimum	0.00
Maximum	3.50
No. of samples	2,081
25th percentile	0.05

B.5.2 Pajaro River – Alluvial Floodplain River Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The Pajaro River is specifically designated for cold freshwater aquatic habitat (COLD) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for COLD beneficial use.

Site:	Pajaro River - Alluvial Floodplain
Analyst:	S. Keeling
Date:	2/19/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 20% Tree Canopy Closure

- Ambient (low) Turbidity:

9 NTU turbidity = 25th percentile of May-Oct. samples of Pajaro River alluvial floodplain monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	491	217	649

	Latitude	Month Range	
Estimate	37.00	May	Oct

Stream Inputs

Stream Depth (m)	0.75
Stream Velocity (m/s)	0.3
Water Temperature (°C)	15.8
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	20
Light Extinction Coeff. (1/m)	1.372

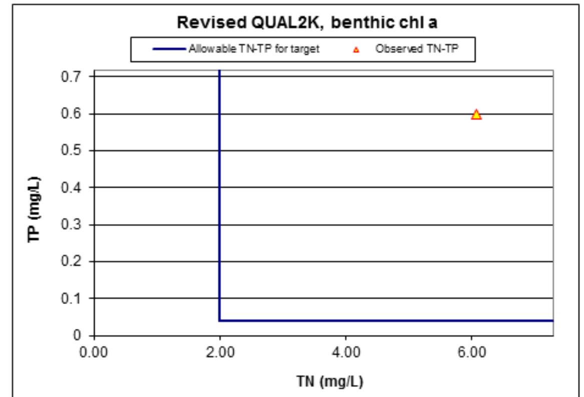
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	3.43



Allowable TN: 2 Allowable TP: 0.041

Site:	Pajaro River - Alluvial Floodplain
Analyst:	S. Keeling
Date:	2/19/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 25% Tree Canopy Closure

- Geomean Dry Season Turbidity:

21 NTU turbidity = turbidity geomean of May-Oct samples of Pajaro River alluvial floodplain monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	491	217	649

	Latitude	Month Range	
Estimate	37.00	May	Oct

Stream Inputs

Stream Depth (m)	0.75
Stream Velocity (m/s)	0.3
Water Temperature (°C)	15.8
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	25
Light Extinction Coeff. (1/m)	2.491

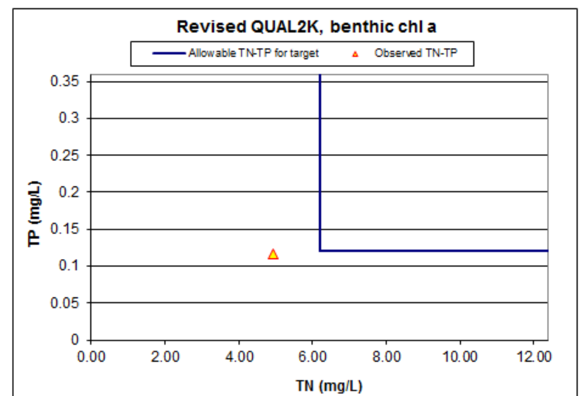
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

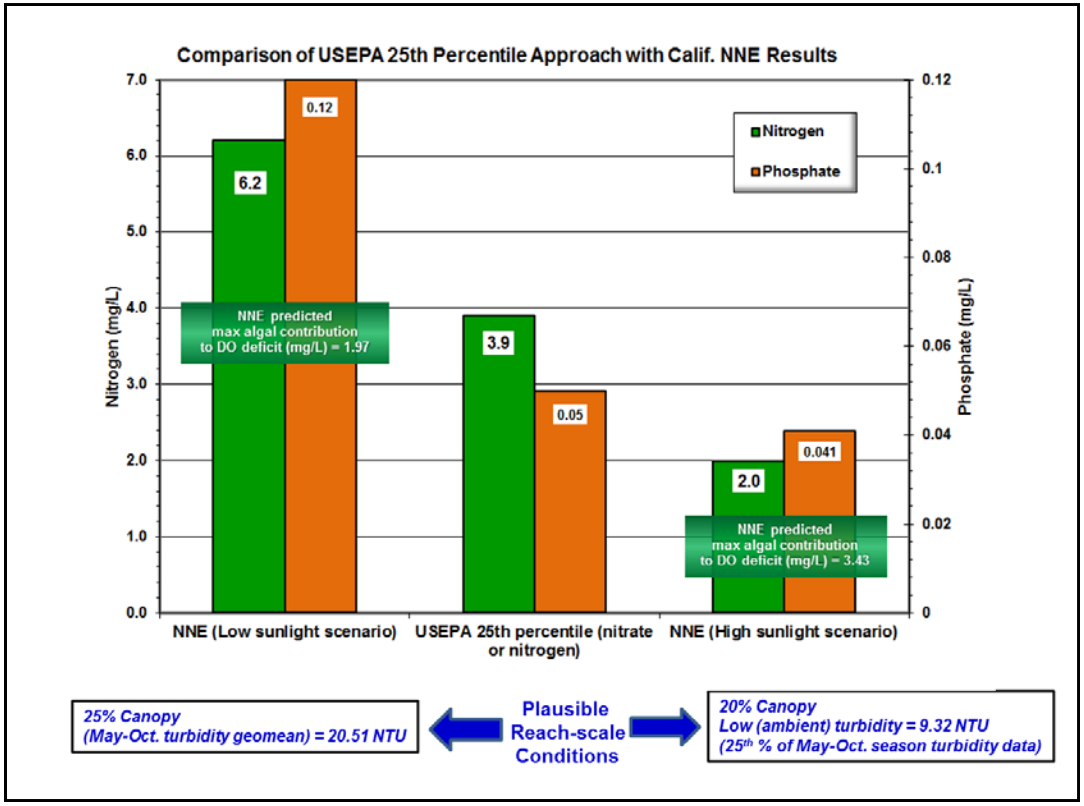
Max algal contribution to DO deficit (mg/L)	1.97



Allowable TN: 6.2 Allowable TP: 0.12

B.5.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Pajaro River – Alluvial Floodplain River)

The USEPA 25th percentile targets shown previously are show relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. This suggests the 25th percentile targets are in reasonably good agreement with NNE predicted nutrient targets that are based on plausible ranges of observed local conditions. It is important to note that the 25th percentiles are calculated on nitrate-N and orthophosphate-P. These constituents are not directly comparable to the total N and total P results that the Calif. NNE spreadsheet tool provides, nevertheless nitrate is typically overwhelming majority of total water column nitrogen in project area inland streams, Orthophosphate is estimated to generally (but not always) be the largest fraction of water column phosphorus in project area inland streams. For purposes of comparing the 25th percentile methodology and the NNE approach, nitrate and orthophosphate are plausible surrogates for total N and P in project area streams. The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the 25th percentile criteria for nitrate **(3.9 mg/L)** is in between the NNE criteria Higher Sunlight scenario and the NNE Lower Sunlight scenario. Consistent with the nutrient target development approach outlined in Section B.4, the 25th percentile is identified here as a potential numeric target. For orthophosphate, the 25th percentile is lower than background reference conditions and would be overly conservative. Therefore, the background reference condition for orthophosphate **(0.14 mg/L)** is selected as potential numeric targets for this stream reach.



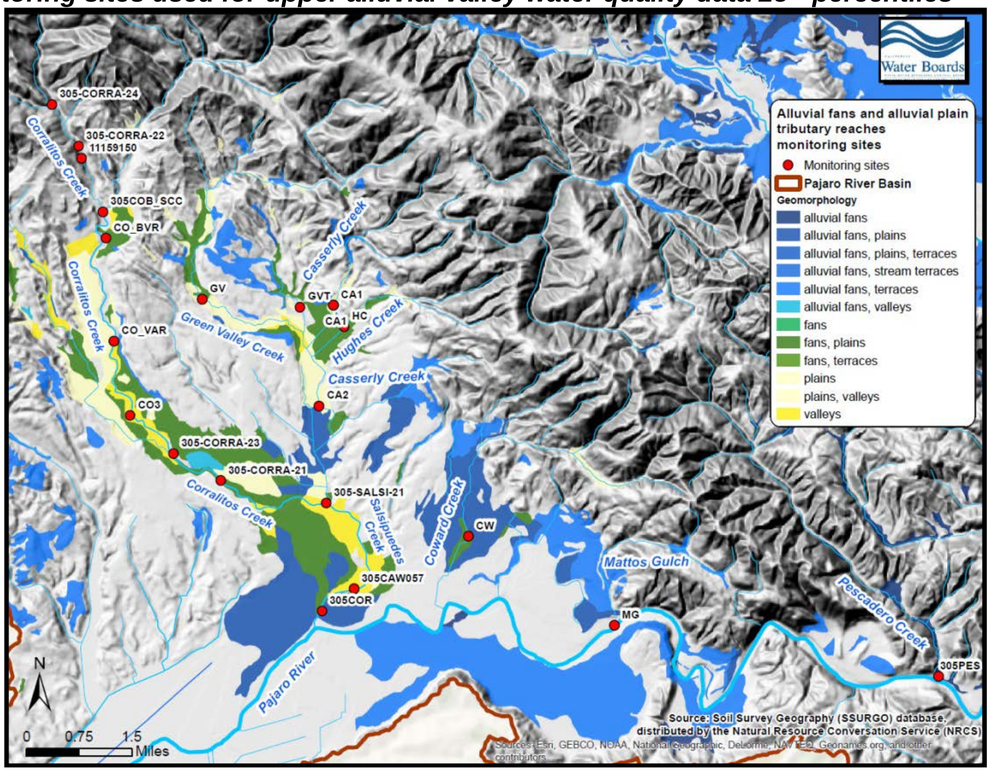
B.6 Pajaro Valley – Alluvial Fans & Plains Tributary Creeks

B.6.1 Alluvial Valley – Alluvial Fan and Plains 25th Percentile Targets

Stream Conditions

- Geomorphic description: Alluvial fans and alluvial plains (source: NRCS-SSURGO).
- Waterbodies: Casserly Creek, Corralitos Creek, Coward Creek, Green Valley Creek, Hughes Creek, Mattos Gulch, Pescadero Creek, and Salsipuedes Creek
- Estimated riparian tree canopy: Varies, but generally 40% to 50% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Sand-rich - generally coarse sand, sandy loam, loamy sand (source: NRCS-SSURGO)
- Turbidity conditions: 2 NTU (geomean-dry season, May-Oct.); 0.1 NTU (25th percentile, dry season, May-Oct)

Monitoring sites used for upper alluvial valley water quality data 25th percentiles



Alluvial fan & plains, tributary creeks: Statistical summary	
Pajaro River tributaries **Statistical summary of nitrate as N (mg/L)**	
Temporal representation	Dec. 1997 - Dec. 2013
Mean	3.41
Median	1.11
Minimum	< 0.0
Maximum	116.6
No. of samples	1,726
25th percentile	0.11

Alluvial fan & plains, tributary creeks: Statistical summary	
Pajaro River tributaries **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	Dec. 1997 - Dec. 2013
Mean	0.21
Median	0.07
Minimum	0.01
Maximum	19.6
No. of samples	1,429
25th percentile	0.01

B.6.2 Pajaro Valley – Alluvial Fans & Plains Tributary Creeks Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The Pajaro River tributary creeks are specifically designated for cold freshwater aquatic habitat (COLD) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for COLD beneficial use.

Site:	Pajaro River tributaries
Analyst:	S. Keeling
Date:	2/19/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 40% Tree Canopy Closure

- Ambient (low) Turbidity:

0.1 NTU turbidity = 25th percentile of May-Oct. samples of Pajaro River alluvial fans and plains tributary creeks monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	491	217	649

	Latitude	Month Range	
Estimate	37.00	May	Oct

Stream Inputs

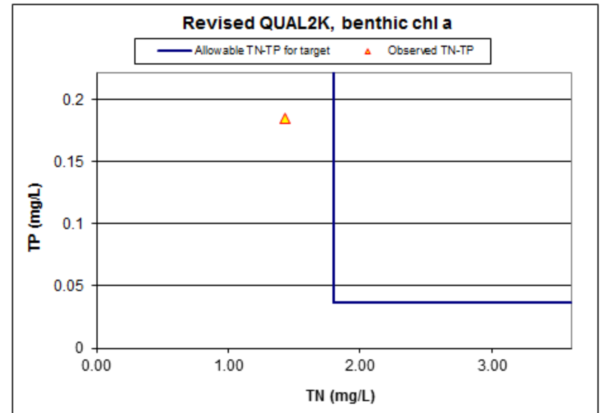
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	15.1
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	40
Light Extinction Coeff. (1/m)	0.445 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	2.18



Allowable TN: 1.8	Allowable TP: 0.037

Site:	Pajaro River tributaries
Analyst:	S. Keeling
Date:	2/19/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 50% Tree Canopy Closure

- Geomean Dry Season Turbidity:

2 NTU turbidity = turbidity geomean of May-Oct samples of Pajaro River alluvial fans and plains tributary creeks monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	491	217	649

	Latitude	Month Range	
Estimate	37.00	May	Oct

Stream Inputs

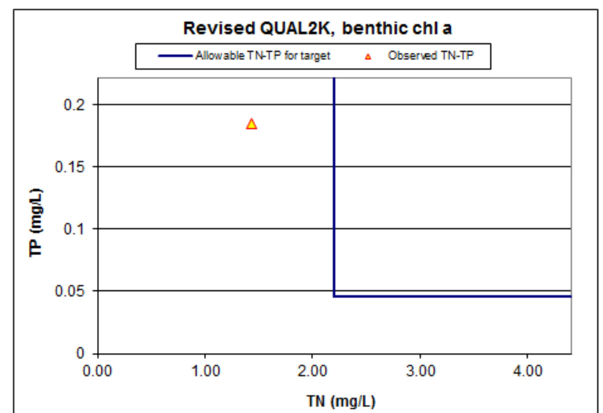
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	15.1
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	50
Light Extinction Coeff. (1/m)	0.652 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

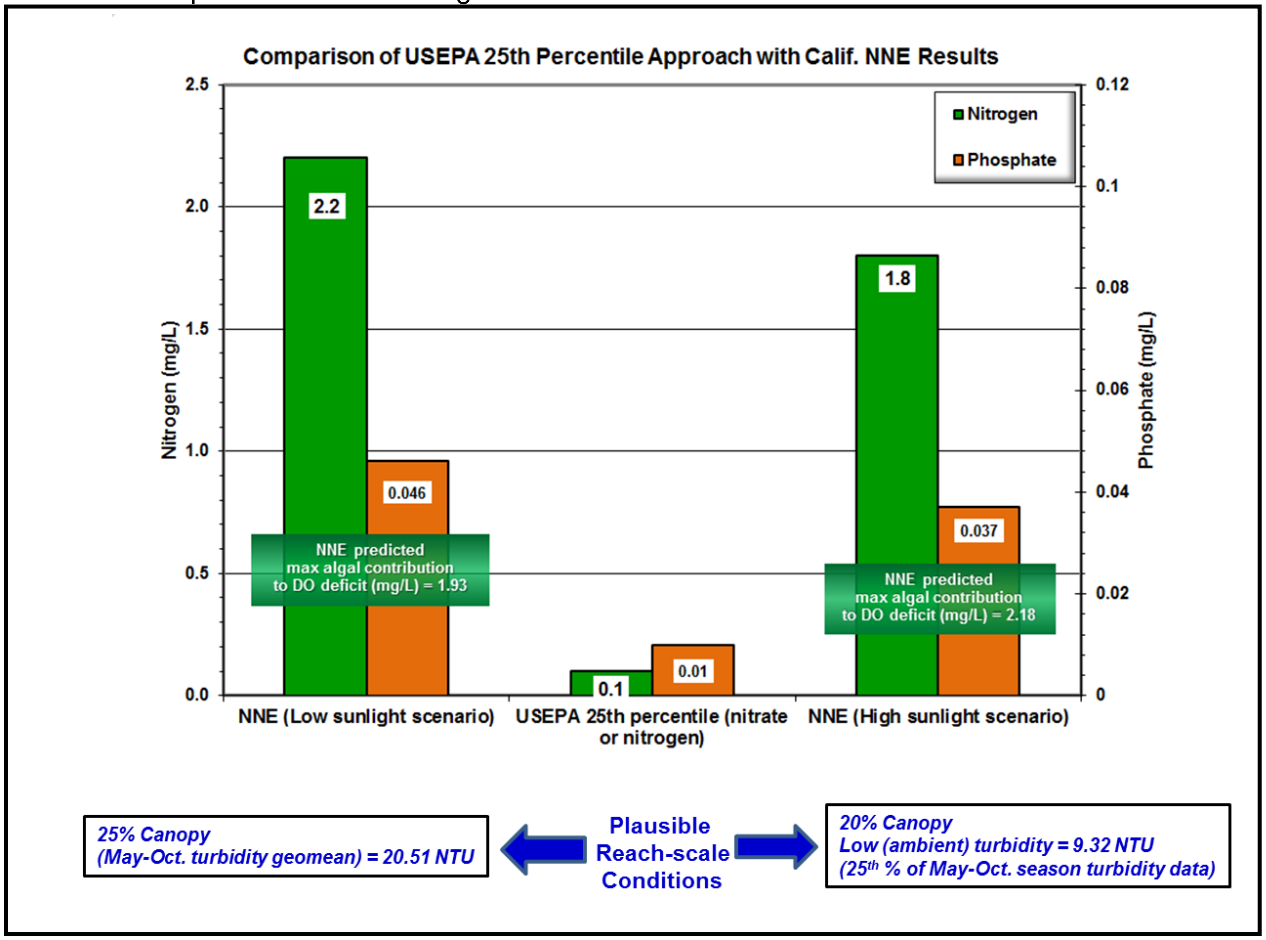
Max algal contribution to DO deficit (mg/L)	1.93



Allowable TN: 2.2	Allowable TP: 0.046

B.6.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Pajaro Valley Alluvial Fans & Plains Tributary Creeks)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the 25th percentile criteria for nitrate (0.1 mg/L) is much lower than both the NNE Higher and Lower Sunlight Availability scenarios. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Higher Sunlight Availability for nitrate **(1.8 mg/L)** is identified here as a potential numeric target. For orthophosphate, the 25th percentile and both NNE scenarios are lower than background reference conditions and would be overly conservative. Therefore, the background reference condition for orthophosphate **(0.14 mg/L)** is selected as potential numeric targets for this stream reach.



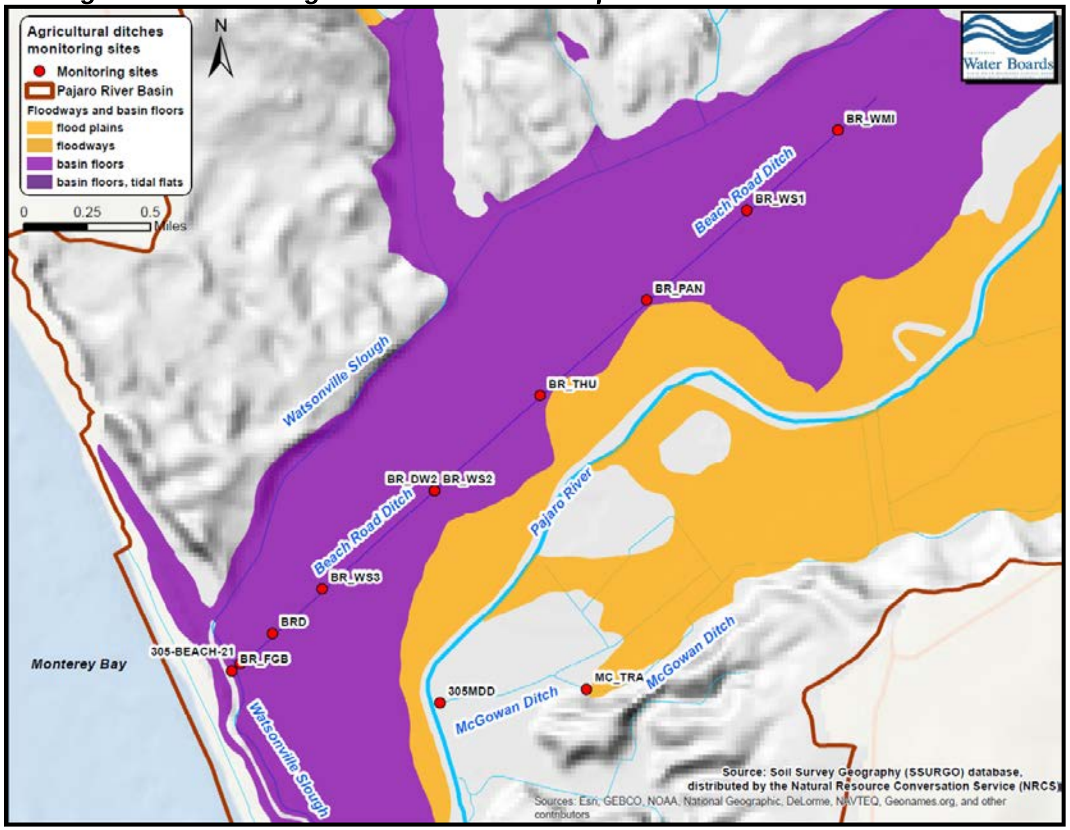
B.7 Pajaro Valley – Agricultural Ditches

B.7.1 Agricultural ditches – 25th Percentile Targets

Stream Conditions

- Geomorphic description: Coastal flood plain, basin floors. (source: NRCS-SSURGO)
- Waterbodies: Beach Road Ditch, McGowan Ditch
- Estimated average riparian tree canopy: 0-15% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Clay and clay loams to stratified sand and sandy loams (source: NRCS-SSURGO)
- Turbidity conditions: 19 NTU (geomean-dry season, May-Oct.); 8 NTU (25th percentile - dry season, May-Oct).

Monitoring sites used for Agricultural ditches 25th percentiles



Agricultural ditches: Statistical summary	
Beach Road and McGowan Ditches **Statistical summary of nitrate as N (mg/L)**	
Temporal representation	Sept. 1994 – Dec. 2013
Mean	40.57
Median	40.3
Minimum	< 0.0
Maximum	315
No. of samples	1,150
25th percentile	22.16

Agricultural ditches: Statistical summary	
Beach Road and McGowan Ditches **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	Oct. 2000 – Dec. 2013
Mean	0.25
Median	0.12
Minimum	< 0.0
Maximum	4.95
No. of samples	1,118
25th percentile	0.06

B.7.2 Pajaro Valley – Agricultural Ditches Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

These agricultural ditches of the Pajaro Valley are not specifically designated for a specific beneficial use in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for WARM beneficial use.

Site:	Agricultural Ditches
Analyst:	S. Keeling
Date:	2/19/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

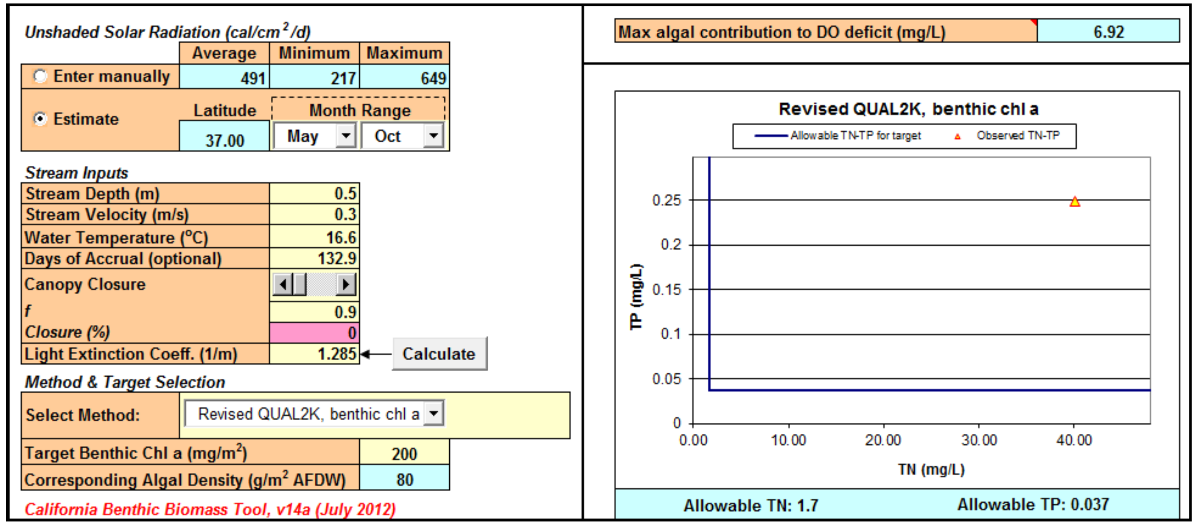
Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity:

8 NTU turbidity = 25th percentile of May-Oct. samples of Pajaro River agricultural ditches monitoring sites.



Site:	Agricultural Ditches
Analyst:	S. Keeling
Date:	2/19/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

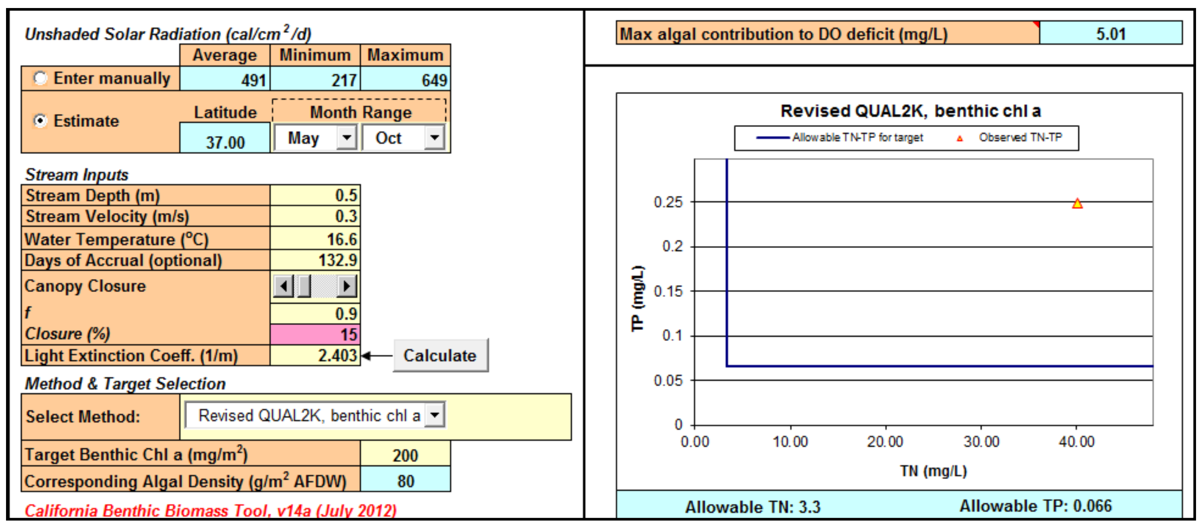
Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 15% Tree Canopy Closure

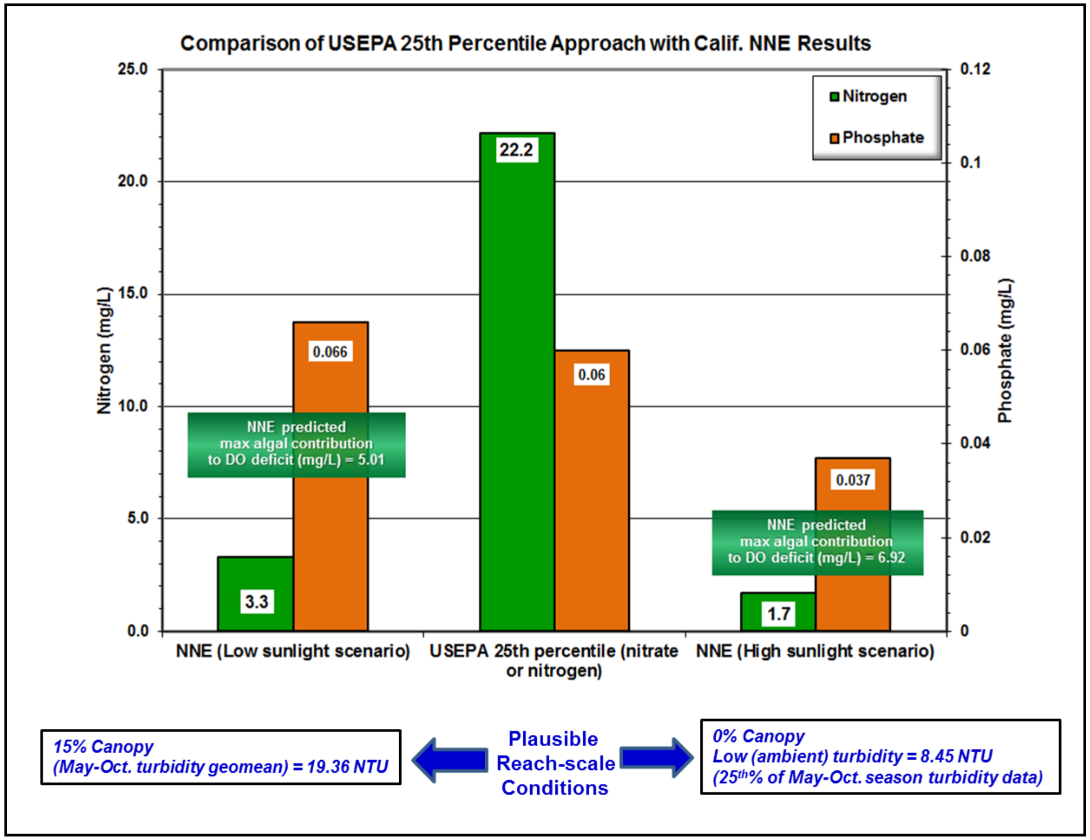
- Geomean Dry Season Turbidity:

19 NTU turbidity = turbidity geomean of May-Oct samples of Pajaro River agricultural monitoring sites.



B.7.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Pajaro Valley Agricultural Ditches)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the NNE Lower Sunlight Availability scenario falls in between the 25th percentile and the NNE Higher Sunlight Availability scenario. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Lower Sunlight Availability scenario for nitrate **(3.3 mg/L)** is identified here as a potential numeric target. For orthophosphate, the 25th percentile and both NNE scenarios are lower than background reference conditions and would be overly conservative. Therefore, the background reference condition for orthophosphate **(0.14 mg/L)** is selected as potential numeric targets for this stream reach.



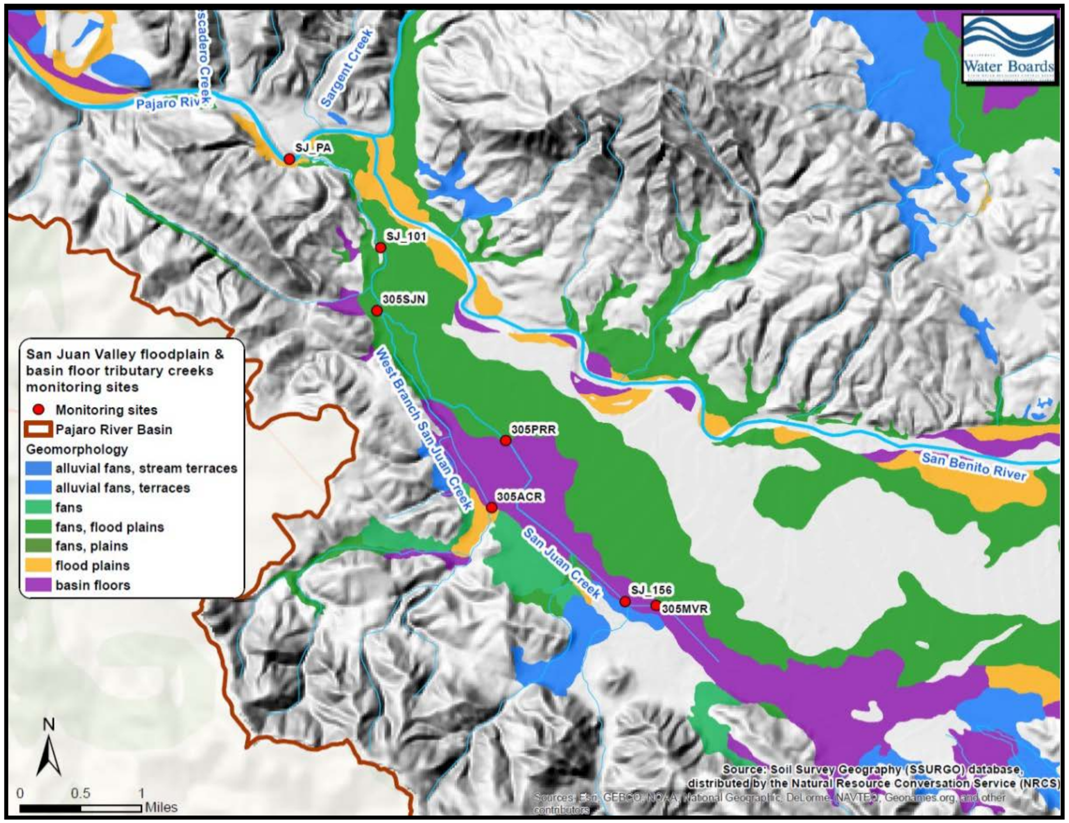
B.8 San Juan Valley – Floodplain & Basin Floor Tributary Creeks

B.8.1 Floodplain & basin floor tributary creeks – 25th Percentile Targets

Stream Conditions

- Geomorphic description: San Juan Valley floodplain and basin floor tributary creeks (source: NRCS-SSURGO)
- Waterbodies: San Juan Creek and west branch of San Juan Creek
- Estimated average riparian tree canopy: 10% - 40% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Mostly silty clay loams with some gravelly sandy loam in the lower reach (source: NRCS-SSURGO)
- Turbidity conditions: 6 NTU (geomean-dry season, May-Oct.); 3 NTU (25th percentile - dry season, May-Oct)

Monitoring sites used for San Juan Valley – floodplain and basin floor tributary creeks 25th percentiles



Floodplain and basin floor tributary creeks: Statistical summary	
San Juan Creek and west branch of San Juan Creek **Statistical summary of nitrate as N (mg/L)**	
Temporal representation	Nov. 2002 – Dec. 2013
Mean	30.09
Median	30.37
Minimum	0.13
Maximum	78.9
No. of samples	428
25th percentile	17.33

Floodplain and basin floor tributary creeks: Statistical summary	
San Juan Creek and west branch of San Juan Creek **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	Nov. 2002 – Dec. 2013
Mean	0.37
Median	0.29
Minimum	0.0011
Maximum	2.5
No. of samples	401
25th percentile	0.17

B.8.2 San Juan Valley – Floodplain & Basin Floor Tributary Creeks Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The San Juan Creek is specifically designated for warm freshwater aquatic habitat (WARM) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for WARM beneficial use.

Site:	San Juan Valley
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 10% Tree Canopy Closure

- Ambient (low) Turbidity: 3 NTU turbidity = 25th percentile of May-Oct. samples of San Juan Valley monitoring sites.

Unshaded Solar Radiation (cal/cm^2/d)

		Average	Minimum	Maximum
Enter manually		536	316	649
Estimate	Latitude	Month Range		
	37.00	May	Oct	

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.0
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	10
Light Extinction Coeff. (1/m)	0.71

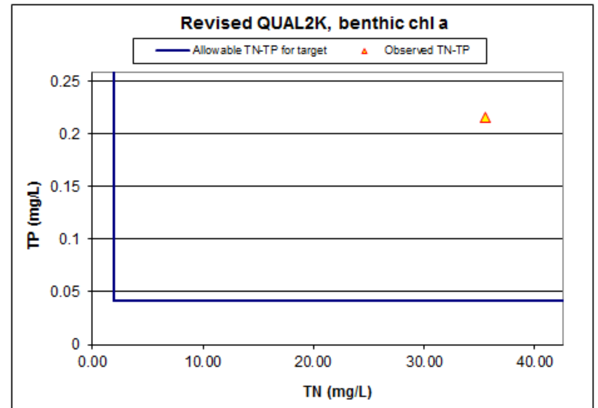
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	7.65



Allowable TN: 1.9 | Allowable TP: 0.041

Site:	San Juan Valley
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 40% Tree Canopy Closure

- Geomean Dry Season Turbidity: 6 NTU turbidity = turbidity geomean of May-Oct samples of San Juan Valley monitoring sites.

Unshaded Solar Radiation (cal/cm^2/d)

		Average	Minimum	Maximum
Enter manually		536	316	649
Estimate	Latitude	Month Range		
	37.00	May	Oct	

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.0
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	40
Light Extinction Coeff. (1/m)	1.07

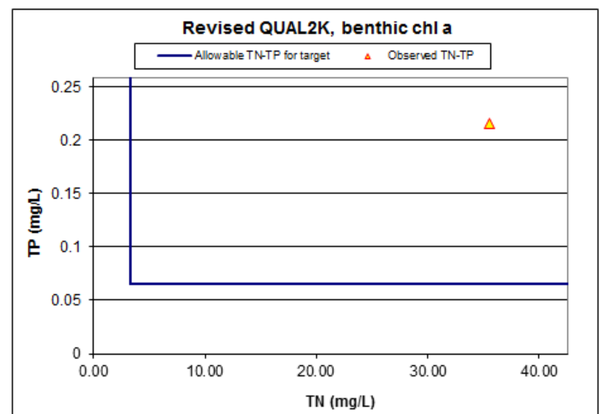
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v14a (July 2012)

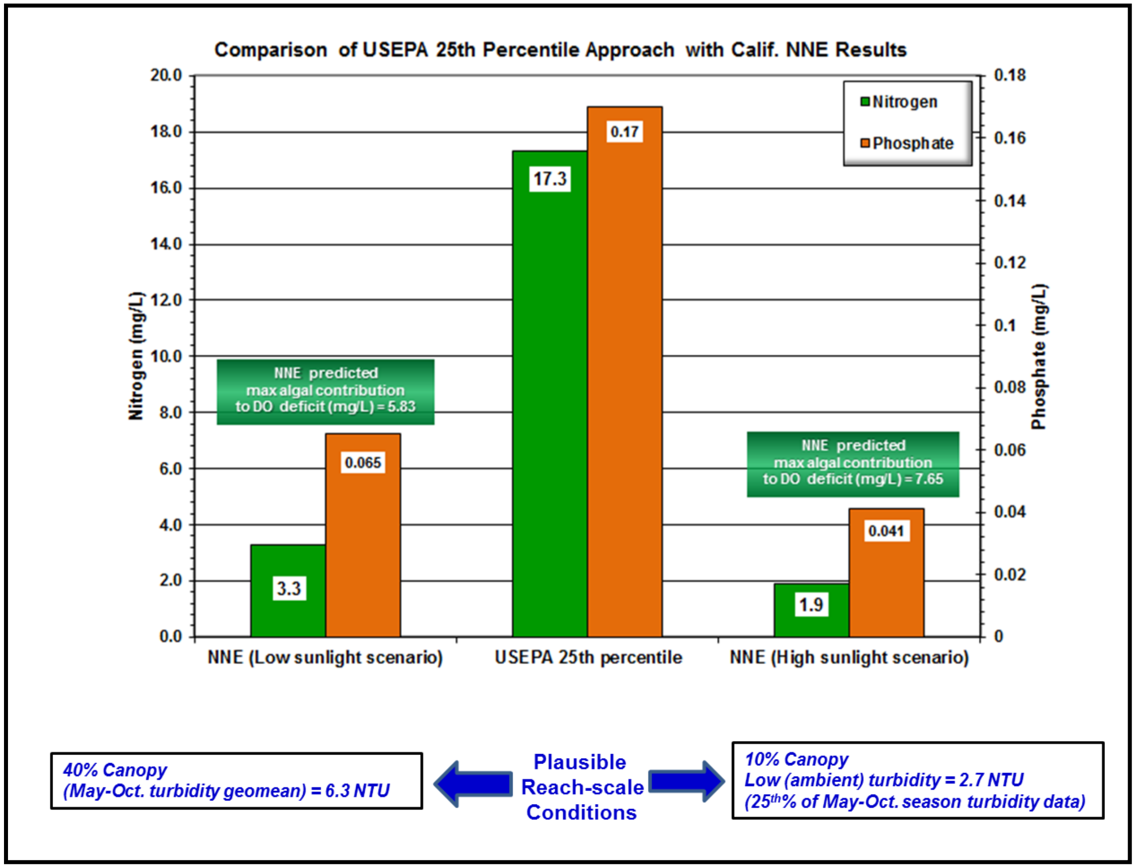
Max algal contribution to DO deficit (mg/L)	5.83



Allowable TN: 3.3 | Allowable TP: 0.065

B.8.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (San Juan Valley)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the NNE Lower Sunlight Availability scenario falls in between the 25th percentile and the NNE Higher Sunlight Availability scenario. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Lower Sunlight Availability scenario for nitrate **(3.3 mg/L)** is identified here as a potential numeric target. For orthophosphate, both NNE scenarios are lower than background reference conditions and would be overly conservative. However, the 25th percentile may not be protective enough. Therefore, the background reference condition for orthophosphate **(0.12 mg/L)** is selected as potential numeric targets for this stream reach.



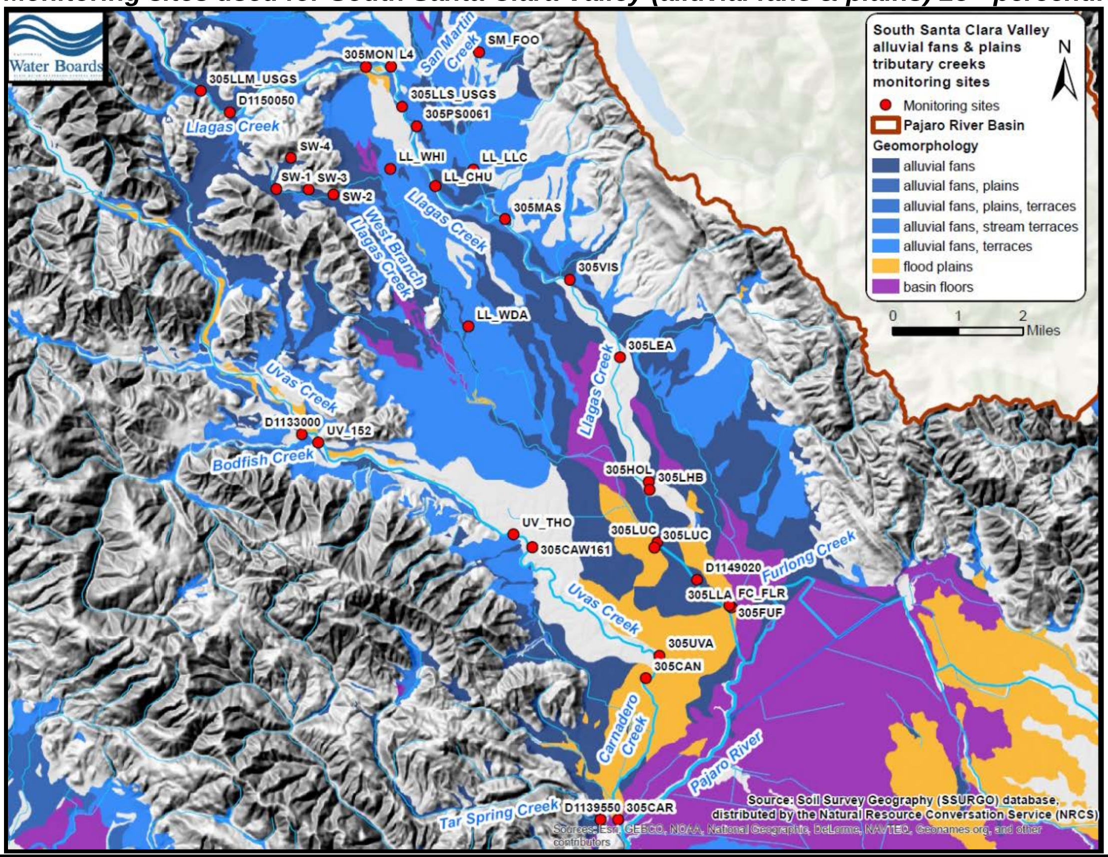
B.9 South Santa Clara Valley – Alluvial Fans & Plains Tributary Creeks

B.9.1 Alluvial Fans & Plains Tributary Creeks - 25th Percentile Targets

Stream Conditions

- Geomorphic description: Alluvial fans and plains (source: NRCS-SSURGO)
- Waterbodies: Bodfish Creek, Carnadero Creek, Furlong Creek, Little Llagas, Llagas Creek, San Martin Creek, Tar Springs Creek, Uvas Creek, West Branch Llagas Creek, and West Branch Llagas Creek Tributary.
- Estimated average riparian tree canopy: 35 – 50% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Silty clay loams to very gravelly loams and sandy loams (source: NRCS-SSURGO)
- Turbidity conditions: 5 NTU (geomean-dry season, May-Oct.); 2 NTU (25th percentile dry season, May-Oct)

Monitoring sites used for South Santa Clara Valley (alluvial fans & plains) 25th percentiles



Alluvial fans and plains tributary creeks: Statistical summary	
South Santa Clara Valley **Statistical summary of nitrate as N (mg/L)**	
Temporal representation	April 1969 – Dec. 2013
Mean	7.15
Median	1.16
Minimum	0.002
Maximum	89.10
No. of samples	1,891
25th percentile	0.50

Alluvial fans and plains tributary creeks: Statistical summary	
South Santa Clara Valley **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	Nov. 1979 – Dec. 2013
Mean	0.08
Median	0.04
Minimum	0.0004
Maximum	6.60
No. of samples	1,554
25th percentile	0.02

B.9.2 South Santa Clara Valley – Alluvial Fans & Plains Tributary Creeks Nutrient Numeric Endpoint Analysis

The alluvial fans & plains tributary creeks are specifically designated for cold freshwater aquatic habitat (COLD) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for COLD beneficial use.

Site:	Santa Clara Valley Alluvial Fan & Plains Tributary Creeks
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 35% Tree Canopy Closure

- Ambient (low) Turbidity: 2 NTU turbidity = 25th percentile of May-Oct. samples of Santa Clara alluvial fan & plains tributary creeks monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	536	316	649

	Latitude	Month Range	
Estimate (selected)	37.00	May	Oct

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	14.5
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	35
Light Extinction Coeff. (1/m)	0.68

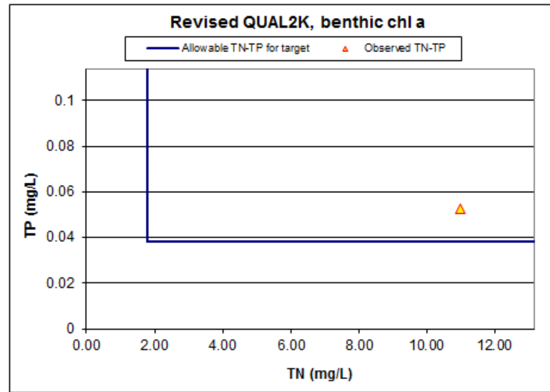
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	2.95



Allowable TN: 1.8 Allowable TP: 0.038

Site:	Santa Clara Valley Alluvial Fan & Plains Tributary Creeks
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 50% Tree Canopy Closure

- Geomean Dry Season Turbidity: 5 NTU turbidity = turbidity geomean of May-Oct samples of Santa Clara alluvial fan & plains tributary creeks monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	536	316	649

	Latitude	Month Range	
Estimate (selected)	37.00	May	Oct

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	14.5
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	50
Light Extinction Coeff. (1/m)	0.91

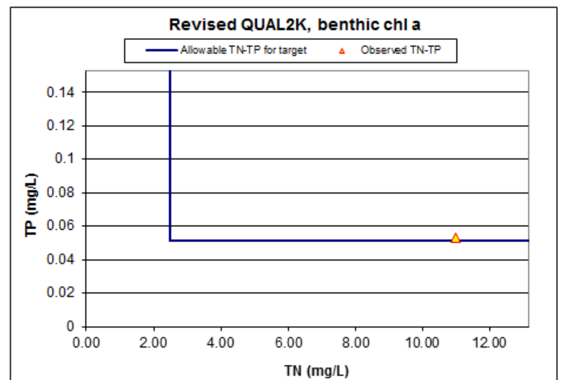
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

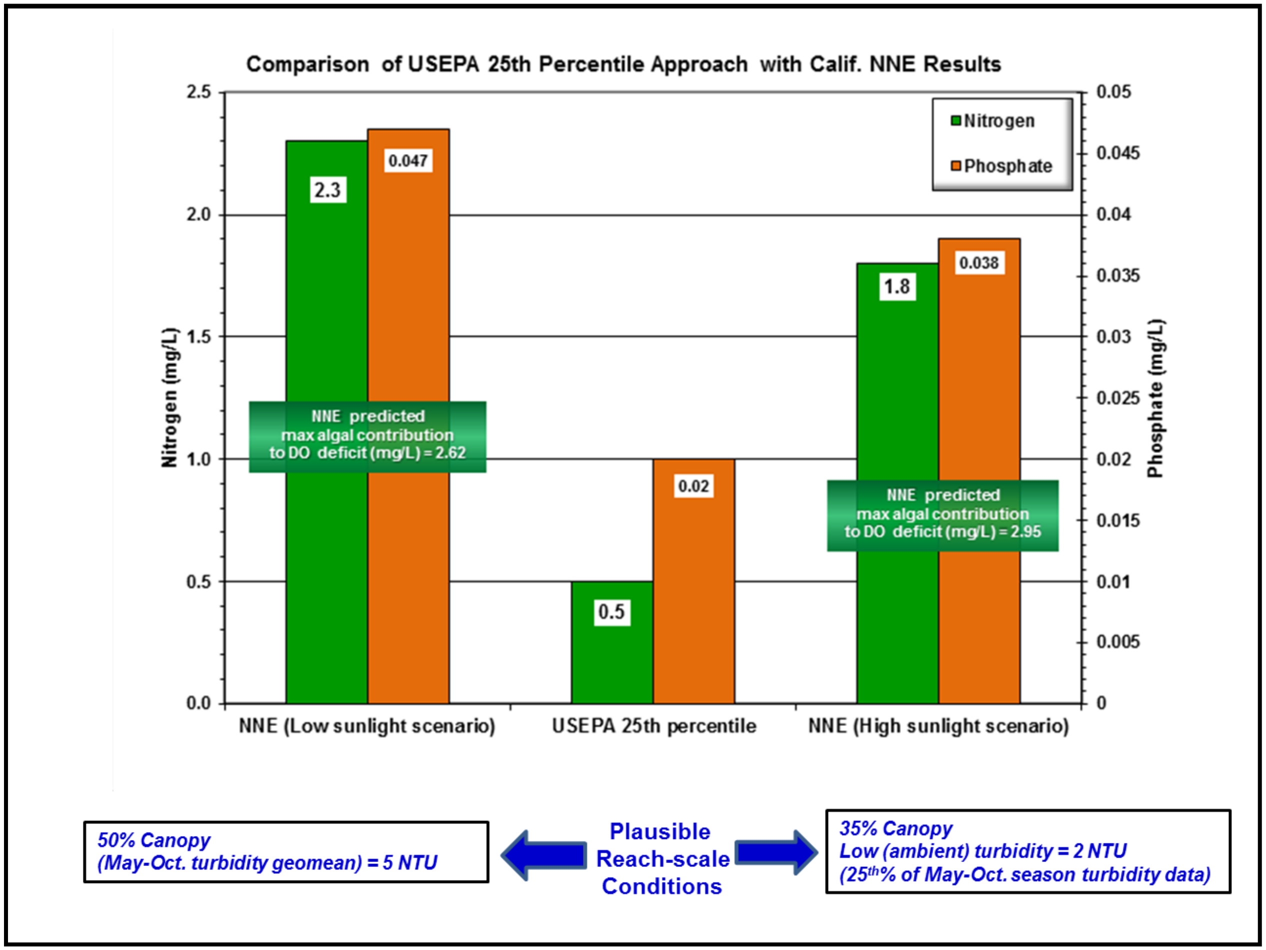
Max algal contribution to DO deficit (mg/L)	2.50



Allowable TN: 2.5 Allowable TP: 0.051

B.9.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (South Santa Clara Valley – Alluvial Fans & Plains Tributary Creeks)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the NNE Higher Sunlight Availability scenario falls in between the 25th percentile and the NNE Lower Sunlight Availability scenario. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Higher Sunlight Availability scenario for nitrate **(1.8 mg/L)** is identified here as a potential numeric target. For orthophosphate, the NNE Higher Sunlight Availability scenario was chosen since it falls between the NNE Lower Sunlight Availability scenario and the 25th percentile. Therefore, the 25th percentile for orthophosphate **(0.04 mg/L)** is selected as a potential numeric target for this stream reach.



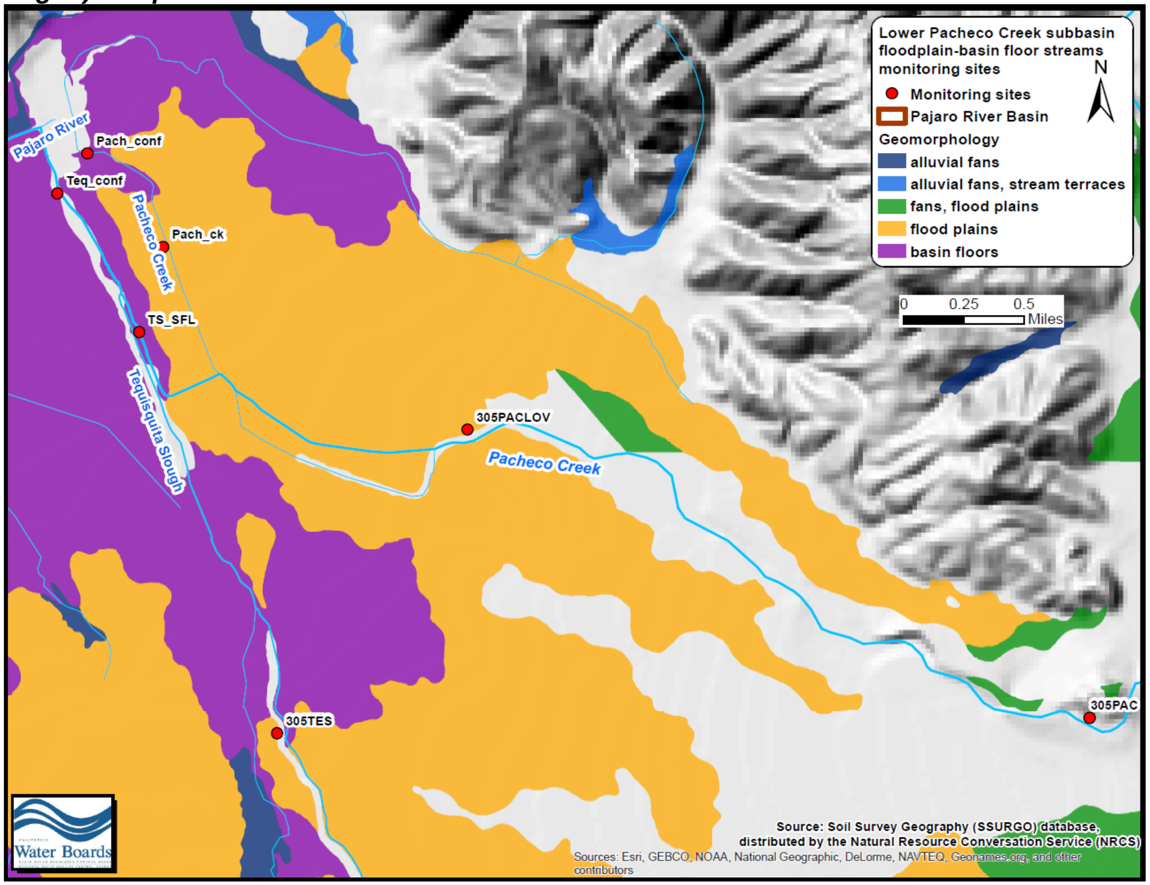
B.10 Lower Pacheco Creek Subbasin – Floodplain & Basin Floor Streams

B.10.1 Floodplain & basin floor creeks and sloughs - 25th Percentile Targets

Stream Conditions

- Geomorphic description: Floodplain & basin floor creeks and sloughs (source: NRCS-SSURGO)
- Waterbodies: Pacheco Creek, Tequisquitas Slough
- Estimated average riparian tree canopy: 10 – 20% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Clay loams, silty clay loams and sandy loams (source: NRCS-SSURGO)
- Turbidity conditions: 27 NTU (geomean-dry season, May-Oct.); 12 NTU (25th percentile dry season, May-Oct)

Monitoring sites used for Lower Pacheco Creek subbasin (floodplain & basin floor creeks and sloughs) 25th percentiles



Floodplains & basin floor creeks and sloughs: Statistical summary	
Lower Pacheco Creek subbasin **Statistical summary of nitrate as N (mg/L)**	
Temporal representation	Dec. 1997 – Dec. 2013
Mean	3.09
Median	1.5
Minimum	0.0045
Maximum	51.75
No. of samples	576
25th percentile	0.53

Floodplains & basin floor creeks and sloughs: Statistical summary	
Lower Pacheco Creek subbasin **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	Dec. 1997 – Dec. 2013
Mean	0.164
Median	0.074
Minimum	0.001
Maximum	2.63
No. of samples	565
25th percentile	0.03

B.10.2 Lower Pacheco Creek Subbasin – Floodplain & Basin Floor Streams Nutrient Numeric Endpoint Analysis

The Lower Pacheco Creek and Tequisquitas Slough are specifically designated for warm freshwater aquatic habitat (WARM) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for WARM beneficial use. Tequisquita Slough was identified as having biostimulation impairments and is therefore given numeric targets. Pacheco Creek was not identified as having biostimulation impairments or contributing to downstream biostimulation impairments, therefore at this time the creek is not being assigned biostimulation water quality targets. However, anti-degradation requirements apply to Pacheco Creek.

Site:	Lower Pacheco Creek Subbasin Streams / Tequisquita Slough
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

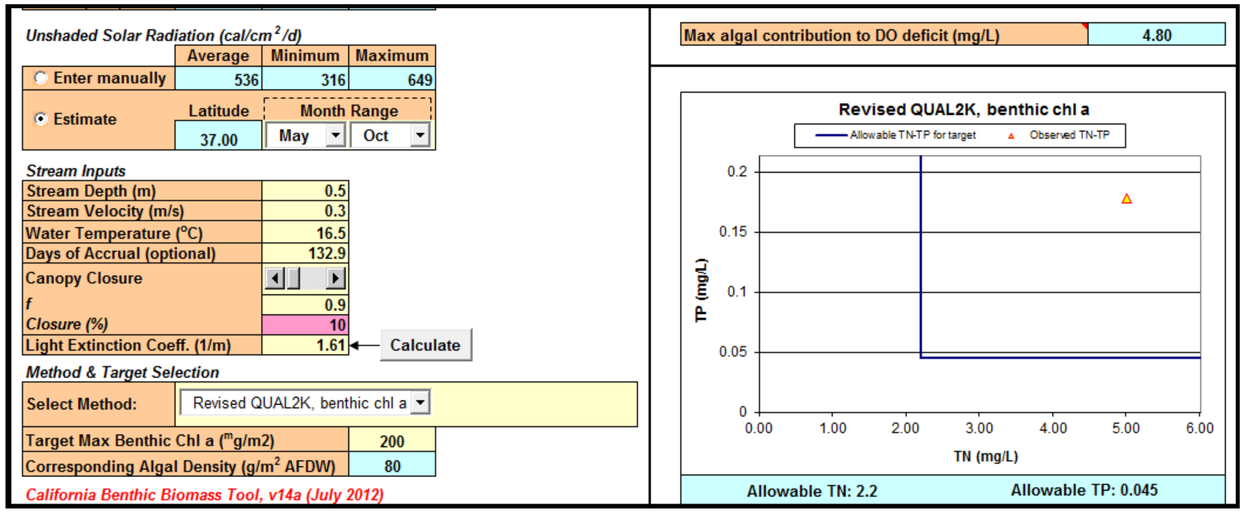
Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 10% Tree Canopy Closure

- Ambient (low) Turbidity: 12 NTU turbidity = 25th percentile of May-Oct. samples of lower Pacheco Creek subbasin monitoring sites.



Site:	Lower Pacheco Creek Subbasin Streams / Tequisquita Slough
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

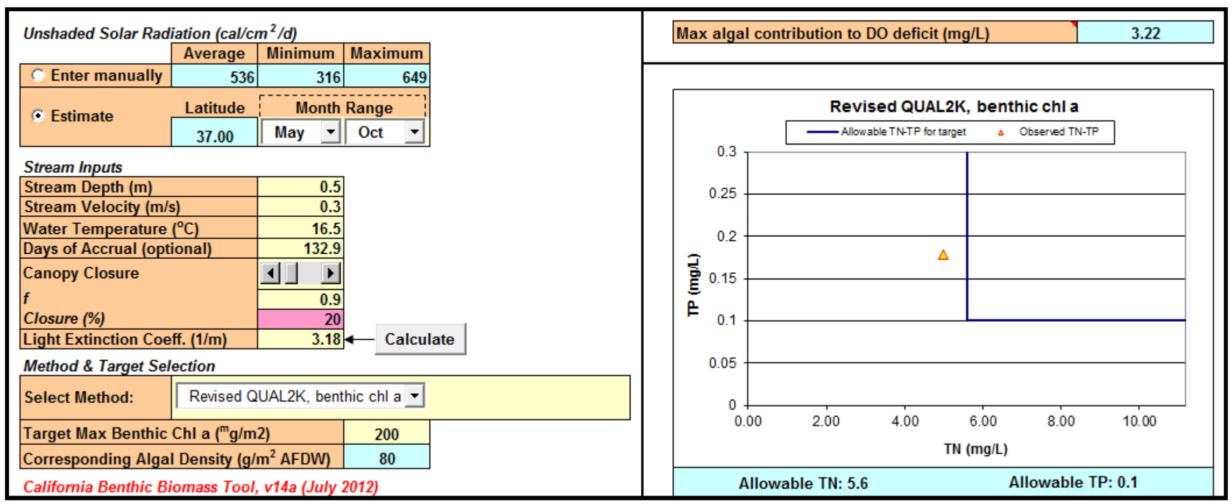
Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

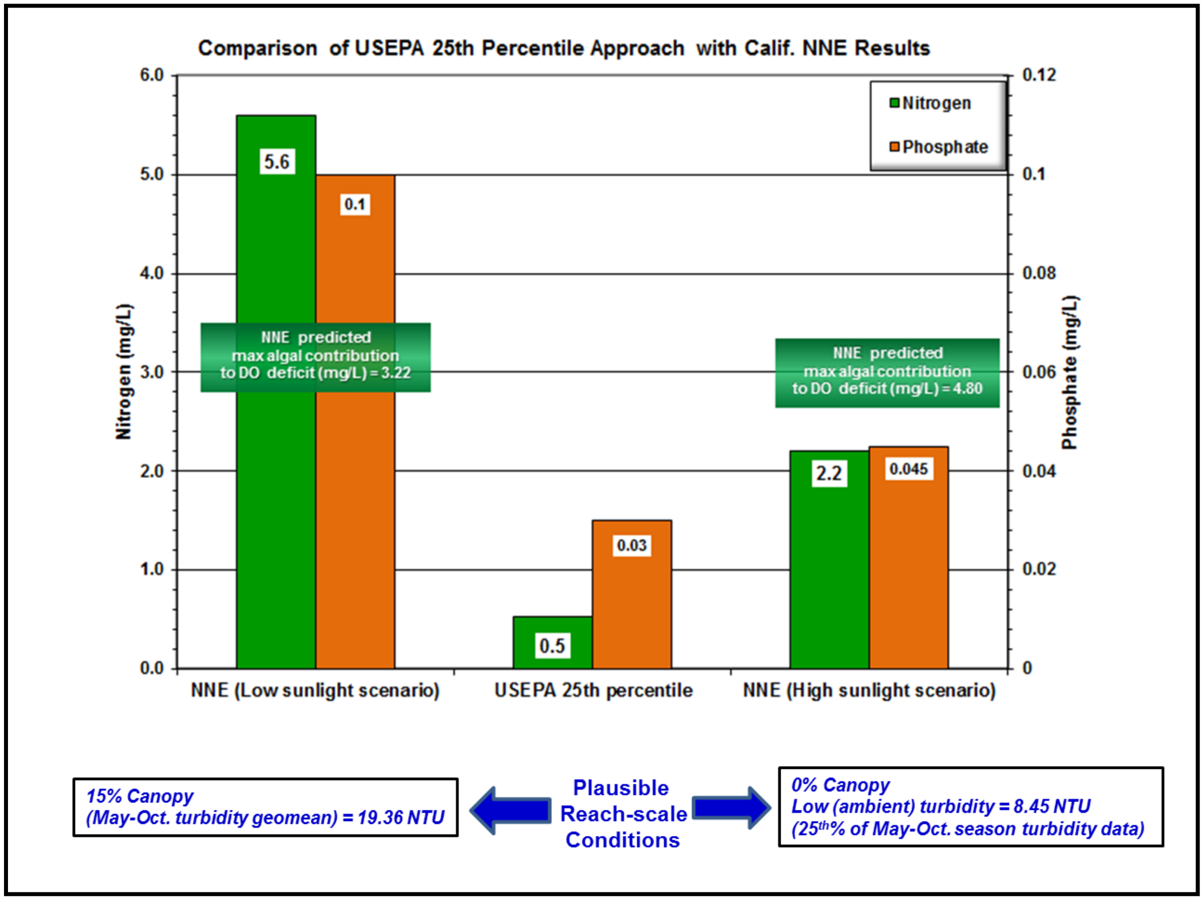
- 20% Tree Canopy Closure

- Geomean Dry Season Turbidity: 27 NTU turbidity = turbidity geomean of May-Oct samples of lower Pacheco Creek subbasin monitoring sites.



B.10.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Lower Pacheco Creek Subbasin – Floodplain & Basin Floor Creeks and Sloughs)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the NNE Higher Sunlight Availability scenario falls in between the 25th percentile and the NNE Lower Sunlight Availability scenario. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Higher Sunlight Availability scenario for nitrate **(2.2 mg/L)** is identified here as a potential numeric target. For orthophosphate, the 25th percentile and both NNE scenarios are lower than background reference conditions and would be overly conservative. Therefore, the background reference condition for orthophosphate **(0.12 mg/L)** is selected as potential numeric targets for this stream reach.



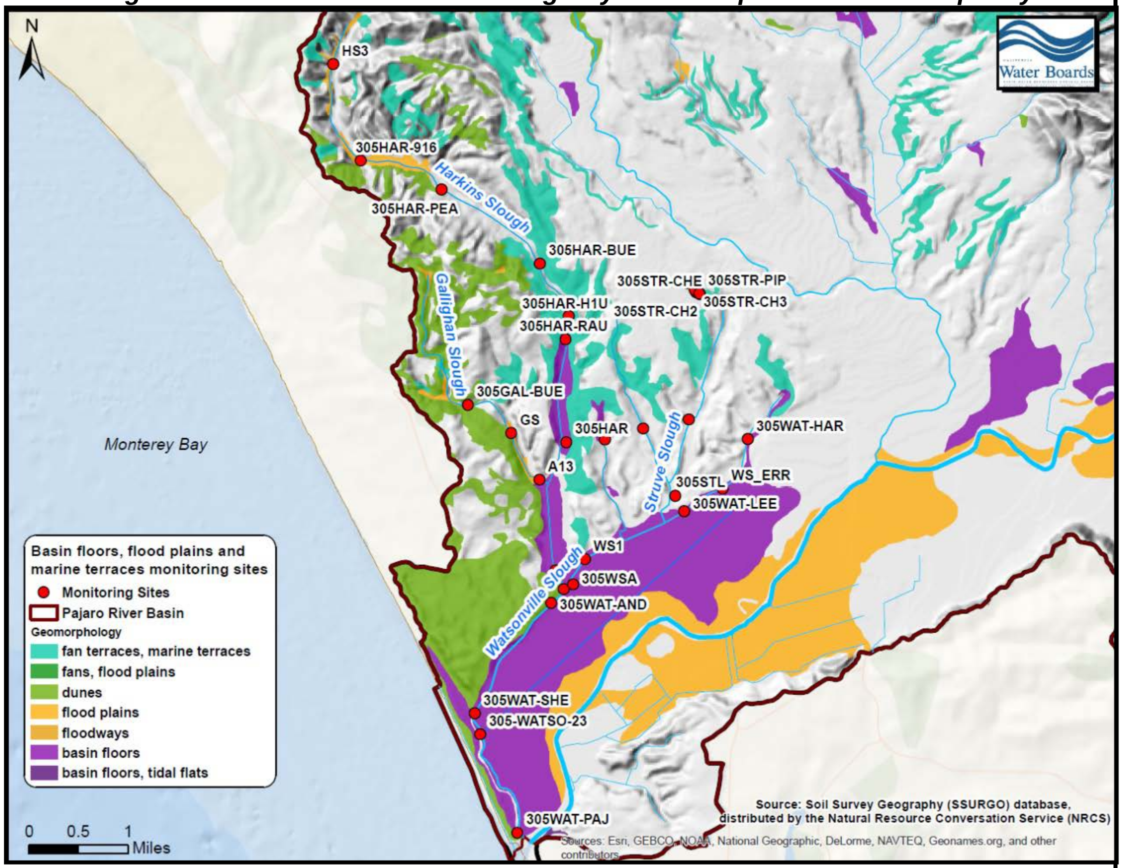
B.11 Watsonville Slough System – Coastal Sloughs

B.11.1 Watsonville Slough System - 25th Percentile Targets

Stream Conditions

- Geomorphic description: Basin floors, tidal flats, marine terraces (source: NRCS-SSURGO)
- Waterbodies: Watsonville Slough, Gallighan Slough, Harkins Slough, and Struve Slough.
- Estimated average riparian tree canopy: close to 0% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Clay and silty clay (source: NRCS-SSURGO)
- Turbidity conditions: 7 NTU (25th percentile-dry season); 21 NTU (geomean-dry season, May-Oct.).

Monitoring sites used for Watsonville Slough System 25th percentile water quality data



Basin floor, tidal flats, marine terraces: Statistical summary	
Watsonville Slough system Statistical summary of nitrogen, total (mg/L)	
Temporal representation	Jan. 2005 - April 2013
Mean	8.61
Median	2.50
Minimum	0.89
Maximum	240.00
No. of samples	89
25th percentile	1.9

Basin floor, tidal flats, marine terraces: Statistical summary	
Watsonville Slough system Statistical summary of orthophosphate as P (mg/L)	
Temporal representation	Aug. 1998 – Dec. 17, 2013
Mean	0.32
Median	0.23
Minimum	0.01
Maximum	6.39
No. of samples	1,489
25th percentile	0.09

B.11.2 Watsonville Slough systems Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The Watsonville Slough system is specifically designated for warm freshwater aquatic habitat (WARM) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for WARM beneficial use.

Site:	Watsonville Slough system
Analyst:	S. Keeling
Date:	2/18/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity:

7 NTU turbidity = 25th percentile of May-Oct. samples of Watsonville Slough system monitoring sites

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	491	217	649
Estimate	Latitude: 37.00	Month Range: May	Oct

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	14.8
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	0
Light Extinction Coeff. (1/m)	1.095

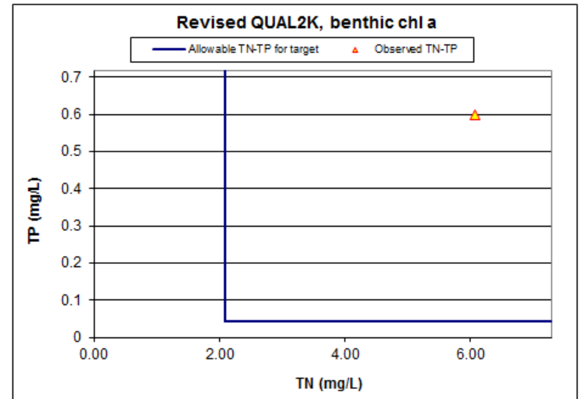
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	200
Corresponding Algal Density (g/m² AFDW)	80

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	5.19



Allowable TN: 2.1 **Allowable TP: 0.044**

Site:	Watsonville Slough system
Analyst:	S. Keeling
Date:	2/18/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 40% Tree Canopy Closure

- Geomean Dry Season Turbidity:

21 NTU turbidity = turbidity geomean of May-Oct samples of Watsonville Slough systems monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	491	217	649
Estimate	Latitude: 37.00	Month Range: May	Oct

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	14.8
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	40
Light Extinction Coeff. (1/m)	2.505

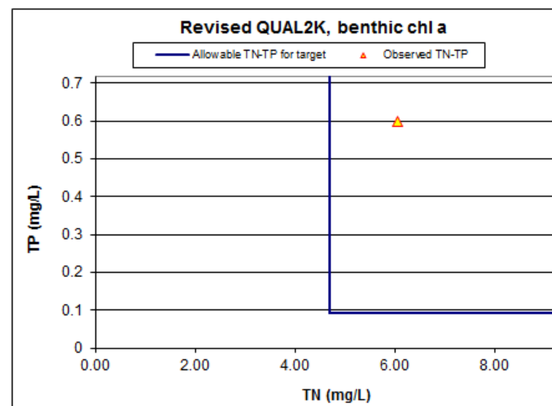
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	200
Corresponding Algal Density (g/m² AFDW)	80

California Benthic Biomass Tool, v14a (July 2012)

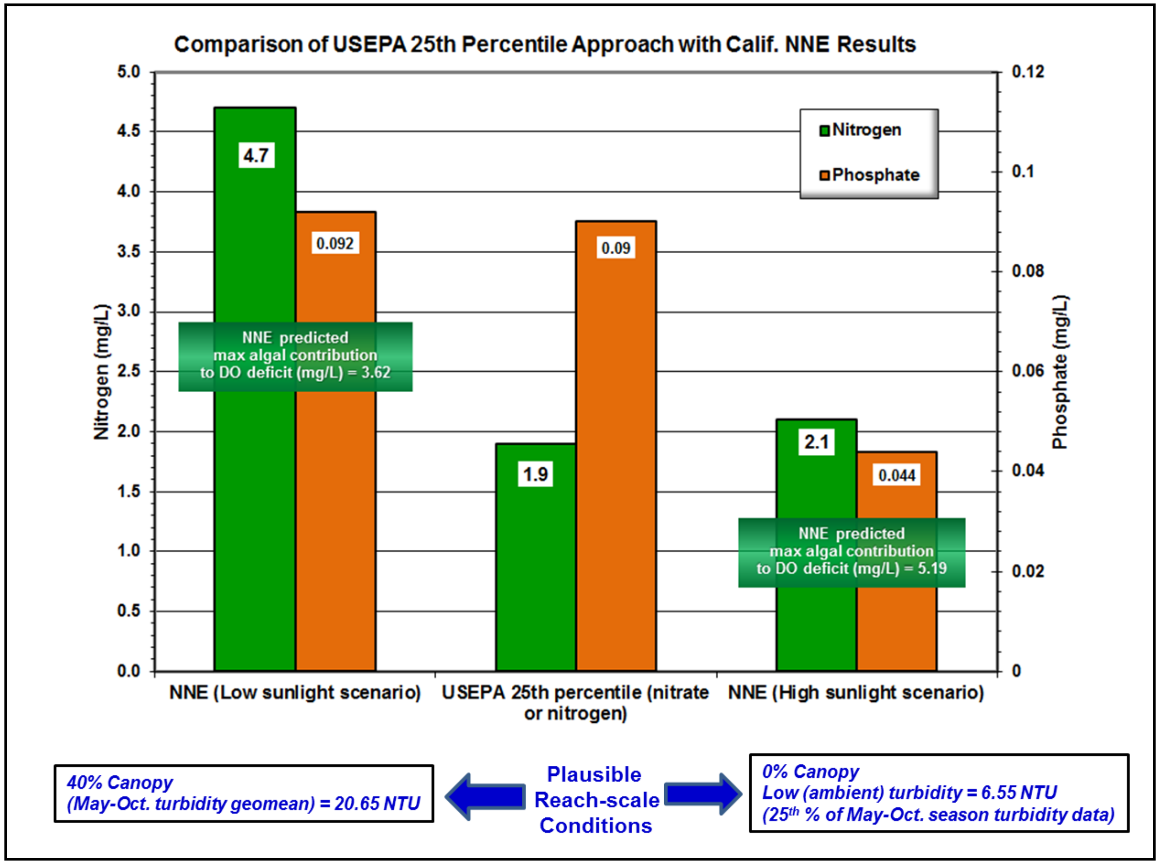
Max algal contribution to DO deficit (mg/L)	3.62



Allowable TN: 4.7 **Allowable TP: 0.092**

B.11.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Watsonville Slough systems)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the NNE Higher Sunlight Availability scenario falls in between the 25th percentile and the NNE Lower Sunlight Availability scenario. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Higher Sunlight Availability scenario for nitrogen **(2.1 mg/L)** is identified here as a potential numeric target. For orthophosphate, the 25th percentile and both NNE scenarios are lower than background reference conditions and would be overly conservative. Therefore, the background reference condition for orthophosphate **(0.14 mg/L)** is selected as potential numeric targets for this stream reach.



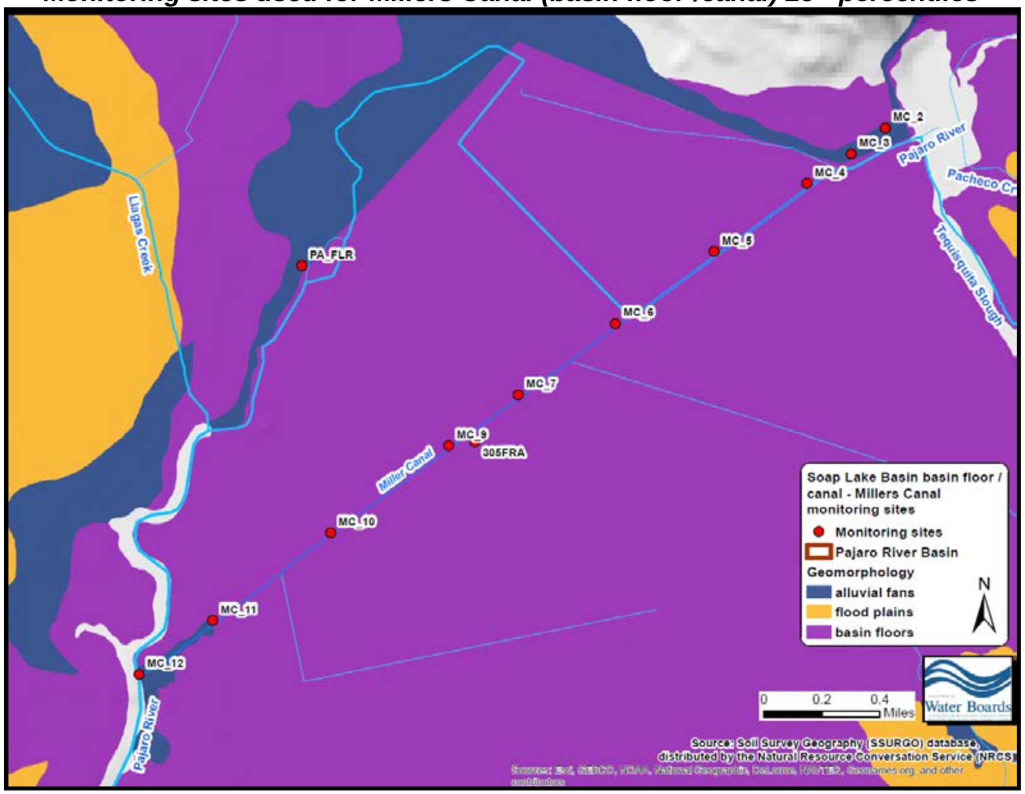
B.12 Soap Lake Basin (basin floor/canal) – Millers Canal

B.12.1 Basin floor/canal - 25th percentile targets

Stream Conditions

- Geomorphic description: Basin floor/canal (source: NRCS-SSURGO)
- Waterbody: Millers Canal
- Estimated average riparian tree canopy: 0 – 10% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Predominantly clay to silty clay (source: NRCS-SSURGO)
- Turbidity conditions: 21 NTU (geomean-dry season, May-Oct.); 12 NTU (25th percentile dry season, May-Oct)

Monitoring sites used for Millers Canal (basin floor /canal) 25th percentiles



Basin floor/canal: Statistical summary	
Millers Canal **Statistical summary of nitrogen, total (mg/L)**	
Temporal representation	June 1992 – May 2013
Mean	0.41
Median	0.305
Minimum	0.059
Maximum	1.9
No. of samples	95
25th percentile	0.20

Basin floor/canal: Statistical summary	
Millers Canal **Statistical summary of orthophosphate as P (mg/L)**	
Temporal representation	July 1992 – May 2013
Mean	0.17
Median	0.075
Minimum	ND
Maximum	6.1
No. of samples	391
25th percentile	0.04

B.12.2 Soap Lake Basin – Millers Canal Nutrient Numeric Endpoint Analysis

Millers Canal is not specifically designated for a specific beneficial use in Table II-1 of the Basin Plan. Since steelhead are known to migrate through Millers Canal into Tequisquitas Slough, NNE analysis was included BURC II /III category for COLD beneficial use as well as WARM.

Site:	Soap Lake Basin - Basin Floor/Canal
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:
- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity: 12 NTU turbidity = 25th percentile of May-Oct. samples of Soap Lake Basin monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	536	316	649
Estimate	Latitude	Month Range	
	37.00	May	Oct

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.6
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	0
Light Extinction Coeff. (1/m)	1.64

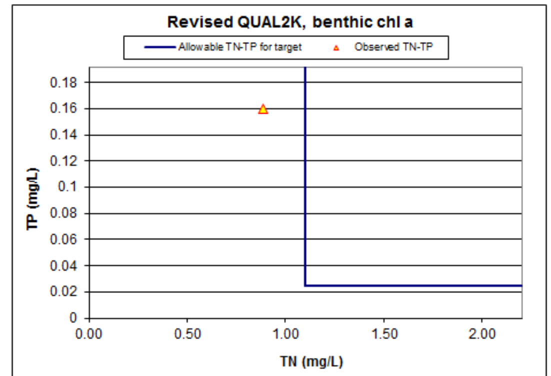
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	2.22



Allowable TN: 1.1 Allowable TP: 0.0245

Site:	Soap Lake Basin - Basin Floor/Canal
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:
- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 10% Tree Canopy Closure

- Geomean Dry Season Turbidity: 21 NTU turbidity = turbidity geomean of May-Oct samples of Soap Lake Basin monitoring sites.

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	536	316	649
Estimate	Latitude	Month Range	
	37.00	May	Oct

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.6
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	10
Light Extinction Coeff. (1/m)	2.57

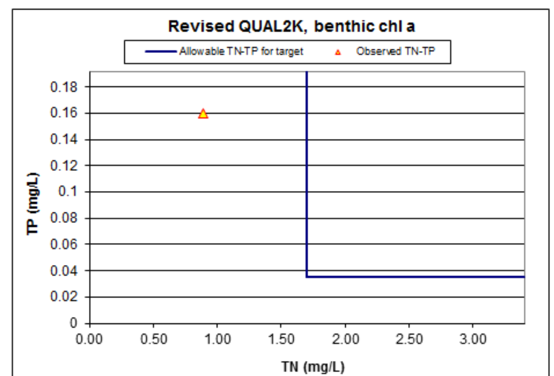
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	1.72



Allowable TN: 1.7 Allowable TP: 0.035

Site:	Soap Lake Basin - Basin Floor/Canal
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity: 12 NTU turbidity = 25th percentile of May-Oct. samples of Soap Lake Basin monitoring sites.

Unshaded Solar Radiation (cal/cm^2/d)

		Average	Minimum	Maximum
○ Enter manually		536	316	649
⦿ Estimate	Latitude	37.00	Month Range	May – Oct

Stream Inputs

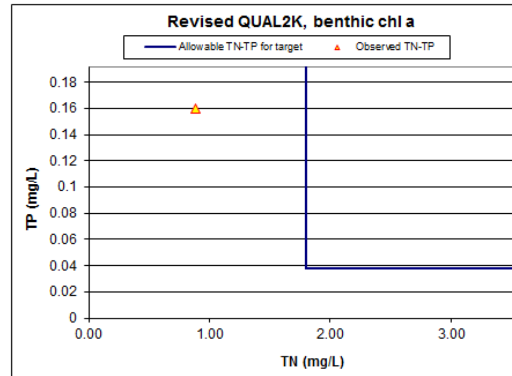
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.6
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	0
Light Extinction Coeff. (1/m)	1.64 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v14a (July 2012)

Max algal contribution to DO deficit (mg/L)	2.22



Allowable TN: 1.8 Allowable TP: 0.038

Site:	Soap Lake Basin - Basin Floor/Canal
Analyst:	P. Osmolovsky
Date:	2/15/2015

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 10% Tree Canopy Closure

- Geomean Dry Season Turbidity: 21 NTU turbidity = turbidity geomean of May-Oct samples of Soap Lake Basin monitoring sites.

Unshaded Solar Radiation (cal/cm^2/d)

		Average	Minimum	Maximum
○ Enter manually		536	316	649
⦿ Estimate	Latitude	37.00	Month Range	May – Oct

Stream Inputs

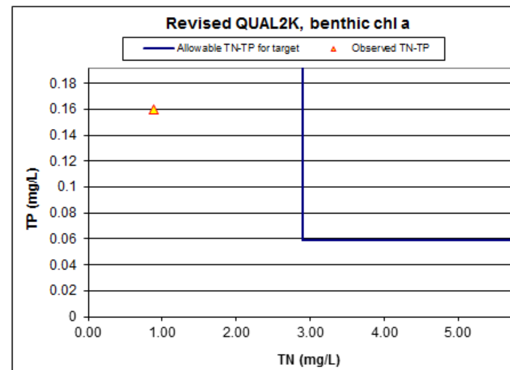
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.6
Days of Accrual (optional)	132.9
Canopy Closure	
f	0.9
Closure (%)	10
Light Extinction Coeff. (1/m)	2.57 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Max Benthic Chl a (mg/m2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v14a (July 2012)

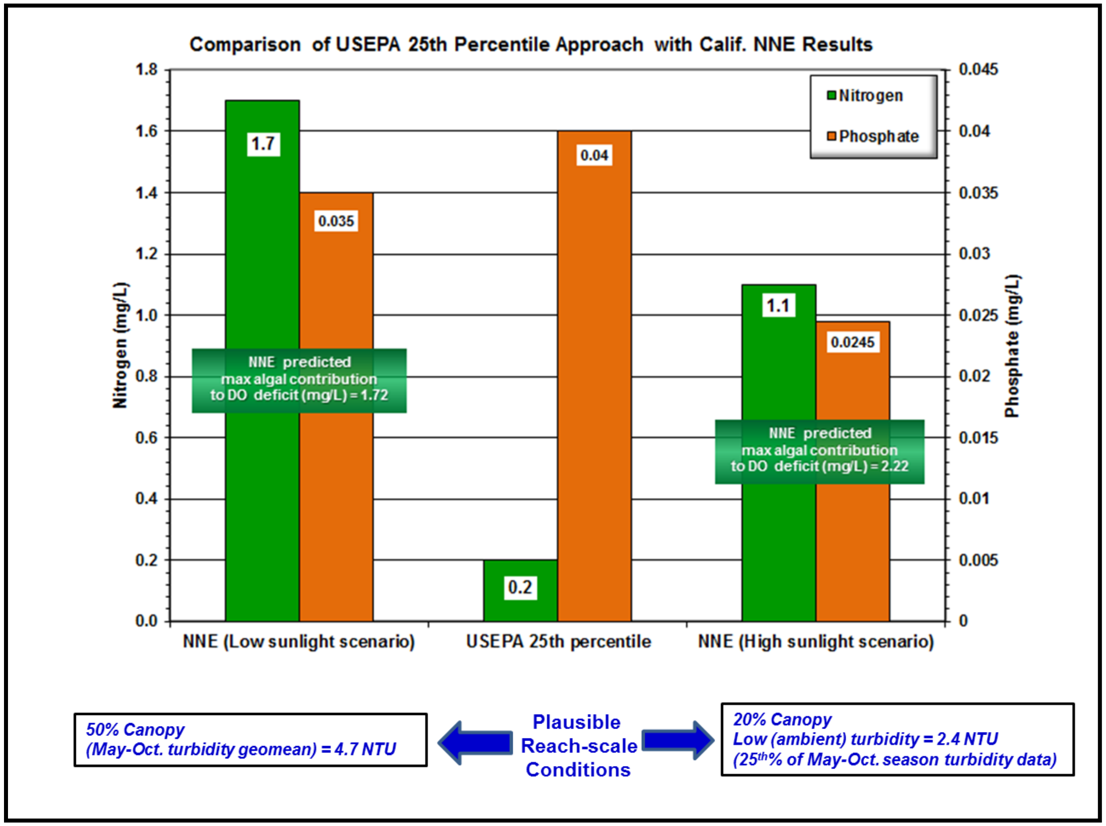
Max algal contribution to DO deficit (mg/L)	1.72



Allowable TN: 2.9 Allowable TP: 0.059

B.12.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Soap Lake Basin – Basin Floor / Canal)

The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the NNE Higher Sunlight Availability scenario falls in between the 25th percentile and the NNE Lower Sunlight Availability scenario. Consistent with the nutrient target development approach outlined in Section B.4, the NNE Lower Sunlight Availability scenario for nitrogen **(1.1 mg/L)** is identified here as a potential numeric target. For orthophosphate, the NNE Lower Sunlight Availability scenario falls in between the 25th percentile and the NNE Higher Sunlight Availability scenario. Therefore, the NNE Lower Sunlight Availability scenario for orthophosphate **(0.04 mg/L)** is selected as potential numeric targets for this stream reach.



B.13 Nutrient Concentrations in Headwater Reaches & Lightly-Disturbed Tributaries of the Pajaro River Basin

An important tenet of the California NNE approach (Tetra Tech, 2006 - refer back to footnote 4) is that targets should not be set lower than the concentrations expected under background or relatively undisturbed conditions. Further, guidance from researchers with expertise in central coast biostimulation issues indicates regulatory nutrient targets should not be more stringent (i.e., lower) than nutrient concentrations found in natural systems in the project area's basin (Dr. Marc Los Huertos[5], California State University, Monterey Bay, personal communication Oct. 14, 2011).

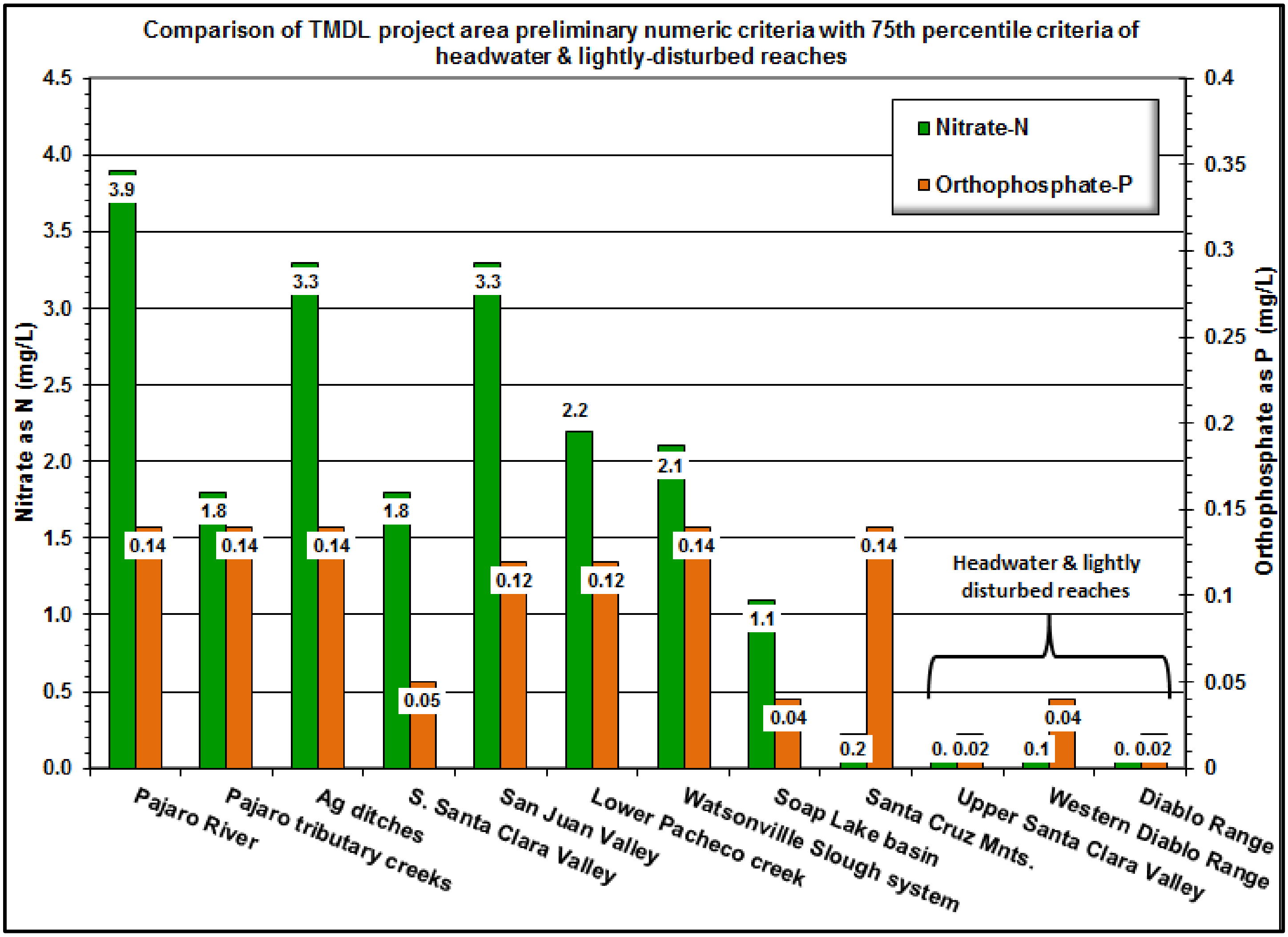
Therefore, staff applied the USEPA reference stream methodology, to ensure that biostimulation nutrient targets are no more stringent than expected nutrient concentrations found in natural or lightly-disturbed headwater and tributary reaches in the Pajaro River basin. USEPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams (USEPA, 2000 - refer back to footnote 2) describes an approach to establish a nutrient reference condition. The approach is to establish the upper 75th percentile of a reference population of streams. The 75th percentile was chosen by USEPA since it is likely associated with minimally impacted conditions, and will be protective of designated uses. USEPA defines a reference stream "as a least impacted waterbody within an ecoregion that can be monitored to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans."

For more information on reference conditions, please see section 6 in the TMDL Report.

B.13.1 Comparison of Preliminary Numeric Criteria with 75th Percentile Numeric Criteria of Headwater Reaches

The preliminary and potential TMDL numeric criterion developed previously in this appendix with the 25th percentile approach and the Calif. NNE approach are shown below relative to the 75th percentile criterion for headwater and lightly-disturbed reaches in the Pajaro River basin. Generally, for nitrate as N, most of the previously developed potential criterion are not less than the 75th percentile reference stream criterion, and therefore conform to technical guidance that nutrient targets should not be lower than nutrient concentrations found in natural systems. However, the preliminary orthophosphate criterion for the six out of the eight categories (all categories except Santa Clara Valley and Soap Lake basin) are lower than the 75th percentile of orthophosphate at reference site conditions. As such, these preliminary nutrient criterion may be over-protective for these stream reaches. Accordingly, the orthophosphate target for these six categories will be set at the less stringent 75th percentile criteria in reference streams (i.e., either 0.12 or 0.14 mg/L orthophosphate as P).

[5] Dr. Marc Los Huertos in an Assistant Professor of Science and Environmental Policy at California State University, Monterey Bay. Dr. Los Huertos has substantial research experience with agricultural water quality, aquatic ecology, and biostimulation in the California central coast region.



B.14 Seasonal Biostimulatory Numeric Targets

B.14.1 Basis for Dry-Season and Wet-Season Numeric Targets

Photo documentation, field observations, and input provided by researchers[6] with expertise in eutrophication issues in Monterey Bay watersheds, including Elkhorn Slough, lower Salinas Valley, and the Pajaro River Basin, indicate clear evidence of algae problems and biostimulation in the summer months, and that eutrophication is primarily a summer-time water quality problem in the Pajaro River Basin (for example, see Figure 6).

[6] Personal communications: Ken Johnson, PhD. (Senior Scientist, Monterey Bay Aquarium Research Institute); Brent Hughes (estuarine ecologist, Elkhorn Slough National Estuarine Research Reserve); Mary Hamilton (environmental scientist, Central Coast Ambient Monitoring Program).

Figure 6. Photo documentation of the difference between summer months and winter months as related to biostimulation.

There is also some evidence of periodic and episodic excessive chlorophyll levels in winter months, based on available water quality data. Staff concludes that it would be unwarranted at this time to apply the nutrient numeric targets developed in this appendix to implement the Basin Plan's biostimulatory objective on a year-round basis. Additionally, winter nutrient loads are often associated with higher velocity stream flows which are likely to scour filamentous algae and transport it out of the watershed. These higher flows also flush nutrient compounds through the watershed and ultimately into the ocean; in other words the residence time of nutrients in inland streams is typically shorter than in lakes, reservoirs, or other static waterbodies. In short, evidence of algal impairment is less conclusive for winter time than for summer conditions.

Therefore, the nutrient numeric criteria develop in preceding sections of this appendix are proposed to apply during the dry season (May 1 to October 31) when excessive algal growth and biostimulation problems appear to be unequivocal.

However, there is some evidence of episodic excessive chlorophyll concentrations in the winter months. There is also substantial scientific uncertainty about the extent to which winter-time nitrogen phosphorus and nitrogen loads from valley floor and headwater reaches of the project area ultimately contribute to summer-time biostimulation problems in downstream receiving waterbodies. Loading during the winter months may have little effect on summer algal densities[7]. Alternatively, substantial internal loading of phosphorus and nitrogen in downstream and coastal confluence waterbodies may result over time from loads released from particulate matter, such as sediment or organic matter. The extent to which this sediment and organic matter-associated internal loading is consequential to summertime biostimulation problems in the project area or in downstream receiving waterbodies is currently uncertain. It is important to note that, in particular, phosphorus loads from headwater reaches which ultimately may be released from sediments when reduction-oxidation conditions changes may be a consequence of decades of natural loads that have nothing to do with current activities (personal communication, Dr. Marc Los Huertos, Oct. 17, 2011).

Therefore, to account for these uncertainties staff conclude that it is necessary to set numeric targets for winter months, but at this time these targets should be less stringent than dry-season nutrient targets in acknowledgement of these uncertainties. Previous California nutrient TMDLs have similarly incorporated seasonal targets for nutrients for the same reasons.

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[7] State of Connecticut Dept. of Environmental Protection. 2005. A Total Maximum Daily Load Analysis for Linsley Pond in North Branford and Branford, Connecticut

At this time, staff proposes a TMDL nitrate target for the wet-season (Nov. 1 to April 30) that is less stringent than the dry-season targets developed previously in this appendix, but more stringent that the Basin Plan numeric objective for nitrate (i.e., the 10 mg/L MUN objective). Staff proposes incorporating a 20% explicit margin of safety to the Basin Plan nitrate MUN numeric objective for the wet-season numeric target to help account for uncertainty concerning biostimulatory problems in the wet season. As such, the proposed wet-season biostimulatory target for nitrate is 8 mg/L. The basis for identifying the 8 mg/L wet-season nitrate-N target is as follows:

1) Photo documentation, field observations, water quality data, and input provided by researchers (refer back to footnote 6) with expertise in eutrophication issues in the central coast region indicate clear evidence of algae problems and biostimulation in the summer months, and that eutrophication is primarily manifested as a summer-time water quality problem in project area waterbodies. In the winter higher flows, cooler temperatures, lower light availability, and scouring evidently limit algal production. There are substantial uncertainties regarding the extent to which winter-time algal biomass problems manifest themselves, and about the extent to which winter time loads of nitrogen ultimately contribute to biostimulation problems in the summer.
2) The USEPA similarly established a nutrient TMDL for inland stream in southern California which contained a winter time nitrogen target of 8 mg/L, based on the application of a 20% margin of safety to the Basin Plan's numeric objective of nitrate and to account for uncertainty regarding winter time algae problems[8].
3) Recent research on biostimulation on inland surface waters from agricultural watersheds in the California central coast region indicates that existing nutrient numeric water quality objectives to protect drinking water standards found in the Basin Plan (i.e., the 10 mg/L nitrate-nitrogen MUN objective) is unlikely to reduce benthic algal growth below even the highest water quality benchmarks. This is because aquatic organisms respond to nutrients at lower concentrations[9,10]. Therefore, the 10 mg/L nitrate-nitrogen objective is insufficiently protective against biostimulatory impairments. Consequently, staff concludes that it is necessary to set nutrient wet-season numeric targets more stringent than the existing numeric objectives found for nitrate in the Basin Plan (i.e., the 10 mg/L MUN objective).

Similarly, staff proposes to establish a wet season orthophosphate target that is less stringent than the dry-season orthophosphate targets developed previously in this appendix. Staff is proposing a wet season target to help account for uncertainty regarding biostimulatory problems associated with wet season loads of orthophosphate. Unfortunately, there are currently no established numeric water quality objectives for phosphates in the Basin Plan on which to base a less stringent wet-season target. However, phosphate targets for streams have been adopted in some other states. The State of Nevada adopted a total phosphate target of 0.3 mg/L for Class B streams, and for most reaches of Class A streams. As such, the proposed wet-season biostimulatory target for orthophosphate is 0.3 mg/L. The basis for identifying the 0.3 mg/L wet-season orthophosphate-P target is as follows:

The basis for this proposal is as follows:

1) Photo documentation, field observations, water quality data, and input provided by researchers (refer back to footnote 6) with expertise in eutrophication issues in the central coast region indicate clear evidence of algae problems and biostimulation in the summer months, and that eutrophication is primarily manifested as a summer-time water quality problem in project area waterbodies. In the winter higher flows, cooler temperatures, lower light availability, and scouring evidently limit algal production. There are substantial uncertainties regarding the extent to which winter time algal

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[8] USEPA. Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed.

[9] University of California, Santa Cruz. 2010. Final Report: Long-term, high resolution nutrient and sediment monitoring and characterizing in-stream primary production. Proposition 40 Agricultural Water Quality Grant Program. Dr. Marc Los Huuertos, Ph.D., project director.

[10] Rollins, S., M. Los Huertos, P. Krone-Davis, and C. Ritz. 2012. Algae Biomonitoring and Assessment for Streams and Rivers of California's Central Coast. Final Report for Proposition 50 Grant Agreement No. 06-349-553-2

biomass problems manifest themselves, and about the extent to which winter time loads of phosphorus ultimately contribute to biostimulation problems in the summer.

2) The State of Nevada adopted a total phosphate numeric criteria of 0.3 mg/L for Class B streams, and for most reaches of Class A streams[11]

3) USEPA nutrient target development guidance recognizes the use of established concentration thresholds from published literature (refer back to footnote 2)

4) A wet season value of 0.3 mg/L comports well with the high end of orthophosphate concentrations observed in reference conditions in the Pajaro River basin (reference conditions are lightly-disturbed and natural stream systems). Therefore, the proposed wet-season of 0.3 mg/L satisfies the conditions that a wet season target at this time should be less stringent than a dry season target, and the proposed target itself falls well within the range of high-end concentrations (sometimes greater than 0.3 mg/L) that can plausibly be expected under relatively undisturbed or reference conditions. In other words, 0.3 mg/L is consistent with high-end orthophosphate concentrations found in natural and lightly-disturbed stream systems in the Pajaro River basin, and consequently does not plausibly appear to be under-protective for use as a less-stringent wet season target.

However, it should be noted that research into eutrophication in inland surface streams and estuaries are an active and ongoing area of research. Should future research and studies indicate systematic biostimulatory impairments in the winter months, or contributions to summertime biostimulation ultimately resulting from winter time loading, the Water Board may consider extending the more stringent dry season numeric targets to the wet season.

Finally, nutrient TMDLs often embed a statistical threshold in targets developed for biostimulatory substances. This is because the application and use of the USEPA-recognized statistical approaches must consider that the published ecoregional approaches that underlies these statistical approaches inherently accounts for natural variability. Therefore, it would be inappropriate to expect project area streams to not exhibit some natural variability, including concentrations that will ultimately be marginally higher than the proposed biostimulatory targets, as well as lower. Therefore, dry-season targets, which are based on USEPA statistical methodologies are established as the geomean values of dry-season samples.

[11] USEPA, 1988. Phosphorus – Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria. (Sept. 1988)

B.15 Final TMDL Numeric Targets for Biostimulatory Substances

Table 1 presents the final TMDL numeric targets for biostimulatory substances on the basis of information developed this appendix.

Table 1. Final TMDL numeric targets for biostimulatory substances.

Stream Reaches Assigned Nitrate (as N) and Orthophosphate Water Quality Targets						
Waterbody Type	**Geomorphology & Stream Characteristics**	**Stream Reaches**	**Allowable Nitrate as N (mg/L)**	**Allowable Orthophosphate as P (mg/L)**	**Methodology for Developing Numeric Target**	**Notes Pertaining to Development of Targets**
Alluvial Floodplain River – Pajaro River	Generally low gradient alluvial basin floor and floodplains. Moderate ambient turbidity (9–21 NTU). Generally moderate canopy cover (20-25%). Substrates variable, but generally characterized by finer-grained material such as loams, clay loams, and fine- sandy loams.	Pajaro River, all reaches including the Pajaro River estuary.	**3.9** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Relatively finer-grained substrates and local soil conditions, such as loads, and clay loams likely result in relatively higher ambient turbidity (9–21 NTU) which limits good sunlight penetration of water column; risk of biostimulation thus occurs at relatively higher nutrient concentrations. Orthophosphate water quality targets in the dry season are based on background, reference conditions (USEPA 75th percentile reference approach) for the Santa Cruz Mountains and Watsonville Plains level IV ecoregions.
Pajaro Valley –Alluvial Fan & Plains Tributary Creeks	Alluvial fans and alluvial plain tributary reaches. Generally low ambient turbidity (0.1–2 NTU). Generally moderate to higher canopy cover (40-50%). Substrates variable, with finer grained material such as clay loams and sandy loams in lower reaches of these tributaries, and coarser grained material such as gravelly loams and sand in middle reaches of these tributaries.	Corralitos Creek, all reaches Salsipuedes Creek, all reaches	**1.8** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Orthophosphate water quality targets in the dry season are based on background, reference conditions (USEPA 75th percentile reference approach) for the Santa Cruz Mountains and Watsonville Plains level IV ecoregions.
Pajaro Valley – Agricultural Ditches	Agricultural ditches located on the basin floor and coastal flood plain of the Pajaro Valley. Low canopy cover (0% to 15%). Substrates expected to be fine-grained mud and clay.	Beach Road Ditch McGowan Ditch	**3.3** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Substrates expected to be muddy and fine-grained substrates based on local soil conditions which contribute to relatively higher ambient turbidity (up to 19 NTU) which could preclude good sunlight penetration of water column; risk of biostimulation occurs at relatively higher nutrient concentrations.

Stream Reaches Assigned Nitrate (as N) and Orthophosphate Water Quality Targets						
Waterbody Type	**Geomorphology & Stream Characteristics**	**Stream Reaches**	**Allowable Nitrate as N (mg/L)**	**Allowable Orthophosphate as P (mg/L)**	**Methodology for Developing Numeric Target**	**Notes Pertaining to Development of Targets**
South Santa Clara Valley – Basin Floor & Floodplain Tributary Creeks	Alluvial fan and alluvial plain tributary creek reaches of the south Santa Clara Valley. Generally moderate canopy cover (35% to 50%). Substrates expected to be variable, fine-grained silts and clays close to the Soap Lake Basin area, and courser grained sands and gravels in upstream reaches.	Llagas Creek, all reaches downstream of Chesbro Reservoir Carnedaro and Uvas Creeks, all reaches Furlong Creek, all reaches	**1.8** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.04** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supported by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Relatively low ambient turbidity (around 5 NTU) can promote good sunlight penetration resulting in somewhat lower predicted nutrient targets protective against biostimulation.
San Juan Valley – Basin Floor & Floodplain Tributary Creeks	Flood plain and basin floor tributary creek reaches of the San Juan Valley. Relatively lower canopy cover (10% to 40%). Substrates expected to be generally silts and clays, with some gravel in the lowermost reaches.	San Juan Creek, all reaches West Branch San Juan Creek, all reaches	**3.3** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.12** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	San Juan Creek is specifically designated in the Central Coast Basin Plan (Table II-1) for warm freshwater aquatic habitat (WARM), and the assigned nutrient targets are protective of WARM habitat.
Lower Pacheco Creek Subbasin – Basin Floor & Floodplain Streams	Flood plain and basin floor tributary streams. Relatively low canopy cover (10% to 20%). Substrates expected to be generally silts and clays	Tequisquita Slough, all reaches	**2.2** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.12** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Tequisquita Slough is specifically designated in the Central Coast Basin Plan (Table II-1) for warm freshwater aquatic habitat (WARM), and the assigned nutrient targets are protective of WARM habitat.

Stream Reaches Assigned Total Nitrogen (as N) and Orthophosphate Water Quality Targets						
Waterbody Type	**Geomorphology & Stream Characteristics**	**Stream Reaches**	**Allowable Total Nitrogen as N (mg/L)**	**Allowable Orthophosphate as P (mg/L)**	**Methodology for Developing Numeric Target**	**Notes Pertaining to Development of Targets**
Watsonville Slough System – Coastal Sloughs	Coastal sloughs located in low gradient basin floor and marine terrace areas. Generally moderate levels of ambient turbidity.(7–21 NTU) Generally lower riparian canopy cover; Generally clayey substrates; some sandy loams in upper slough reaches.	Watsonville Slough, all reaches Harkins Slough, all reaches Gallighan Slough, all reaches Struve Slough, all reaches	**2.1** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Generally moderate ambient turbidity, clayey substrate, moderate sunlight penetration, low canopy cover indicates moderate risk of biostimulation at relatively low concentrations of nutrients. Downstream nutrient-related impacts to the Critical Coastal Area (CCA) of the Pajaro River-Watsonville Slough Estuary are possible. Total nitrogen water quality targets are assigned because nitrate generally only measures a small fraction of the total nitrogen in this system, presumably because these sloughs and wetlands are areas of high primary productivity and thus much nitrogen is bound up in organic phases and biomass.
Soap Lake Basin – Floodplain & Basin Floor Canal	Valley basin floor canal located in the inland Santa Clara Valley Estimated relatively higher levels of ambient, background turbidity.(12–21 NTU), on the basis of turbidity data from 26 agricultural drains in the Central Valley and in the Pajaro Valley. Low riparian canopy cover; Clayey substrates.	Millers Canal	**1.1** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.04** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Downstream nutrient-related impacts to the Pajaro River are possible. Total nitrogen water quality targets are assigned because nitrate because nitrate generally only measures a small fraction of the total nitrogen in this system, possible because much of the available nitrogen may be bound up in organic phases and biomass – field observation and water quality data indicate high levels of chlorophyll *a* in Millers Canal.

Information Links

The State Water Board has easy to use information on surface water, groundwater, water rights and other programs at its website. Key sites include:

About the Water Board: The "About Us" tab on the State Water Board website is a one stop location to find information such as Board membership, meetings, budget information, important policy documents, fact sheets and important contact information. http://www.waterboards.ca.gov/about_us/

My Water Quality: This site provides information to the public from multiple perspectives and presents California water quality monitoring data and assessment information that may be viewed across space and time in order to better address the public's questions. http://www.waterboards.ca.gov/mywaterquality/

Electronic Water Rights Information Management System (eWRIMS): This water rights tracking system contains information on water right permits and licenses issued by the Water Board that is available to the public and staff. http://www.waterboards.ca.gov/water_issues/programs/ewrims

GeoTracker Groundwater Ambient Monitoring and Assessment Program (GAMA): GeoTracker GAMA is an online groundwater information system that provides access to water quality data and connects users to groundwater basics and protection information. http://www.waterboards.ca.gov/gama/geotracker_gama.shtml

State Water Board Performance Reports: This annual report provides information on the Water Boards' efforts to protect and allocate the state's waters for beneficial uses. http://www.waterboards.ca.gov/about_us/performance_report/

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