Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Upper Penitencia Creek Stressor Source Identification Project

Final Work Plan - Water Year 2015 (FY 14-15)

March 15, 2015

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1. INTRODUCTION

The purpose of this work plan is to identify monitoring tasks to address requirements listed under Provision C.8.d.i of the San Francisco Bay Region Municipal Regional Stormwater NPDES Permit (MRP). This MRP provision requires Permittees to conduct monitoring projects to identify and isolate potential stressors and/or sources associated with observed potential water quality impacts. In FY 2013-14, the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) successfully completed two stressor/soruce identification projects (i.e., Guadalupe River and Coyote Creek) (SCVURPPP 2014). The project described in this work plan is the third and final project to be completed consistent with MRP requirements.

The Upper Penitencia Creek Stressor/Source Identification Project described in this work plan was triggered by creek status/condition data previously collected in 2013 and 2014 by the Program. Data suggest that an urban section of Upper Penitencia Creek has reduced biological integrity. Specifically, two bioassessment sites located within the reach between Interstate 680 and Piedmont Road had poor biological condition scores, as measured via benthic macroinvertbrate bioassessments.

The Causal Analysis/Diagnosis Decision Information System (CADDIS) framework was used to identify and evaluate probable stressors and sources affecting biological condition in Upper Penitencia Creek. The following steps associated with the CADDIS process were applied:

- Define the type and location of the impact to be evaluated (i.e., the case)
- Identify the potential factors impacting biological condition;
- Analyze existing data for links between stressor indicators and biological response;
- Identify information gaps
- Develop monitoring plan to address data gaps

Planned investigative monitoring activities are presented at the end of this work plan. SCVURPPP staff plan to conduct montoring during spring/summer season 2015.

2. BACKGROUND

2.1 Study Area

The Upper Penitencia Creek subwatershed drains approximately 24 square miles area within the larger Coyote Creek watershed in Santa Clara County (Figure 1). The creek flows approximately eleven miles from its headwaters in the Diablo Range to its confluence with Coyote Creek approximately 10 miles upstream of the San Francisco Bay. The upper reach of the creek flows into Cherry Flat Reservoir, a small reservoir (500 acre-feet), that was constructed in 1936 for water supply. The creek continues to flow through Alum Rock Park (ARP), managed by the City of San Jose, where it exits the foothills onto the valley floor. The creek continues west for approximately four miles through an urbanized section of creek in the eastern edge of the Santa Clara Valley.

Historical flow condition in the upper reaches of the creek are typically perennial with the majority of flow derived from springs and tributary inputs from Arroyo Aguague (Stillwater Sciences 2006). In the lower reaches of the valley floor, the creek was historically intermittent, with majority of dry season flow permeating into the alluvial fan deposits of the valley floor and recharging the groundwater aquifer. Transition from perennial to intermittent flow regime is supported from historical observations of the change in the riparian vegetation from a mixed riparian forest in the foothill region to a more sycamore-dominated riparian canopy in the valley floor (Beller et al 2012).

A number of hydromodifications in Upper Penitencia Creek subwatershed have altered the dry season hydrology of the creek. Periodic flow augmentation downstream of the Cherry Flat Reservoir dam is believed to have increased the extent and duration of the wetted channel in Alum Rock Park (SCVURPPP 2003). There are two diversions structures, located at Toyon Avenue and Mabury Avenue, that divert water to offchannel percolation ponds for groundwater percolation. When creek flows begin to decrease during the declining hydrograph, additional water from the South Bay Aquaduct is diverted directly into the Penitencia Creek Percolation Ponds. Some of the water from the percolation pond is typically diverted back into the main channel during the dry season to maintain baseflows supporting resident fish populations.

Throughout much of Alum Rock Park, Upper Penitenica Creek provides cool temperatures and physical habitat that support rearing and spawning lifestages for steelhead. This reach also supports a predominately native fish community of Pacific lamprey, hitch, California roach, stickleback, Sacramento pikeminnow, Sacramento sucker and sculpin species. Lower reaches may also support a mix of native and non-native warm water fish communities when adequate flow is available (SCVURPPP 2003).

2.2 Biological Condition Assessments

The Stressor/Source Identification Project was triggered by creek status/condition data suggesting an urban section of Upper Penitencia Creek has reduced biological integrity. Three locations in Upper Penitencia Creek were sampled by the Program for benthic macro-invertebrates (BMIs) during spring season of 2012 and 2013 (Figure 1). Sampling locations were selected using a probabilistic monitoring design (SCVURPPP 2014). The BMI results were interpreted using two existing tools: the Southern California Index of Biological Integrity (SoCal IBI) (Ode et al. 2005) and the California Stream Condition Index (CSCI) (Mazor et al. in review). Methods for calculating both indices for biological condition are described in SCVURPPP 2014.

Two of the sampling locations (sites 105 and 114), located in an urban reach of Upper Penitencia Creek between Interstate 680 and Piedmont Road, had SoCal IBI scores of 21 and 30 and CSCI scores of 0.67 and 0.72, respectively (Table 1). Both scores were within SoCal IBI scoring range for “poor” condition. The third monitoring location (site 141), located about 3 miles upstream of Piedmont Road in Alum Rock Park, received a SoCal IBI score of 99 and CSCI score of 1.19. The upper site was ranked as “very good” condition based on SoCal IBI score. Condition categories for CSCI are currently under development.

The Program previously conducted biological assessments using BMIs at six sites in Upper Penitencia Creek in 2008 as part of its Annual Monitoring Program (SCVURPPP 2008). The SoCal IBI scores for these sites ranged between 4 and 90 and CSCI scores ranged from 0.58 to 1.19 (Table 1). Sampling locations in 2008 were selected using a targeted design to conduct monitoring across a wide range of stream conditions in the watershed (Figure 1). One probabilistic sampling location (site 114) was about 100 meters from an existing targeted sampling location (site 115). The probabilistic and targeted sample reach overlapped at site 140 and thus, were considered the same site.

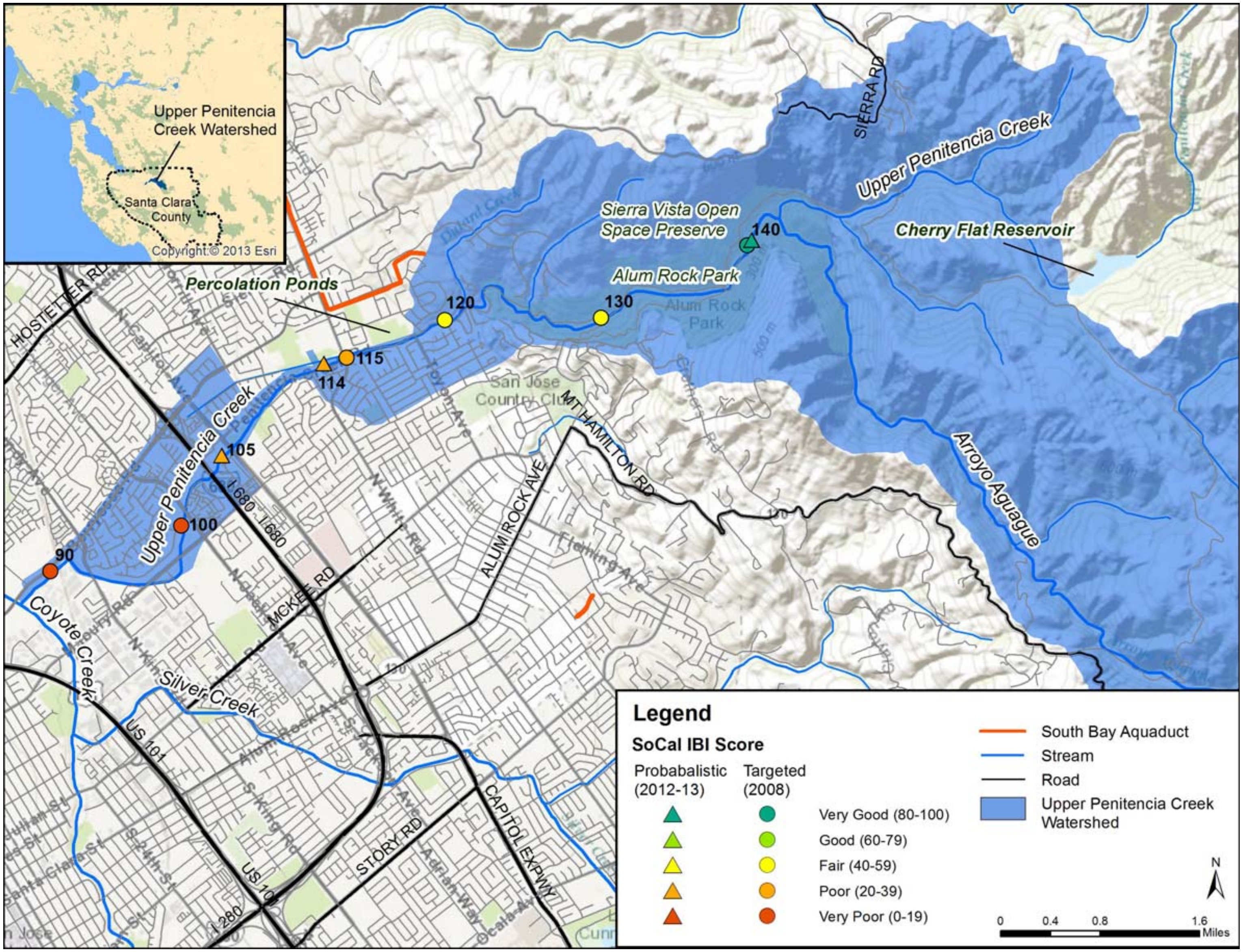

Figure 1. Nine bioassessment locations in Upper Penitencia Creek sampled between 2008 and 2013.

Table 1. Location and date of bioassessments conducted by SCVURPPP in 2008 through 2013. Biological condition scores using SoCal IBI and CSCI are also presented.

Site Id[1]	Station Code	Elevation (ft)	SampleDate	Monitoring Design	SoCal IBI Score	Condition Category	CSCI Score
90	205COY090	74	4/30/2008	Targeted	7	Very Poor	0.58
100	205COY100	123	4/30/2008	Targeted	4	Very Poor	0.55
105	205COY105	145	5/24/2012	Probablistic	21	Poor	0.67
114	205COY114	194	6/5/2013	Probablistic	30	Poor	0.72
115	205COY115	206	5/1/2008	Targeted	29	Poor	0.78
120	205COY120	256	5/1/2008	Targeted	52	Fair	0.97
130	205COY130	431	5/2/2008	Targeted	54	Fair	1.03
140	205COY140	597	5/2/2008	Targeted	90	Very Good	1.18
140	205COY140	607	6/12/2013	Probablistic	99	Very Good	1.19

The biological condition scores decreased across both probabilistic and targeted sites in an upstream to downstream direction (Figure 2). A relatively large decrease in SoCal IBI score is observed between sites 120 and 115, with scores of 52 and 29, respectively. A similar decrease between these sites is observed with CSCI scores, 0.97 and 0.78, respectively.

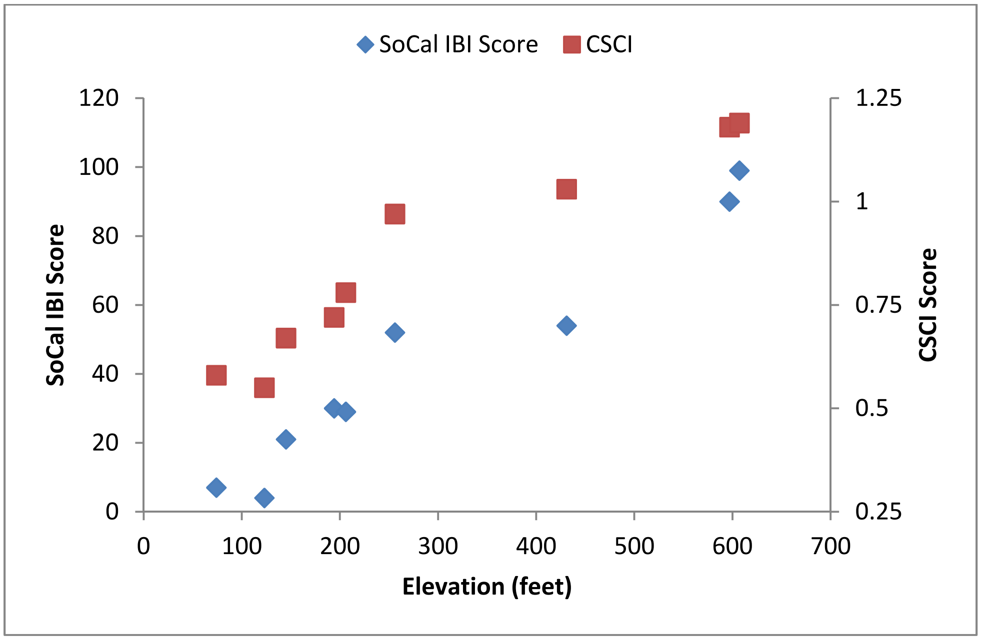

Figure 2. SoCal IBI and CSCI scores for nine bioassessment sites in Upper Penitencia Creek sampled between 2008 and 2013.

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[1] Site IDs are based on the last three numbers of the station codes used by SCVURPPP for identifying monitoring stations (e.g., 90 represents monitoring station 205COY090).

2.3 Causal Assessment Approach

The Causal Analysis/Diagnosis Decision Information System (CADDIS) was applied to evaluate potential biological impacts observed at the case site in Upper Penitencia Creek. CADDIS was developed by the US EPA as an online guidance application for users to conduct causal assessments (US EPA 2010). The online tool provides a logical, step-by-step framework for Stressor Identification (SI) for biologically impacted aquatic ecosystems. CADDIS identifies a five-step process for conducting a causal assessment:

- Step 1: Define the Case
- Step 2: List Candidate Causes
- Step 3: Evaluate Data from the Case
- Step 4: Evaluate Data from Elsewhere
- Step 5: Identify Probable Causes

The five step process is illustrated in Figure 3.

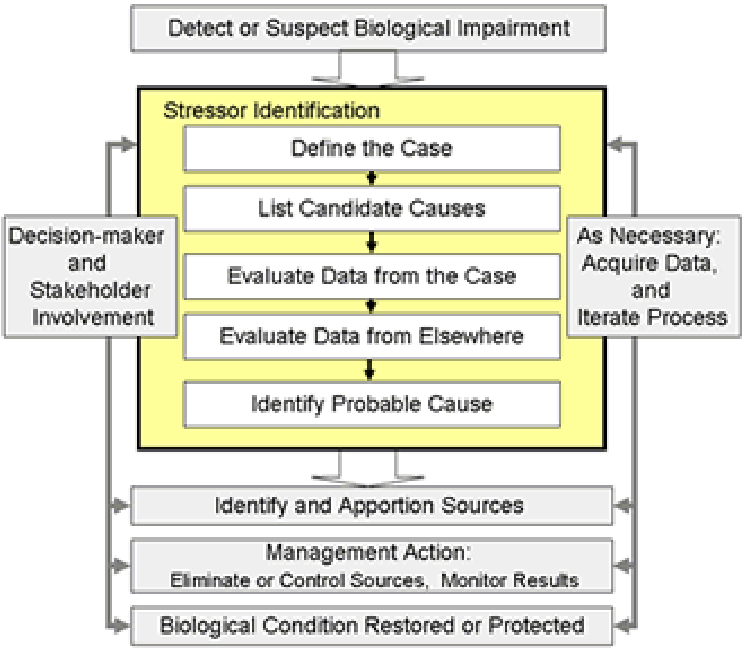


Figure 3. Causal assessment process defined in CADDIS (US EPA 2010)

The first step of the SI process is to define the subject of the analysis (i.e., the case), by determining the geographic area of the investigation and the effects to be analyzed. The case definition sets the stage for the rest of the causal analysis in terms of the information that will be assembled, the causes to be evaluated, and how conclusions will be presented.

The next step (Step 2) is to develop a comprehensive list of candidate causes, or stressors, to be evaluated for potential impacts to biological conditions observed at the case site. Identification of the stressors further refines the scope of the causal analysis, and provides a framework for assembling available data and determining what data are needed for the causal analysis.

In Step 3, existing data is analyzed to compare measures of the biological response (e.g., invertebrate taxonomic richness) with direct measures of proximate stressors (e.g., toxicant concentrations or percent embeddedness values), or intermediate measures that link sources, stressors, and biological effects. Data is analyzed with two goals in mind:

- To develop consistent and credible evidence that allows one to confidently eliminate very improbable stressors, or to use symptoms to refute or diagnose a stressor, and
- To begin building the body of evidence for those candidate stressors that cannot be eliminated or diagnosed, which will be used in Step 5 to identify the most probable stressor.

The candidate stressor that remain are evaluated further in Step 4, by bringing in data from studies conducted outside of the case. The evidence developed from this information completes the body of evidence used to identify the most probable stressors of the observed biological effects. The key distinction between data from elsewhere and data from the case is location: data from elsewhere are assumed to be independent of what is observed at the case sites. The last step in the Stressor Identification (SI) process is to distinguish the most probable stressor(s) (Step 5). Each candidate stressor must be compared to every other candidate stressor to determine which stressor led to the specific effects. The rationale for identifying one stressor relative to the others needs to be clear, reasonable, and convincing if management action is to be motivated and effectively directed.

Steps 1-4 of the CADDIS process for the Upper Penitencia Creek SSID Project are described in the next section. Majority of the data available was suitable to evaluate most of the candidate stressor that directly impacted the case site. Thus, there was limited application of *Step 4 Evaluate Data from Elsewhere*. In some cases, however, existing data did not consistently provide both spatial and temporal co-occurrence to evaluate all stressors. As a result, this work plan identifies further monitoring activities that will be conducted to address the data gaps. *Step 5 Identify Probably Cause* will be conducted following additional data collection.

3. CAUSAL ANALYSIS

3.1 Identify the Case

The Stressor Source ID project will focus the causal analysis on potential stressors impacting sites 114 and 115 (i.e., case sites). Sites 114 and 115 are located directly downstream and upstream (approximately 100 meters apart) of the Piedmont Road crossing, respectively. Both sites are located downstream of the discharge point for the off-channel Percolation Ponds. The case sites will be compared to two sites (site 120 and 121) further upstream on the eastern edge of the valley plain. These sites, herein referred as the comparator sites, represent existing monitoring locations that were closest to the case site (i.e., upstream direction) and exhibited much higher biological condition scores (as compared to the case site). Site 120 is located approximately 500 m upstream of the Percolation Pond outfall, and approximately 1 km upstream of site 115. Site 121 is located at Dorel Drive, approximately 50 meters uprstream of site 120, which is approximately the upstream extent of the percolation zone and where the creek becomes intermittent during the late dry season.

3.2 Data Inventory

A list of previously conducted SCVURPPP monitoring projects and associated data types for sites in Upper Penitencia Creek are shown in Table 3. In 2008, the SCVURPPP conducted bioassessments at six locations in Upper Penitencia Creek and PHAB and general water chemistry samples were measured. The Program also conducted monitoring in 2012 and 2013 to satisfy Provision C.8 of its NPDES Municipal Regional Permit (MRP). A probabilistic monitoring design was used to select sites throughout Santa Clara County for the collection of several parameters, including bioassessments (BMIs and algae), physical habitat assessments (PHAB), general water chemistry and conventional water quality (i.e., nutrients). In addition, sediment chemistry (i.e., pesticides and metals) and water and sediment toxicity tests were conducted at a subset of the probabilistic sites. Sediment chemistry and toxicity sampling was conducted at two of the six sites. Bioassessment sampling locations for both probabilistic and targeted monitoring projects are shown in Figure 1.

In 2012 and 2013, temperature loggers were continuously deployed at 4 and 6 sites, respectively (Table 2). Temperature monitoring locations are shown in Figure 4.

Site selection was based on a targeted design, although three of the sites were also probabilistic sites. Monitoring was conducted between the months of April and September.

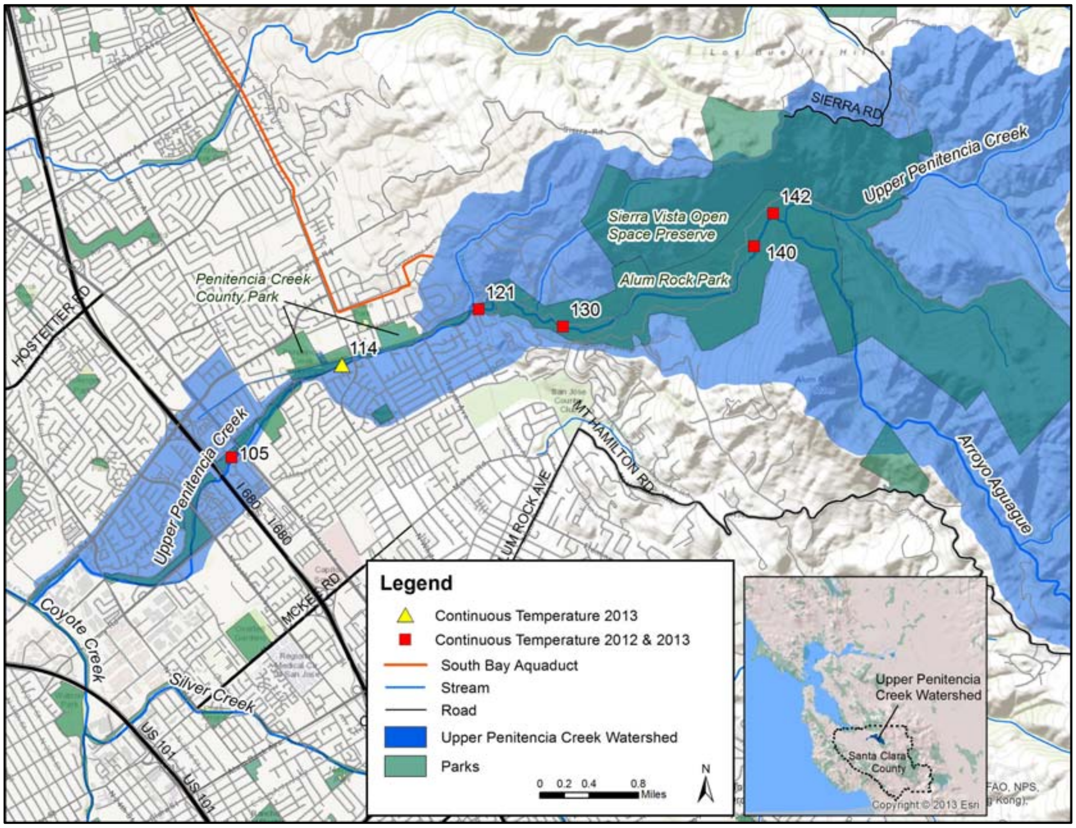


Figure 4. Continuous temperature sites in Upper Penitencia Creek monitored April through September in 2012 and 2013.

Specific indicators for each data type and the associated sampling location where data are available to evaluate the candidate stressors are presented in Table 4 (see Section 3.1 for a discussion of candidate causes).

Sites 114 and 115 were identified as the case sites. They both have low biological condition scores, similar hydrologic conditions (i.e., downstream of percolation pond discharge) and similar channel morphology and physical habitat conditions. The two sites are only 100 meters apart. Similarly, sites 120 and 121 are approximately 100 meters apart and are both used to represent the comparator site. These sites have similar flow regime (i.e., natural perennial with no influence by percolation pond discharges) and similar channel morphology and physical habitat conditions.

Bioassessment data collected in 2008 from site 115 and site 120 were used to assess physical habitat condition. Bioassessment data collected in 2012 and 2013 were not used to evaluate stressor variables due to absence of data collected at or near the comparator site(s). Continuous water temperature data collected in 2013 from site 114 and 121 were used to assess potential temperature impacts to case site. Similarly, flow data available from Dorel Drive (site 121) and Piedmont Av (site 114) were used to assess impacts associated with flow alteration. Nutrient, sediment chemistry and toxicity data collected at site 105 in 2012 were used to evaluate nutrient and pesticide causes of biological impact to site 114.

Table 2. Type of data collected for both probabilistic and targeted monitoring projects.

Data Source	Year Sampled	# Sites	BMI	Algae	PHAB	Riparian Assmt	Gen WQ	Temp Loggers	Nutrients	Sediment Chemistry	Toxicity
Creek Status Monitoring Project – Probabilistic sites	2012	1	x	x	x	x	x		x	x	x
	2013	2	x	x	x	x	x		x		
Creek Status Monitoring Project – Targeted Study	2012	4						x			
	2013	6						x			
Annual Monitoring Project – Targeted Study	2008	6	x		x		x			2 sites only	2 sites only

Table 3. Data collected by SCVURPPP across10 sampling locations during monitoring projects conducted in 2008, 2012 and 2013.

Causal Factor	Evidence Type		Downstream Sites			Case		Comparator		Upstream Sites		
	Data Type	Indicator	90	100	105	114	115	120	121	130	140	142
Biological Response	BMI	SoCal IBI; CSCI	x	x	x	x	x	x		x	x	
Physical Habitat Sedimentation	PHAB	PHAB score; % fines+sands	x	x	x	x	x	x		x	x	
Reduced Dissolved oxygen	General WQ	DO concentration	x	x	x	x	x	x		x	x	
Nutrients	Nutrients	N and P chl a, AFDM			x	x					x	
Pesticides and Petroleum	Sediment Chemistry	pyrethroids	x		x					x		
	Toxicity Testing		x		x					x		
Increased Temperature	Temperature Logger	Mean C			x	x			x	x	x	x
Altered Flow Regime	Flow gage or velocity	cfs				x			x			

3.3 Identify Candidate Stressors

There are a number of factors that may be reducing the biological condition in the urban reach of Upper Penitencia Creek. Six candidate stressors were evaluated for further investigation based on existing data and prior knowledge of stream characteristics, the surrounding landscape, and human activities present in the watershed. These include:

- Increased Temperature
- Altered Flow Regime
- Altered Physical Habitat
- Reduced Dissolved Oxygen
- Nutrients
- Insecticides

Conceptual diagrams linking the candidate stressor with potential sources and effects are presented in the next section. Each conceptual diagram is structured with sources and contributing landscape changes at the top of the figure, followed by steps in the causal pathway, proximate stressors, modes of action and biological responses toward the bottom of the diagram. The conceptual models are from the EPA website (http://www.epa.goc/caddis/ssr_home.html).

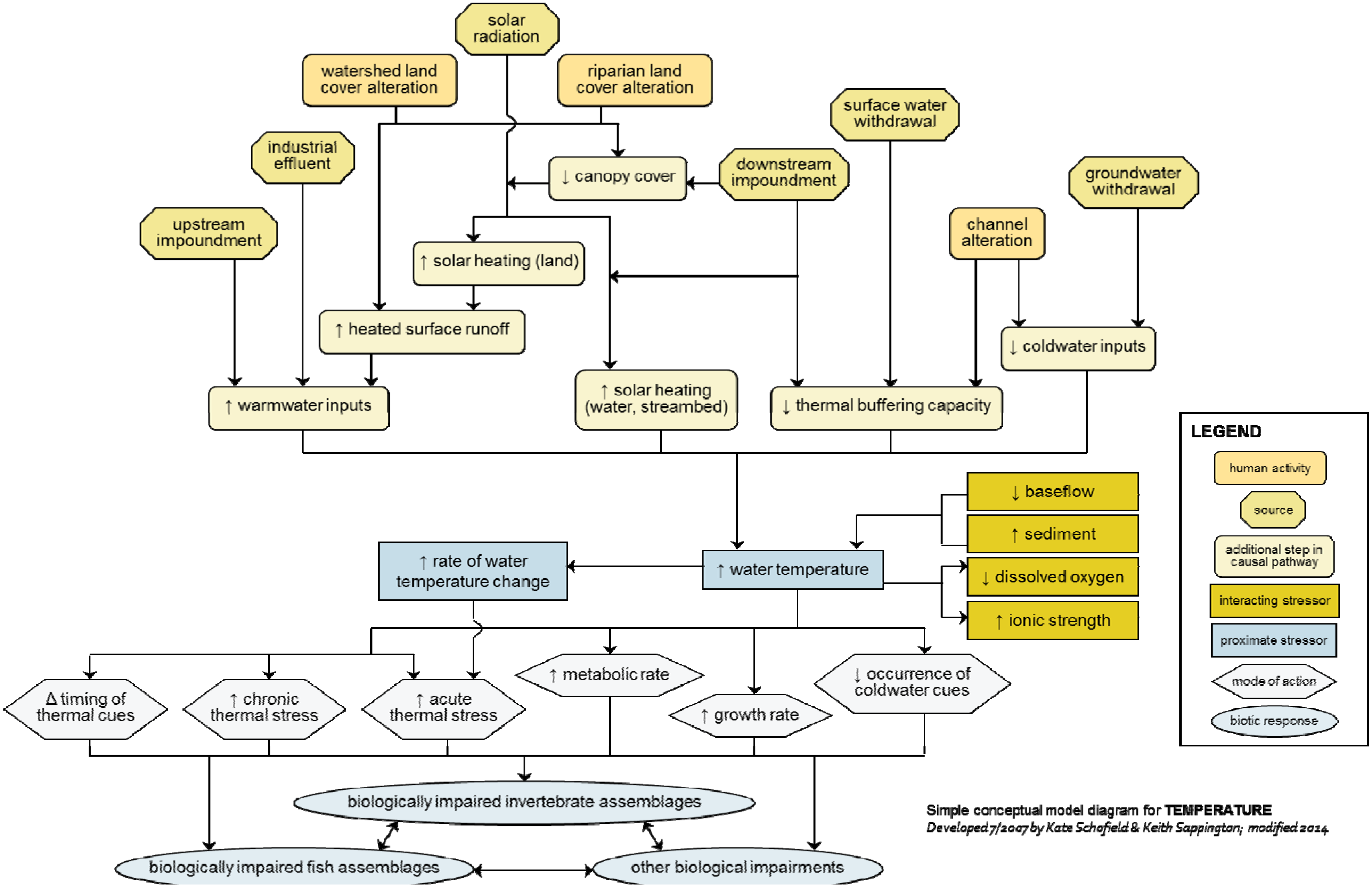
3.3.1 Increased Temperature

Potential Impacts

Human activities may cause temperature regime changes in a variety of ways (Figure 5). Many human activities that alter stream temperature regimes involve land cover alteration, which subsequently changes solar heating of landscape surfaces, runoff, or the streambed itself. Vegetation removal in the watershed and development that increases impervious land cover increases heated runoff inputs to the stream. Vegetation removal in the riparian corridor directly results in increased solar heating of water in the stream.

Additionally, reductions in coldwater inputs or otherwise decreasing the thermal buffering capacity of the system can result in large temperature changes. Groundwater inputs to streams often functions as a thermal buffer, especially in summer when groundwater is typically cooler than surface waters. If groundwater inputs are reduced, (e.g., due to decreased groundwater recharge), coldwater inputs may decrease resulting in a loss of thermal-buffering capacity and potentially increased temperatures.

Changes in temperature extremes, average temperature, or fluctuations (e.g. diurnal temperature cycles) can affect several biological processes (Figure 5). The temperature regime is a key factor in organism survival, growth, reproduction, development, behavior, habitat preference, and competition. Aquatic organisms have maximum and minimum temperature tolerance limits, which vary for specific taxa and life stages. Water temperatures exceeding these limits can cause acute or chronic stress. In addition, changes in average temperature and subsequent changes in the rate of total heat accumulation affects key developmental cues. For example, seasonal temperature changes cue the timing of fish migration and spawning and the emergence of benthic insects. Alterations to temperature regime may also induce significant physiological and behavioral changes in fishes and aquatic invertebrates, from metabolic rates to activity levels, which can lead to biological impairment.



Simple conceptual model diagram for TEMPERATURE
Developed 7/2007 by Kate Schofield & Keith Sappington; modified 2014

Figure 5. Conceptual model for primary stressor of Increased Temperature (EPA 2010).

Specifically, observable biological effects that may be caused by changes in temperature include:

- Absence of coldwater taxa (e.g., salmonids, stoneflies) where they are expected;
- Presence of warmwater taxa in streams where they are not expected;
- Changes in the onset of certain reproductive or developmental events cued to temperature (e.g., earlier insect emergence or fish migration in warmer waters); and
- Behavioral changes, such as congregation of fish near cold- or warmwater inputs.

Evaluation of Existing Data

General water quality grab measurements taken during the 2008 bioassessments show the highest water temperature across all sites was observed at the case site 115 (18.4 °C), which was about 3°C higher than the comparator site 120 (located about 1 km upstream) (Table 4). Site 115 had higher percent canopy cover (72%) compared to site 120 (61%), which suggest that solar radiation is not causing the difference in water temperature between these two sites.

Table 4. Water quality data collected during bioassessment sampling at six sites in Upper Penitencia Creek during 2008. Biological condition scores are indicated for each site.

Stressor Variable	90	100	115	120	130	140
Water Quality						
Water temperature (°C)	13.4	16.5	18.4	15.5	11.7	12.8
Dissolved oxygen (mg/L)	10.31	11.39	10.54	10.42	10.69	10.74
pH	6.69	8.06	8.43	8.27	7.37	7.57
Conductivity (uS/cm)	614	609	619	1433	1424	701
Biological Response						
SoCal IBI Score	7	4	29	52	54	90
CSCI Score	0.58	0.55	0.78	0.97	1.03	1.18

The SoCal IBI scores from 2008 assessments dropped dramatically between site 120 and 115, 52 to 29, respectively. Individual metric scores shows a shift in the benthic macro-invertebrate community between these two sites (Table 5). Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa, predator taxa and percent intolerant taxa were consistently lower at sites downstream of site120. In contrast, percent non-insect taxa and tolerant taxa were consistently higher at sites downstream of site 120. Increase in temperatures typically support higher tolerance BMI taxa and are less favorable to low tolerance taxa, such as EPT.

Table 5. Raw metric scores used to calculate SoCal IBI scores at six bioassessment sites in Upper Penitencia Creek sampled in 2008.

Station Code		90	100	115	120	130	140
Sample Date		4/30/2008	4/30/2008	5/1/2008	5/1/2008	5/2/2008	5/2/2008
Raw Metric	EPT Taxa	4	3	9	13	25	25
	Number Coleoptera Taxa	0	0	1	2	7	7
	Number Predator Taxa	4	4	9	10	15	15
	Percent CF + CG Individuals	97	95	92	90	64	64
	Percent Intolerant	0	0	1	7	28	28
	Percent Non-Insecta Taxa	56	59	48	25	17	17
	Percent Tolerant Taxa (8-10)	31	41	24	16	15	15
SoCal IBI Score		7	4	29	52	54	90

Continuous water temperature data collected at six sites between April and September, 2013 are presented in Table 6. The highest mean water temperature (21 °C) across all sites was observed at site 114 (just upstream of site 115). The mean temperature at site 114 was nearly 4°C warmer than site 121. Table 6 inludes biological condition scores for three of the sites sampled in 2012 and 2013; bioassessments were not conducted at the comparator site in 2012 or 2013.

Table 6. Summary statistics of continuous water quality data collected at six locations in Upper Penitencia Creek between April and September, 2013. Biological condition scores are indicated for each site. Sites with no available bioassessment data are indicated as "NA".

Temperature (°C)	105	114	121	130	140	142
Minimum	15.3	15.7	11.5	11.7	11.1	9.5
Median	20.4	21.0	17.4	17.9	15.7	16.2
Mean	20.4	21.0	17.3	18.1	15.7	16.1
Maximum	27.4	27.6	24.2	26.7	20.5	22.3
Max 7-day Mean	24.1	25.1	20.6	22.3	18.1	19.1
SoCal IBI Score	21	30	NA	NA	99	NA
CSCI Score	0.67	0.72	NA	NA	1.19	NA

The combined grab sample and continuous water temperature data provide evidence supporting the conclusion that altered water temperature may be impacting the biological condition at site 114 and 115. It is important to note that both of these sites occur in the dryback zone, but are typically wet during part of the dry season due to augmented flow from the percolation pond (see next section). Conductivity was over two times the levels at comparator site compared to case site, indicating a major change in water chemistry likely occurs between the two sites.

3.3.2 Altered Flow Regime

Potential Impacts

The channel flow regime, as characterized by water velocity, water depth, and water discharge patterns, can affect aquatic biota. The flow regime can be altered by human activities such as water management, construction of impervious surfaces, agriculture-related extraction and discharge, point source discharges, or industrial or mining extraction.

Flow characteristics are regionally and temporally variable. Variance in rainfall patterns, vegetation, development, geology, and other characteristics of the landscape in the watershed results in natural variability of flow. Channel morphology also plays a role, with reach characteristics such as the presence of pools or riffles affecting local flow velocities. Biological characteristics can be affected by flow alteration through a variety of mechanisms (Figure 6). The volume, velocity, and variance of both low flows (baseflows or average flows) and high flows (peak or stormflows) affect which types of species are best able to survive. Changes in flow may harm some species and help others, resulting in changes to biotic community structure. For example, if water is abstracted, the magnitude of flow may decrease and low-flow duration will increase. This could lead to channel drying which in turn results in a greater abundance of drought-tolerant taxa. However, if runoff or other inputs increase, then the magnitude and duration of high flows will increase. This can result in scouring and displacement of biota and subsequent reduction in benthic taxa or life stages.

Biological effects that may be caused by flow alteration include:

- Reduced productivity
- Changes in community composition
- Increased generalists and decreased specialists
- Replacement of native species by invasive or exotic species
- Disrupted reproductive cycles
- Decreased taxonomic richness and diversity

Human activities can alter flow on a watershed scale, affecting discharge based on hydrologic variables, and at the reach scale, affecting local stream velocity based on hydraulic variables (Figure 6). These changes can be indirect, due to development or land use changes in the surrounding landscape, or direct, due to channel alteration, impoundments, or point source inputs and withdrawals. Removal of forest, vegetation, or development of the watershed causes increases in surface runoff, resulting in higher magnitudes and frequencies of peak discharges.

Flow may also interact with other biological stressors such as temperature, physical habitat, dissolved oxygen, and sediment. If flow causes change in temperature or physical habitat, it may be considered a proximate cause of biological impairment. For example, urbanization and related watershed devegetation may reduce groundwater recharge resulting in lower groundwater coldwater inputs. This may cause or contribute to increases in temperature. Flow is also closely tied to physical habitat. Geomorphic features may be affected by many flow-related processes including scoring, sediment transport and deposition, and erosion.

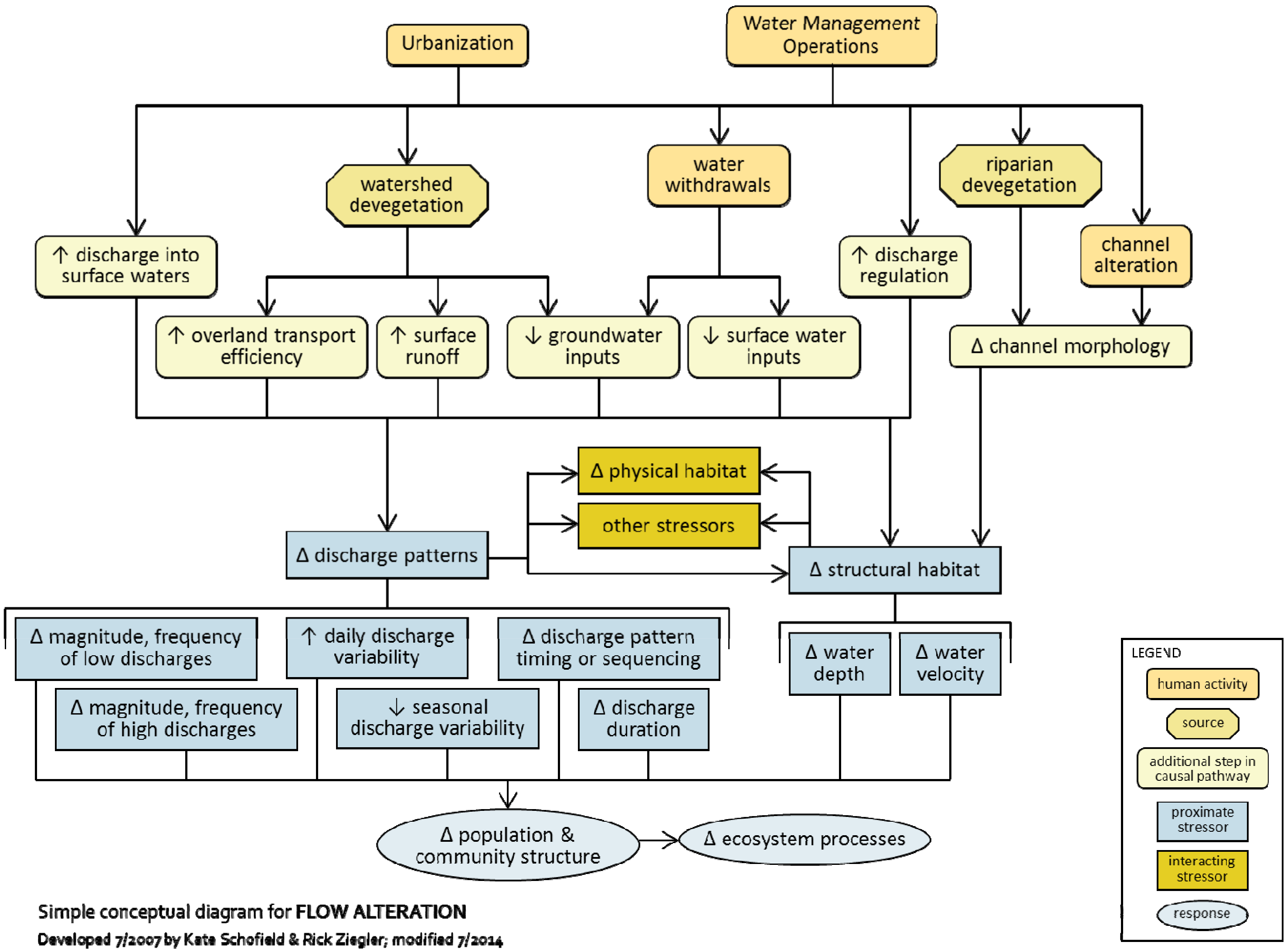


Figure 6. Conceptual model for primary stressor of Flow Alteration (EPA 2010).

Evaluation of Existing Data

Stream flow data are available from two gages, located at Dorel Road crossing (site 121) and Piedmont Road crossing (site 114). The Santa Clara Valley Water District (SCVWD) operates both stream gages. Stage heights and flow rates recorded at Dorel and Piedmont gages during 2013[2] are graphed in Figure 7. At the Dorel site, stream flow measured between mid-June and mid-September was generally < 0.1 cfs and for some periods, the channel appears to be dry. During the same time period, flow measured at Piedmont Road (approximately 1 km downstream of Dorel) was between 3 and 5 cfs. This increase in flow can be explained by releases from the percolation ponds just upstream of Piedmont Road. Thus stream flow was greater and more persistent at the case site versus the comparator site.

Higher flow conditions from percolation pond discharges during the dry season would generally be associated with improved biological conditions. Augmented flows would likely support a native fish community in a reach that typically dries up during the summer. Lower BMI condition at the case site, however indicates that something other than altered stream flow (e.g., water quality) is impacting BMIs.

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[2] Flow data from both Piedmont and Dorel gages were not available prior to 2010.

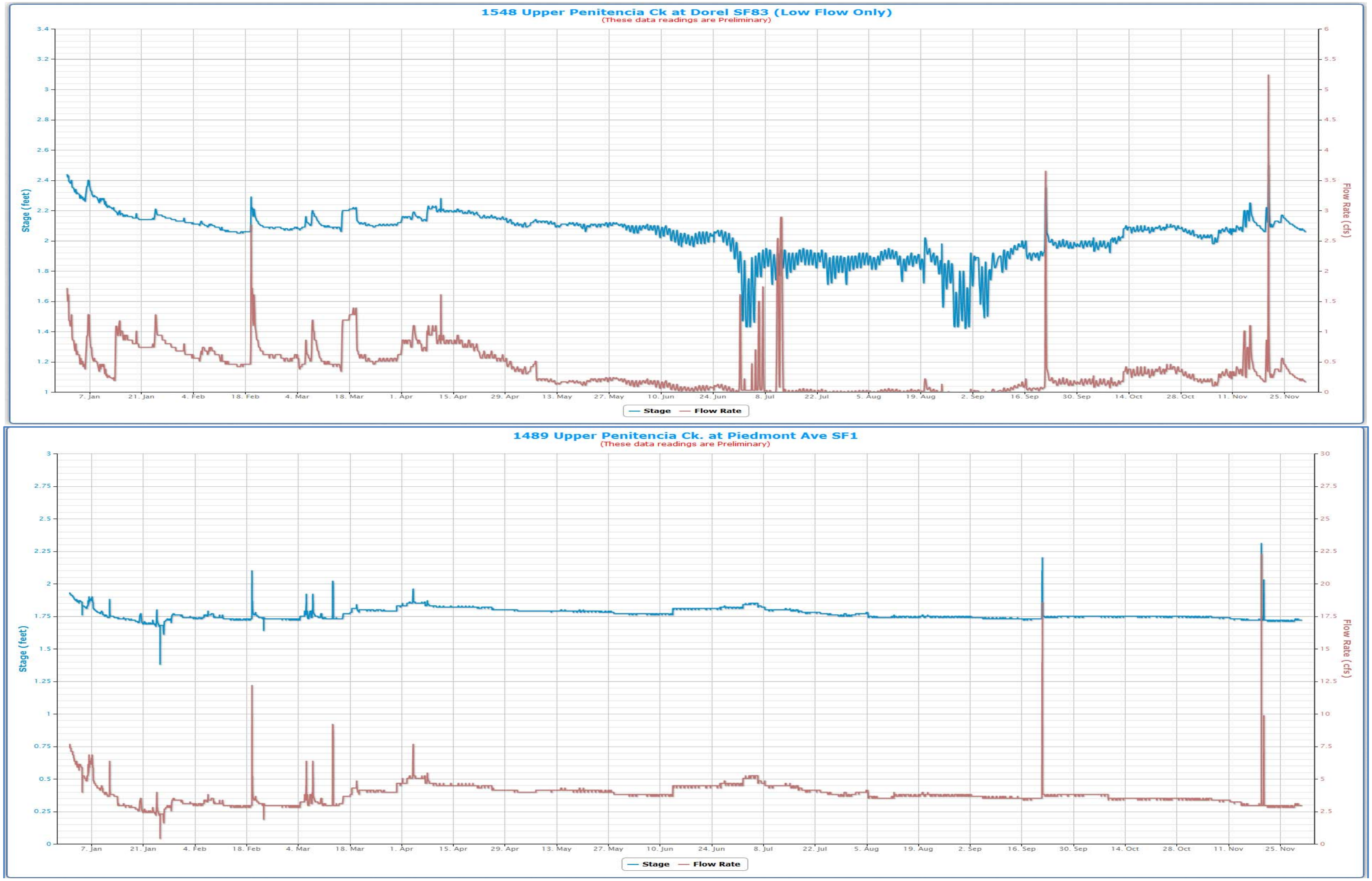

Figure 7. Flow data recorded from from Dorel Drive (site 121) stream gage (upper figure) and Piedmont Av (site 114) stream gage (lower figure) during 2013.

3.3.3 Altered Physical Habitat

Potential Impacts

Physical habitat in the stream, as characterized by structural geomorphic or vegetative features of the channel, can also affect aquatic biota (Figure 8). Physical habitat can be affected by human activities that alter these features, such as the construction of in-stream or riparian man-made structures (e.g. dams, channelization) or the development of local areas affecting riparian vegetation or other stream habitat qualities.

Physical habitat varies naturally and organisms are adapted to various stream conditions. Therefore, the quality of physical habitat is defined by its natural condition. The primary attributes of stream physical habitat are 1) Stream size and channel dimensions, 2) Channel gradient, 3) Channel substrate size and type, 4) Habitat complexity and cover, 5) Vegetation cover and structure in the riparian zone, and 6) Channel-riparian interactions.

A high-quality stream habitat is likely to be characterized by the presence of riffles and pools in alternating sequence, stream channels that are unaltered (e.g. not incised or channelized), stream banks and riparian zones that are well-vegetated with native plants. Organisms may require specific habitat attributes for specific life stages or aquatic conditions. For example, during low flow periods fish may require deep pools for survival. Fish and macroinvertebrates rely on vegetation and deep pools in the channel as refugia from predators and competitors. High-quality physical habitat provides cover and diversity of substrate and hydraulic conditions to fulfill the various requirements of aquatic biota.

Biological effects that may be caused by alteration of physical habitat include:

- Reduced abundance of young-of-year fish
- Reduced fish taxonomic richness
- Reduced relative abundance of clinging and sprawling invertebrates
- Changes in relative abundance of invertebrate functional feeding groups (e.g., grazers)
- Changes in periphyton biomass and species composition.

Human activity can alter any of the six attributes of stream habitat (Figure 8). Man-made structures in the stream such as dams, rip-rap, culverts, revetments, bridge abutments, and channelization are clear interruptions of natural physical habitat altering flow, erosion, and sediment deposition. They can pose barriers to migration and impede riparian habitat. Indirect anthropogenic factors affecting physical habitat include changes in watershed or riparian land uses that cause erosion or changes in stormwater runoff. These may be the result of urbanization or agricultural, industrial, forestry, or resource extraction practice.

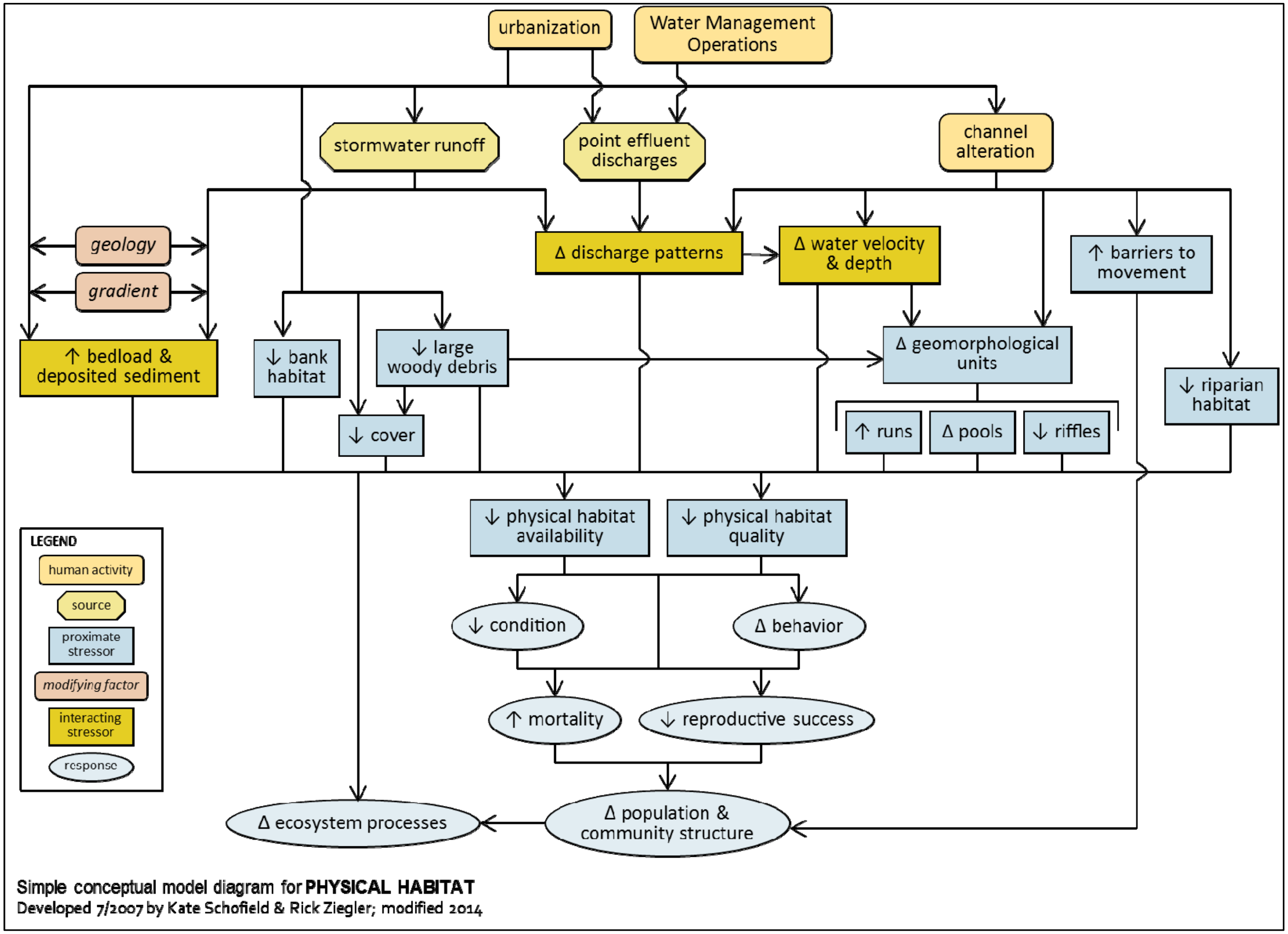

Figure 8. Conceptual model for primary stressor of Physical Habitat Alteration (EPA 2010).

Data Evaluation

The stressor variables related to physical habitat for 2008 bioassessment sites are presented in Table 7. The habitat variables did not provide a conclusive line of evidence for causing biological impact at the case site. The PHAB condition metrics epifaunal substrate and channel alteration scores were very similar between both sites (115 and 120). Mean substrate size was also similar between sites. However, site 120 had higher percent riffles, which would positively affect biological condition. However, site 120 also had higher percent sands and fine substrate, which would negatively affect biological condition. As a result, the existing physical habitat data does not conclusively indicate positive or negative line of evidence for impacts to the biological condition scores.

Table 7. Physical habitat collected during bioassessment sampling at six sites in Upper Penitencia Creek during 2008. Biological condition scores are indicated for each site.

Stressor Variable	90	100	115	120	130	140
Physical Habitat						
% Canopy Cover	62	65	72	61	51	46
% Sands & Fines	34.3	41.0	18.1	24.8	12.4	16.2
Mean Substrate Size (cm)	34.6	22.4	91.0	95.6	207.6	184.8
Epifaunal Substrate Score (0-20; 0: low; 20:high)	8	8	15	16	17	17
Channel Alterations Score (0-20; 0: low; 20:high)	6	10	16	17	14	19
% Pools	6	31	10	7	19	0
% Riffles	30	20	28	38	36	39
Biological Response						
SoCal IBI Score	7	4	29	52	54	90
CSCI Score	0.58	0.55	0.78	0.97	1.03	1.18

3.3.4 Low Dissolved Oxygen

Potential Impacts

In healthy aquatic ecosystems, oxygen becomes dissolved in the water column as it is absorbed from the atmosphere and released into the water column by aquatic plants during photosynthesis (Figure 9). This dissolved oxygen supports aquatic life including fish and invertebrates. However, if dissolved oxygen levels are severely depleted, fish and invertebrates may be impaired or killed. Large fluctuations in DO over a short period of time (i.e. daily) can also stress aquatic organisms. Urban and agricultural land uses can cause low DO through chemical, nutrient, and organic waste pollution or through the alteration of stream channels and riparian vegetation.

Changes in aquatic community structure may be due to DO levels below that of healthy ecosystems. Species that are particularly sensitive to low DO include some species of mayflies, stoneflies, caddisflies, and beetles. Tolerant worms and fly larvae that are more tolerant to low DO may be able to out-compete these organisms when DO drops. When DO reaches acute low levels, the following biological effects may occur:

- Kills of aquatic life especially
    - species with highest oxygen demands
    - large fish of certain species
    - during the night/early morning hours
- Fish gulping air and staying in shallow water

- Body movements to increase water flow (e.g. stonefly larvae “push-ups” or caddisfly larvae undulating)
- Abundance of decaying vegetation
- Dead or dying zooplankters

Many human activities can contribute to loss in dissolved oxygen in aquatic ecosystems through the reduction of natural aeration or the addition of chemical or biological oxygen demand (Figure 9). Some agricultural, forestry, and channel or steam alterations (e.g. channel straightening or creation of downstream impoundments) may reduce the aeration of water flowing through creeks and streams. In addition to this direct loss of aeration, particulate and dissolved materials that enter waterways through human activities can biologically or chemically convert oxygen, thereby decreasing its concentrations. This biological or chemical oxygen demand comes from nutrients, chemical contaminants, or organic matter, which may be released from municipal waste treatment plant overflows, septic seepage, and industrial point sources. Commonly, biological or chemical oxygen demand may enter streams as fertilizers or pesticides from agricultural and urban runoff. Devegetation of riparian areas can also play a role. Removing vegetation decreases shading, affecting temperatures and plants; DO production from aquatic plants increases in daylight hours, but oxygen demand increases during the night. Aquatic plant decomposition and reduction of woody debris from riparian trees or shrubs (reducing aeration) can also lead to depleted DO as a result of reduced riparian vegetation. DO can also interact with other stressors, primarily temperature, ionic strength, and sediments.

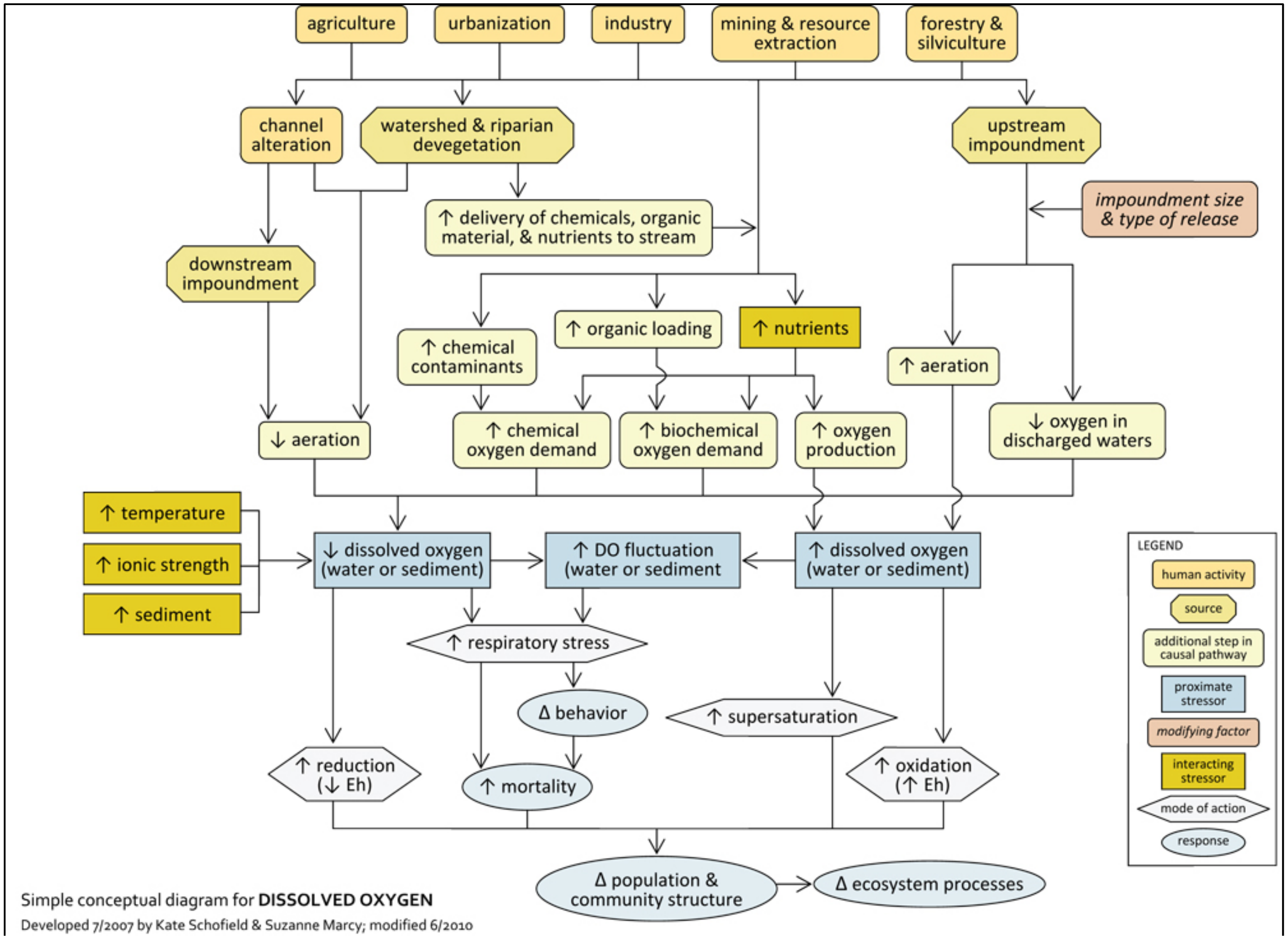

Figure 9. Conceptual model for primary stressor of Reduced Dissolved Oxygen (EPA 2010).

Data Evaluation

Spot measurements of dissolved oxygen concentration at sites 115 and 120 during the 2008 bioassessments were 10.5 mg/L and 10.4 mg/L, respectively, suggesting that DO is not impacting the biological condition at the case site (see Table 4 in Section 3.3.1). Furthermore, these DO levels are not considered detrimental to biological condition for BMIs or fish communities. However, single grab sample measurement of DO does not provide conclusive evidence to support or not support the cause. Continuous water quality measurements collected at both the case and comparator sites would provide data to more conclusively evaluate this potential cause.

3.3.5 Nutrients

Nutrients such as Nitrogen (N) and Phosphorus (P) are essential for plant growth and reproduction. The balance of nutrients available in the aquatic environment plays a role in limiting the growth rate of aquatic plants and algae (Figure 10). Commonly, when nutrient concentrations in waterways become too high, excess algal growth occurs, causing changes in fish and macroinvertebrate food resources and habitat structure. Additionally, algal toxins may be produced when nutrients lead to excessive algal growth. Through this process, nutrients entering waterways from point sources or runoff can indirectly cause harm to aquatic biological communities.

A wide range of human activities can cause excessive nutrients to enter waterways. Point-source discharges containing high nutrient levels may be released from industrial or wastewater treatment plant effluents, combined sanitary sewer outfalls, or septic systems. Runoff may also carry nutrients from many sources in the watershed. These land-based nutrient sources include agricultural land, pasture or rangeland, animal feeding operations, landfills, landscaped areas (e.g. lawns, golf courses), impervious surfaces in urban/suburban areas, or construction and development sites. Changes in land use that result in changes to surface runoff or erosion can mobilize Nitrogen and Phosphorus, resulting in higher concentrations reaching waterways.

Many factors interact with nutrient levels and resulting algal growth (Figure 10). Excessive algal growth may also be limited by factors such as available sunlight and may interact with other stressors such as dissolved oxygen (growth depletes oxygen), pH, and sediments. The proliferation of filamentous algae or algal mats, phytoplankton blooms, and abundant macrophytes are evidence of excessive nutrient concentrations that may be harming biological communities.

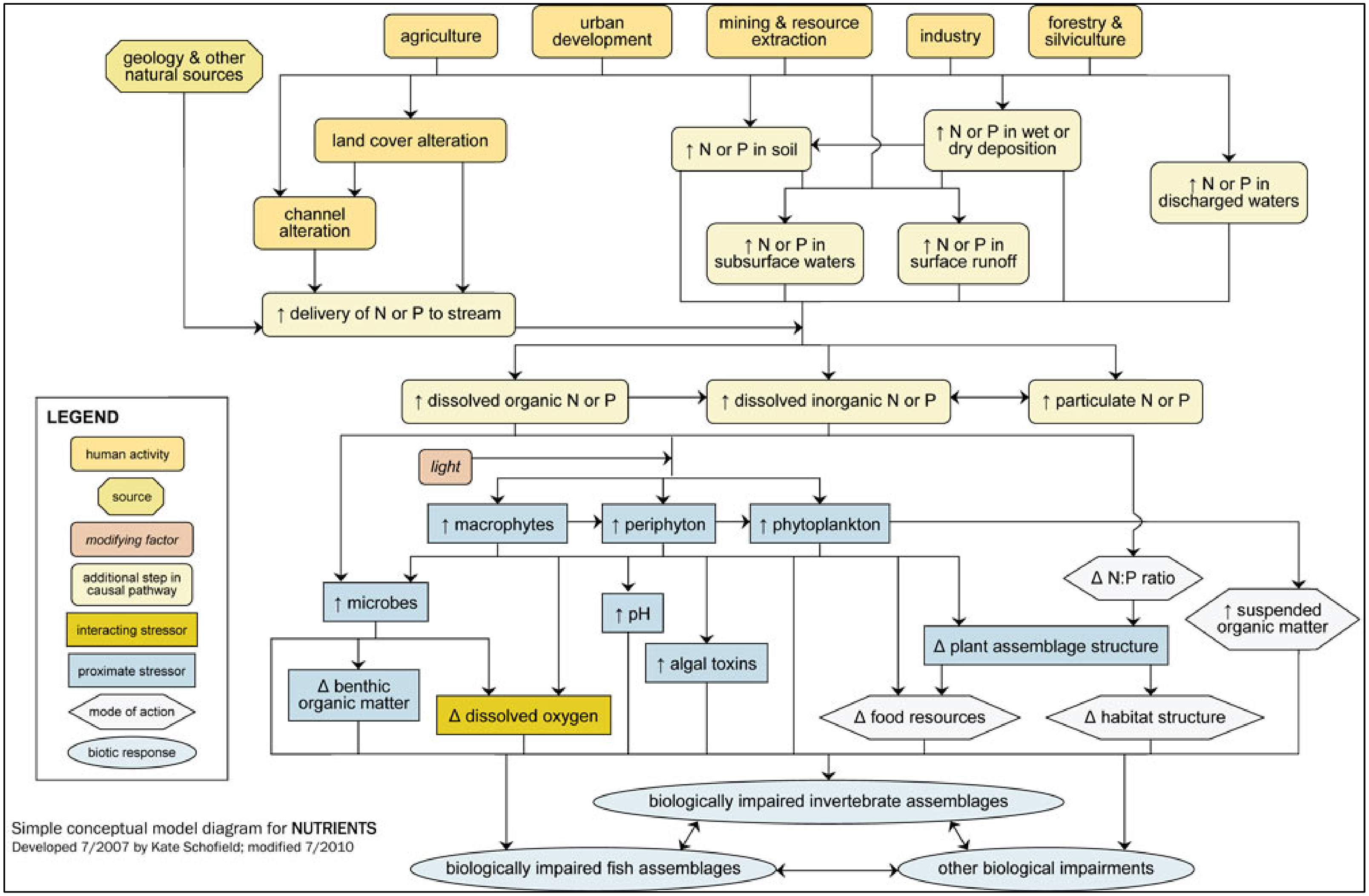

Figure 10. Conceptual model for primary stressor of Increased Nutrients (EPA 2010).

Data Evaluation

Nutrient data was collected at site 105 in 2012 and sites 114 and 140 in 2013 (Table 8). A causal assessment for nutrients was inconclusive due to a lack of nutrient data from a comparator site. In general, concentrations for all nutrients at sites 105 and 114 were higher compared to site 140, which is located much further upstream of the comparator site. Additional nutrient data collected from both case and comparator sites are needed to assess potetnial correlations between BMIs and nutrients.

Table 8. Nutrient data collected during bioassessment sampling at site 105 in 2012 and at sites 115 (case site) and 140 in 2013

Stressor Variable	105	114	140
Monitoring Year	2012	2013	2013
Nutrients			
Un-ionized ammonia *(µg/L)*	2.05	8.74	1.10
Ammonia as N *(mg/L)*	0.12	0.12	0.044
Chloride *(mg/L)*	46	54	16
Dissolved Organic Carbon *(mg/L)*	4.2	4.5	2.2
Nitrate as N *(mg/L)*	0.33	0.37	0.096
Nitrite as N *(mg/L)*	0.001	0.002	0.001
Nitrogen, Total Kjeldahl *(mg/L)*	0.44	0.59	0.13
OrthoPhosphate as P *(mg/L)*	0.072	0.1	0.034
Phosphorus as P *(mg/L)*	0.087	0.11	0.027
Chlorophyll a *(mg/m^2)*	68.6	70.4	6.9
Ash Free Dry Mass *(g/m^2)*	213	126.7	42.2
Biological Response			
SoCal IBI Score	21	30	99
CSCI Score	0.67	0.72	1.19
Diatom IBI Score	48	58	66

Nutrient data and bioassessment data are presented in Table 8. It is important to note that increased nutrients are not expected to directly impact BMIs (i.e., nutrients are not the proximate stressor), making it difficult to assess relationships between nutrients and BMIs. Effects from nutrients may alter primary production (i.e., biomass) which may in turn impact BMI composition. An increase in algal biomass may especially occur in the percolation ponds, where sunlight exposure is dramatically increased compared to stream conditions. Algae diatom IBI scores could be used as a more direct measure of the effects of nutrients on biological communities. Interpretative tools for algal data, developed for Southern California creeks, are being tested in other ecological regions in California (Fetscher et al. 2013). Specifically, the "H20" hybrid IBI (Algae IBI), which combines eight metrics that measure both diatom and soft algae community assemblage, had the greatest performance for detecting changes in nutrient concentrations. Nutrient concentrations will be compared to Algal IBI scores, as well as the chlorophyll a and ash free dry weight concentrations, both analytes generated from the benthic algae samples.

3.3.6 Insecticides

Potential Impacts

Insecticides bound to sediments or dissolved in the water column can be harmful to aquatic organisms (Figure 11). Bioaccumulation of pesticides may occur as small organisms transfer larger concentrations of insecticides to their predators, consequently affecting the aquatic community and ecosystem. Insecticides applied in agricultural or urban areas can enter waterways through stormwater or irrigation runoff.

Even if concentrations in the water column of a stream are below detection, insecticides bound to sediments or occurring in episodic patterns from temporally varying sources (e.g. storm events) may yet be affecting aquatic biota. The toxicity of insecticides may be influenced by local water quality characteristics such as dissolved organic carbon or suspended sediment and temperature or by interactions with other pollutants.

Possible biological effects of increased insecticides in stream water or sediment include:

- Decreased biological condition
- Decreased growth
- Altered behavior
- Increased susceptibility to other stressors
- Increased mortality
- Decreased reproductive success in affected biota
- Altered population and community structure

Because of the prevalence of Pyrethroids in urban insecticide applications and its existence in Bay Area waterways (SCVURPPP 2013), this insecticide type is a more likely candidate stressor than other types. Extremely toxic to fish, Pyrethroids function “by keeping open the sodium channels in neuronal membranes affecting both the peripheral and central nervous systems causing a hyper-excitable state causing such symptoms as tremors, incoordination, hyperactivity, and paralysis” (USEPA 2010).

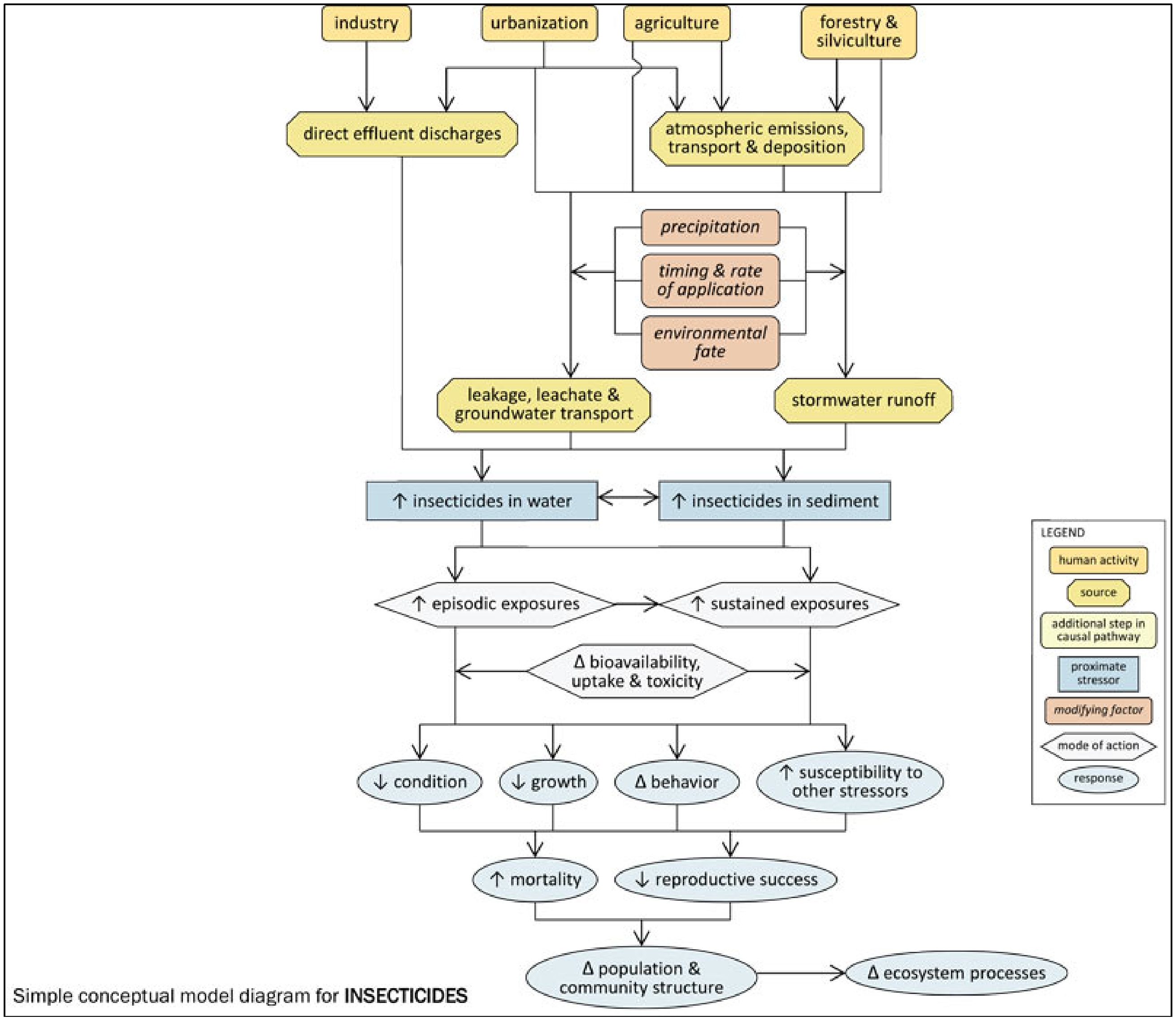

Figure 11. Conceptual model for primary stressor of Increased Insecticides (EPA 2010).

Data Evaluation

Existing sediment chemistry data and water and sediment toxicity testing conducted on samples collected at site 105 in 2012 indicate that pesticides and metals were not present in concentrations that are toxic to aquatic life uses (SCVURPPP 2013). Although no data are available from the case or comparator sites, available data suggest that pesticides or metals were not present in concentrations to impact biological conditions at site 105, approximately one mile further downstream of the case site. That said, pesticide-related impacts are episodic and are known to cause toxicity in creeks in the Bay Area and throughout California, suggesting that pesticides could be a causal factor of reduced biological integrity in Upper Penitencia Creek.

3.4 Preliminary Evaluation of Probable Causes

Existing data sources used to evaluate each of the candidate causes is presented in Table 9. The quality of existing data sources for spatial temporal co-occurrence evaluation of the candidate causes is provided, as well as information gaps. Table 9 also shows a preliminary assessment of probably causes for impact at the case site.

Table 9. Data quality assessment for evaluation of the candidate causes.

Causal Factor	Evidence Type		Spatial/Temporal Co-occurrence Evidence	Conclusions	Probable Cause
	Data Type	Indicator			
Physical Habitat; Sedimentation	PHAB	PHAB score; % fines+sands	Yes, only for 2008	Similar habitat conditions; no clear correlations	Unknown
Reduced Dissolved Oxygen	General WQ	DO concentration	Yes, only for 2008	DO levels not problematic for life uses; grab samples only	Unlikely
Increased Nutrients	Nutrients	N and P chl a, AFDM	No (case only)	Nutrients may impact benthic algae. Impacts to BMIs unclear	Unknown
Pesticides and Metals	Sediment Chemistry	Metals; Pyrethroids	No (case only)	Pesticide levels at site just below case site; No toxicity observed	Unknown
	Toxicity Testing	% survival			
Increased Temperature	Temperature Logger	Mean °C	Yes (not synoptic with bioassessment)	Approximate 4 C increase below ponds	Likely
Altered Flow Regime	Flow gage or velocity	Stream discharge (cfs)	Yes (not synoptic with bioassessment)	Higher flow at impacted site; however, altered flow may result in change to BMI	Unknown

4. MONITORING DESIGN

A coordinated and integrated sampling design will be implemented to measure biological condition across a range of stressor gradients in the Upper Penitencia Creek reach of interest. The study area includes an approximately one mile reach of Upper Penitencia Creek between Piedmont Avenue and Dorel Drive. The monitoring data will be used as evidence to further evaluate probable causes that were identified as likely or unknown factors impacting the case site (Table 9), including:

1. Increased Temperature
2. Increased Nutrients
3. Insecticides/Toxicity
4. Physical Habitat

Monitoring activites will be conducted at the case (114) and two comparator sites (120 and 121) (Figure 12). Sites 114 and 120 are located directly downstream existing stream gage locations, Piedmont and Dorel, respectively, that record stream flow. Site 120 is an existing bioassessment site located in reach that is typically non-perennial and is upstream of the diversion structure for the percolation ponds. Site 121 is an existing continuous temperature monitoring site located in a reach that is typically perennial flow (Figure 12). Thus, there will be comparator sites with different flow regimes that can be used to evaluate the case site, which is typically wet during the dry season due to flow releases from the percolation pond.

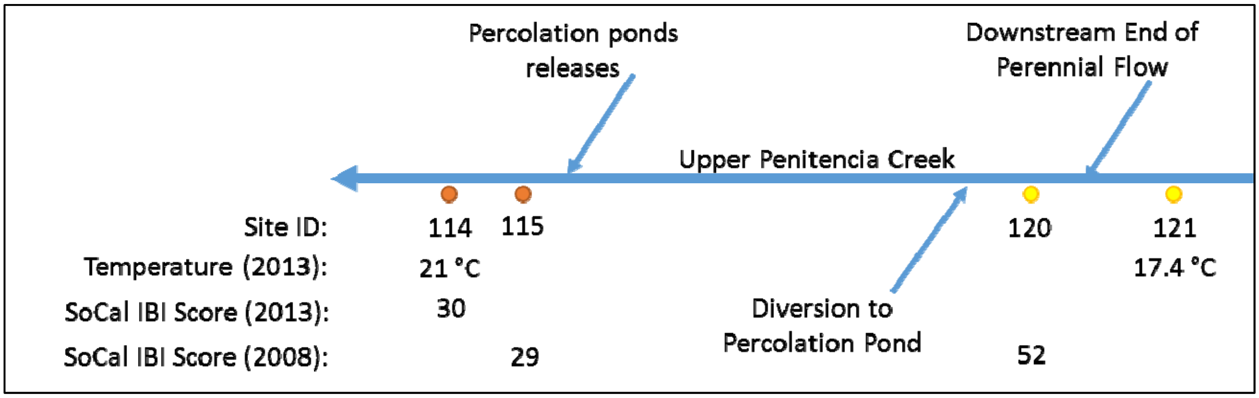

Figure 12. Conceptual diagram of sites in Upper Penitencia Creek showing biological response and water temperature as stressor variable.

It is important to note that in early spring 2014, existing drought conditions resulted in dry channel condititions downstream of site 121 as early as April 2014. In addition, all water imports from the State Water Project to the Santa Clara Basin were stopped for conservation measure, and SCVWD stopped releases into Upper Penitencia Creek from the percolation pond. As a result, the creek went dry before bioassessments could be conducted. Thus, bioassessment sampling for this monitoring project will be dependent upon suitable flow throughout the study area to allow water quality and biological sampling.

4.1 Sampling Location and schedule

The study area includes a one mile section of Upper Penitencia Creek between Piedmont Av and Dorel Drive. Monitoring activities would occur between April and July 2015. Monitoring parameters, sampling frequency and location are presented in Table 10 and illustrated in Figure 13. Stormdrain network and percolation outfall are also indicated in Figure 13. The monitoring period may get moved to late March if minimal flows are present due to lack of rainfall.

Table 10. Parameter, frequency and location of monitoring in spring/summer season of 2015.

Monitoring Parameter	Frequency and Timing	Sample Location		
		114	120	121
		Piedmont	Toyon	Dorel
Bioassessment	1x – April/May			
BMI		x	x	x
Algae		x	x	x
Physical Habitat		x	x	x
Nutrients		x		x
Sediment Toxicity and pesticides	1x – April/May	x		x
Continuous Temperature	April - July	x	x	x
Continuous Water Quality (DO, pH, conductivity)	2 weeks prior to bioassessment	x		x

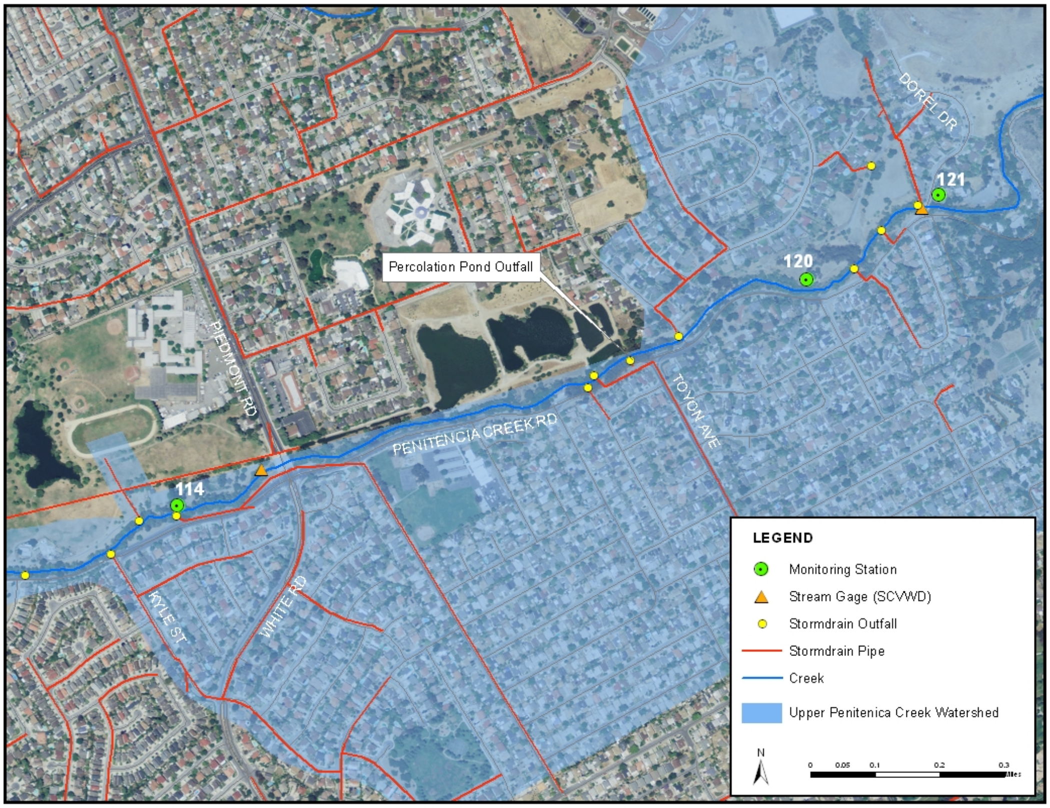

Figure 13. Monitoring locations in Upper Penitencia Creek for 2015.

4.2 Sampling methods

The sampling methods used for this project will be consistent with methods used by SCVURPPP for the RMC Creek Status Monitoring Project (BASMAA 2014). A summary of these methods is provided below.

4.2.1 Benthic Macroinvertebrates

Each bioassessment sampling site will consist of an approximately 150-meter stream reach divided into 11 equidistant transects placed perpendicular to the direction of flow. The sampling position within each transect will alternate between 25%, 50% and 75% distance of the wetted width of the stream. Benthic macroinvertebrates (BMIs) will be collected from a 1 square foot area approximately 1 m downstream of each transect (Ode 2007). The benthos are disturbed by manually rubbing coarse substrate followed by disturbing the upper layers of substrate to a depth of 4-6 inches to dislodge any remaining invertebrates into the net. Material collected from the eleven subsamples will be composited in the field by transferring the entire sample into one or two 1000 ml wide-mouth jar(s) and preserving it with 95% ethanol.

4.2.2 Algae

Filamentous algae and diatoms will be collected using the Reach-Wide Benthos (RWB) method (Fetscher et al 2009). Algae samples will be collected synoptically with and immediately after BMI sample collection. The sampling position within each transect is the same as used for BMI sampling; however, samples are collected six inches upstream of the BMI sampling position. The algae will be collected using a range of methods and equipment, depending on the particular substrate occurring at the site (i.e., erosional, depositional, large and/or immobile, etc.). Erosional substrates included any material (substrate or organics) small enough to be removed from the stream bed, but large enough in size to isolate an area equal in size to a rubber delimiter (12.6 cm2 in area). When a sample location along a transect is too deep to sample, a more suitable location will be selected, either on the same transect or from one further upstream.

Algae samples will be collected at each transect prior to moving on to the next transect. Sample material (substrate and water) from all eleven transects is combined in a sample bucket, agitated, and a suspended algae sample was then poured into a 500 mL cylinder, creating a composite sample for the site. A 45 mL subsample is taken from the algae composite sample and combined with 5 mL glutaraldehyde into a 50 mL sample tube for taxonomic identification of soft algae. Similarly, a 40 mL subsample is extracted from the algae composite sample and combined with 10 mL of 10% formalin into a 50 mL sample tube for taxonomic identification of diatoms. Laboratory processing will include identification and enumeration of 300 natural units of soft algae and 600 diatom valves to the lowest practical taxonomic level.

The algae composite sample will be used for the collection of chlorophyll a and ash free dry mass (AFDM) samples following methods described in Fetscher et al (2009). For the chlorophyll a sample, 25 mL of the algae composite volume is removed and run through a glass fiber filter (47 mm, 0.7 um pore size) using a filtering tower apparatus. The AFDM sample is collected using a similar process using pre-combusted filters. Both samples are placed in whirlpaks, covered in aluminum foil and immediately placed on ice for transportation to laboratory.

4.2.3 Physical Habitat

Physical habitat assessments (PHAB) will be conducted at each BMI bioassessment sampling site using the PHAB protocols described in Ode (2007). Physical habitat data is collected at each of the 11 transects and at 10 additional inter-transects (located between each main transect) by implementing the "Basic" level of effort, with the following additional measurements/assessments as defined in the "Full" level of effort: water depth and pebble counts, cobble embeddedness, flow habitat delineation, and instream habitat complexity. At algae sampling locations, additional assessment of presence of micro- and macroalgae is conducted during the pebble counts. In addition, water velocities were measured at a single location in the sample reach (when possible) using protocols described in Ode (2007).

4.2.4 Physico-chemical Measurements

General water quality parameters (dissolved oxygen, temperature, specific conductivity, and pH) will be measured concurrent with BMI bioassessment sampling using multi-parameters probes. Direct field measurements or grab samples for field measurement purposes will be collected from a location where the stream visually appears to be completely mixed. Ideally this is at the centroid of the flow, but site conditions do not always allow centroid collection. Measurements should occur upstream of sampling personnel and equipment and upstream of areas where bed sediments have been disturbed, or prior to such bed disturbance. Field meters will be calibrated prior to use and results are recorded on the Field Meter Calibration Record form.

4.2.5 Nutrients and Conventional Analytes

Water samples will be collected at sites for nutrients and conventional analytes using the Standard Grab Sample Collection Method (BASMAA 2014). Sample containers are rinsed using ambient water and completely filled and recapped below water surface whenever possible. An intermediate container is used to collect water for all sample containers with preservative already added in advance by the laboratory. A syringe filtration method is used to collect samples for analyses of Dissolved Ortho-Phosphate and Dissolved Organic Carbon. All sample containers will be labeled and stored on ice for transportation to laboratory.

4.2.6 Sediment Toxicity and Chemistry

Sediment samples will be collected at sites for toxicity and chemical analysis. Field personnel will survey the sampling area for appropriate fine-sediment depositional areas before stepping into the stream, to avoid disturbing possible sediment collection sub-sites. Personnel will carefully enter the stream and sampling at the closest appropriate reach, continuing upstream. Sediment samples will be collected from the top 2 cm of sediment in a compositing container, thoroughly homogenized, and then aliquotted into separate jars for chemical or toxicological analysis using standard clean sampling techniques.

4.2.7 Continuous Temperature Monitoring

Digital temperature loggers (Onset HOBO Water Temp Pro V2) will be programmed to record data at 60-minute intervals. Procedures used for calibrating, deploying, programming and downloading data are described in BASMAA (2014).

4.2.8 Continuous General Water Quality Measurements

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH at 15-minute intervals (YSI 6600 data sondes) will be deployed for two 2-week period prior to the bioassessment sampling event. Procedures used for calibrating, deploying, programming and downloading data are described in BASMAA (2014).

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