Appendix D - Santa Clara River Causal Assessment Case Study

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Executive Summary

A causal assessment was conducted in the middle reaches of the Santa Clara River in Santa Clarita, California. This assessment was conducted to determine the causes behind observed biological impairments in the stream. Specifically, the impairment in the Santa Clara River was a low (35.8 out of 100) Southern California Index of Biotic Integrity (IBI) (Ode et al. 2005) score observed in 2006 at the long-term monitoring site (designated RD) immediately downstream of the Los Angeles County Sanitation District's (LACSD) Valencia Water Reclamation Plant outfall. Seven monitoring sites along the Santa Clara River and its tributaries (RB, RC, RE, RF, SAP8, SAP11, and SAP14) were selected as the comparator sites. All of the sites had similarly poor to fair IBI scores (27.2 - 45.8) to the test site. To better differentiate among the sites, four submetrics of the Southern California IBI: 1.) % abundance of collector-gatherer taxa (e.g., *Baetis* spp); 2.) % of non-insect taxa (e.g., oligochaetes); 3.) % of tolerant taxa (e.g., *Physa* spp.); and 4.) number of predator taxa were used as biological endpoints in a number of the analyses.

This causal assessment was performed following the USEPA's CADDIS causal assessment framework (USEPA 2000). In brief, this approach consists of: 1.) Identifying a site with biological impairment (test site); 2.) Selecting similar sites within the same stream network for comparison (comparator sites); 3.) Identifying the potential stressors to the stream (candidate causes); 4.) Analyzing differences in stressors, biology, and their interaction at the test and comparator sites (within the case); 5.) Comparing stressors, biology, and their interaction at the test site to similar data from elsewhere (outside the case); and 6.) Summarizing these results into a narrative classifying the potential stressors as likely, unlikely, or uncertain causes to the biological impairment.

This assessment was conducted as a partnership between the Southern California Coastal Water Research Project, the Sanitation Districts of Los Angeles County, and the Los Angeles Regional Water Quality Control Board. The assessment partners decided to focus on seven candidate cause stressors potentially responsible for the biological impairment observed at the RD site in Santa Clara River: 1.) Habitat simplification; 2.) Metals; 3.) Elevated conductivity; 4.) Increased nutrients; 5.) Pesticides; 6.) Temperature; and 7.) River discontinuity. These stressors were chosen by the project partners based upon input from the local stakeholders familiar with the stream, the watershed characteristics, and potential anthropogenic disturbances to the system. Each one of these candidate cause stressors was comprised of a number of proximate stressors (e.g., dissolved metals, sediment-bound metals, periphyton-bound metals), upon which the actual analyses were conducted to assess the impact of the candidate cause. Data were not available for every proximate stressor within each candidate cause at every site (e.g., pyrethroid pesticides or sediment-bound metals), but enough data were available for some degree of evaluation for all seven of the candidate causes.

The causal assessment was conducted with preexisting data provided by LACSD. The RD, RB, RC, and RE sites are part of LACSD's National Pollutant Discharge Elimination System (NPDES) monitoring network associated with their Valencia and Saugus outfalls. The remaining comparator sites were part of special study related to nitrogen loads in the Santa Clara River conducted concurrently with the routine monitoring in October 2006. The chemical, biological (benthic macroinvertebrates), and physical habitat data from the NPDES monitoring program provided the bulk of the information needed for the within the case portion of the causal assessment. These data were also supplemented with algal community structure and temporally intensive water quality data from the test and all comparator sites as part of the special nitrogen study. Data used in the outside the case portion of the causal assessment were assembled from a variety of sources, including: the State of California's State of California's Reference Condition Monitoring Program (RCMP), the Surface Water Ambient Monitoring Program (SWAMP), various probabilistic stream biomonitoring programs (e.g., Perennial Stream Assessment [PSA] and Stormwater Monitoring Coalition [SMC]), and appropriate examples from the scientific literature.

Within the CADDIS causal assessment framework, there are a number of potential types of evidence (i.e., analyses) that can be brought to bear in the within the case and the outside of the case portions of the assessment. The spatial temporal co-occurrence and stressor-response types of evidence were used in the within the case step. The field stressor-response, laboratory stressor-response, and reference condition comparison evidence types were used in the outside the case step.

The overall results from the causal assessment are summarized in Table ES-1. Of the seven candidate causes, there was supporting evidence that elevated conductivity and temperature may be partially responsible for the impaired biological condition at the test site. Conversely, the evidence indicated that heavy metals (dissolved metals), pesticides (non-pyrethroid pesticides), and increased nutrients were likely not a cause for the impairment. There was inconsistent or contradicting evidence for both habitat simplification and river discontinuity in the within the case portion of the analyses. Furthermore, there was limited data available for these candidate causes in the outside the case analyses. Consequently, both habitat simplification and river discontinuity were ruled as indeterminate; not excluded, but not confirmed as causes for the observed biological impairment.

Table ES-1. Overall results from the causal assessment.

Outcome	Candidate Cause	Evidence & Comments
Probable Stressors	Conductivity	Elevated conductivity and TDS at RD compared to some of the comparator sites and outside the case sites. Consistent stressor response relationships with outside the case.
	Temperature	Elevated mean temperature and reduced range compared to inside the case comparator sites. Stressor response relationship w/ non-insect taxa inside the case. No outside the case data were availabe for evaluation.
Refuted Stressors	Heavy Metals	Levels of some metals in the water column at RD similar to or below comparator sites, but there was supporting stressor response evidence inside the case. However, all concentrations were well below toxic effect levels. No data were available for sediment or periphyton-bound metals.
	Pesticides	All measured pesticides and herbicides in the water column were below detection limit. Pyrethroids were not measured in the water column and no sediment pesticide measurements of any kind were available.
	Nutrients	Consistent inverse stressor respsonses and lower nutrient responses at RD compared to inside the case sites. No data from outside the case were available for evaluation.
Unresolved Stressors	Habitat Simplification	Lower or indeterminate levels at RD compared to in- and outside the case. Inconsistent stressor response relationship in- and outside the case. There was relatively little outside the case data available for evaluation.
	River Discontinuity	Lower or indeterminate levels at RD compared to inside the case. Inconsistent stressor response relationship in- and outside the case. There was relatively little outside the case data available for evaluation.

The most confident conclusions that could be made about candidate causes were those examples where both within the case and outside the case data were available. For the stressor-response and reference condition comparison outside of the case evidence types, data were selected from sites with similar geographic/environmental characteristics to the RD site. Sites were selected to reduce the variability in the observed biological communities due to non-anthropogenic forcing factors (e.g., elevation, slope, or underlying geology) known to have an influence on benthic macroinvertebrate community structure (e.g., Allan 2004, Mykrä et al. 2008). These outside of the case evidence types were extremely valuable in the causal assessment process, as there was degraded biology, not only at the test site, but at nearly all of the within case comparator sites. This pattern weakened our confidence in the diagnostic power of the within the case analyses used by themselves. Contextualizing the stressors and observed biotic response(s) with data from outside the case allowed us to come to more definitive conclusions about the role of conductivity, pesticides, and metals in the observed impairments. Conversely, the lack of these types of evidence was one of the contributing factors to our uncertainty about the roles of river discontinuity and habitat simplification.

The assessment provided enough evidence that, based upon the available data, allowed us to exclude three candidate causes (metals [dissolved metals], pesticides [non-pyrethroid], and increased nutrients) and indicate two others (conductivity and temperature). As noted previously, this success was due in large part to the ability to bring in data from environmentally similar streams from outside the watershed to compare against data from within the stream.

Case Definition

This causal assessment was conducted as a response to low Southern California Index of Biotic Integrity (IBI) (Ode et al. 2005) scores observed in the upper Santa Clara River in October 2006. The assessment was conducted as a partnership between the Southern California Coastal Water Research Project, the Sanitation Districts of Los Angeles (LACSD), and the Los Angeles Regional Water Quality Control Board. The actual test site for the assessment was the long-term monitoring site RD located immediately downstream of the Los Angeles County Sanitation District (LACSD) Valencia Water Reclamation Plant outfall in Santa Clarita, CA. The Southern California IBI is a multi-metric index that uses community structure of benthic macroinvertebrates to evaluate the condition of a stream. During the 2006 Autumn sampling (Table 1), the RD site had a score of 35.8; below the existing threshold for impairment of two standard deviations of the mean score of reference sites (39).

Table 1. Top 90+ % most abundant taxa at each of RD and the comparator sites in Autumn 2006.

Site	Taxon	Relative Abundance
RB	Chironomidae	65.3
	Oligochaeta	15.1
	Argia sp	5.8
	Physa /Physella sp	5.6
RC	*Fallceon quilleri*	44.1
	Baetis sp	25.7
	Chironomidae	5.7
	Tricorythodes sp	5.5
	Ostracoda	4.3
	Oligochaeta	3.1
	Hydroptila sp	2.7
RD	Chironomidae	28.0
	Physa /Physella sp	14.3
	Fallceon quilleri	10.5
	Tricorythodes sp	9.9
	Ostracoda	9.1
	Planariidae	6.2
	Hydroptila sp	5.0
	Caloparyphus /Euparyphus sp	3.0
	Oligochaeta	3.0
	Baetis sp	2.4
RE	*Fallceon quilleri*	31.3
	Chironomidae	30.0
	Oligochaeta	9.7
	Tricorythodes sp	9.3
	Baetis sp	5.5
	Ostracoda	3.7
	Hydrellia sp	2.6
RF	*Tricorythodes* sp	25.2
	Chironomidae	17.6
	Fallceon quilleri	16.4
	Physa /Physella sp	7.3
	Hydroptila sp	5.7
	Dasyhelea sp	4.5
	Oligochaeta	4.1
	Prostoma sp	3.2
	Planariidae	3.2
	Callibaetis sp	2.4
	Simulium sp	2.2
SAP 8	Chironomidae	43.2
	Fallceon quilleri	17.1
	Hydroptila sp	9.0
	Oligochaeta	5.9
	Simulium sp	5.0
	Ostracoda	4.5
	Tricorythodes sp	4.1
	Hydrellia sp	4.1
SAP 11	Chironomidae	58.5
	Fallceon quilleri	15.0
	Tricorythodes sp	13.0
	Physa /Physella sp	4.8
SAP 14	Chironomidae	87.3
	Oligochaeta	6.2

Comparator sites were located in the Santa Clara River above (RB and RC) or below (RE, SAP8 and RF) the test site, as well as on nearby tributaries (SAP11 and SAP14; Figure 1). The test and comparator sites comprised the within the case portion of the assessment. The test and mainstem comparator sites were part of the LACSD Valencia and Saugus water reclamation plant outfall National Pollutant Discharge Elimination System (NPDES) Permit monitoring network. As part of the NPDES monitoring network, synoptic measures of biological, chemical, and physical habitat data from the 2006 period of interest were collected at the same time as the RD test site. Additionally, there was monthly chemistry/water quality data collected from most of the sites prior to the collection of the biological data. Data from the RF, SAP8, SAP11, and SAP14 comparator sites were part of a special study where macrobenthic community structure, physical habitat, algal community structure, nutrients, and temporally intensive water quality were collected. Tributaries sites were free from the influence of the LACSD wastewater outfalls. These data formed the core of the comparative analyses that made up the causal assessment and were used in the within the case spatial co-occurrence and stressor-response lines of evidence.

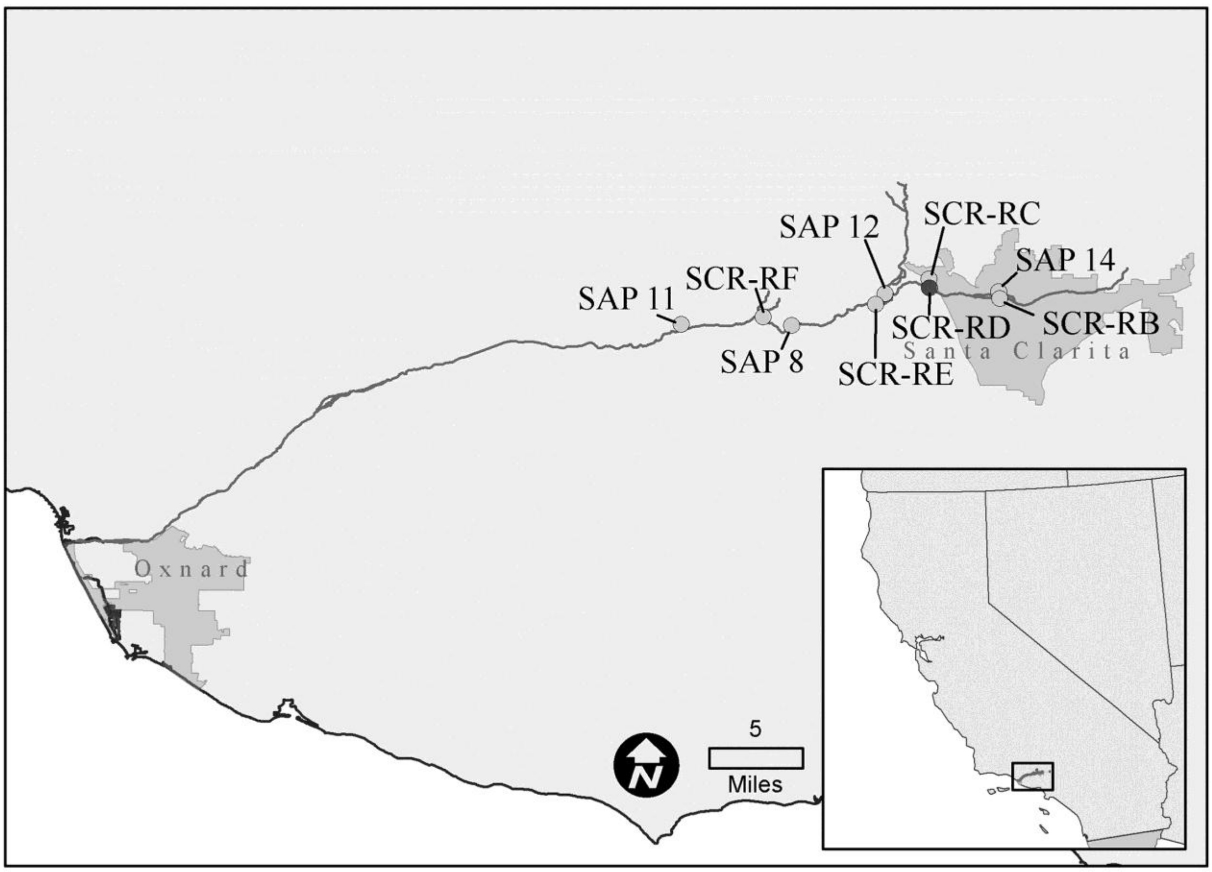


Figure 1. A map of the Santa Clara River showing the location of the RD test site and the comparator sites RB, RC, RE, RF, SAP8, SAP11, and SAP12. Inset with a map of the west coast of US for reference.

The upper of the Santa Clara River and its tributaries that comprise the test and comparator sites are part of a low gradient (<1% slope) system with a relatively mobile, sandy bottom. The constrained flood plain is consolidated sand with some riparian vegetation (e.g., grasses and small woody growth). The surface water of the river is intermittently discontinuous during dry weather flows. The test site was wetted year round due to the LACSD discharge and surface water flow at RD was contiguous with RC and RE, but was disconnected from the RB site. There is shallow-groundwater /hyporheic connection between all of the NPDES sites (Markle pers. comm.). The upper reach of the Santa Clara River runs through urban and suburban development and this portion of the river (State Water Resources Control Board [SWRCB] Reach 5 and Reach 6) is on the US Environmental Protection Agency (USEPA) 303(d) list for chlorpyrifos, fecal coliform bacteria, diazinon, and toxicity impairments (CA EPA 2012).

The actual biological endpoints chosen as response variables in the assessment, in addition to the total IBI score, consisted of four submetrics of the Southern California IBI: 1.) % abundance of collector-gatherer taxa (e.g., *Baetis* spp); 2.) % of non-insect taxa (e.g., oligochaetes); 3.) % of tolerant taxa (e.g., *Physa* spp.); and 4.) number of predator taxa (e.g., *Dicranota* spp). The four submetrics were chosen because they were of specific interest to the stakeholders and they allowed for greater differentiation among the target and comparator sites (Figure 2). Additionally, as components of the IBI, insights into the poor scoring of these metrics should provide direct insights to the causes behind the low overall IBI scores.

All of the comparator sites had relatively similar macrobenthic community structure (Table 2) and IBI scores (Figure 2a) to RD. The macrobenthic communities of the RD and comparator sites were dominated by chironomids, *Fallceon quilleri*, *Tricorythodes* sp., and *Physa* sp. These taxa are indicative of degraded macrobenthic conditions and observed across the entirety of the upper portions of the Santa Clara River. Similar taxa were observed at the comparator sites, hindering the contrasts that lead to causal inference.

Macrobenthic community and stream physical habitat data were collected in October of 2006. Macrobenthic community sampling was conducted using a kick-net, and individual samples from multiple transects were composited along a 150-m reach, encompassing approximately 1.0 m^2 of streambed. Macrobenthic and physical habitat were collected, processed, and analyzed using California Bioassessment Procedures (Harrington 2002). Water chemistry and water quality data were collected as monthly grab or point samples. The NPDES data were supplemented with algal community data, monthly water grabs for nutrients, and quarterly diurnal water quality (pH, dissolved oxygen, temperature, and conductivity) measurements collected as part of the nitrogen TMDL special study (see Santa Clarita Valley Sanitation District of Los Angeles County [2007] for methodology details).
The statewide perennial wadeable stream assessment data (Ode et al. in prep) was used for casual assessment. These data from elsewhere were comprised of >600 reference sites and >1500 sites with varying level of stress. There is a great deal of heterogeneity among this population of streams and it was thought that only streams with a similar ecosystem setting should be used in the analysis. There are a number of different approaches to characterizing and selecting streams and a simple approach based upon elevation and slope was chosen for this assessment. Streams selected for comparison to the RD site were filtered for similar natural gradients: slope <1.5%; elevation <333m. There were 32 samples from 22 reference sites and there were 540 samples from 515 stressed sites.

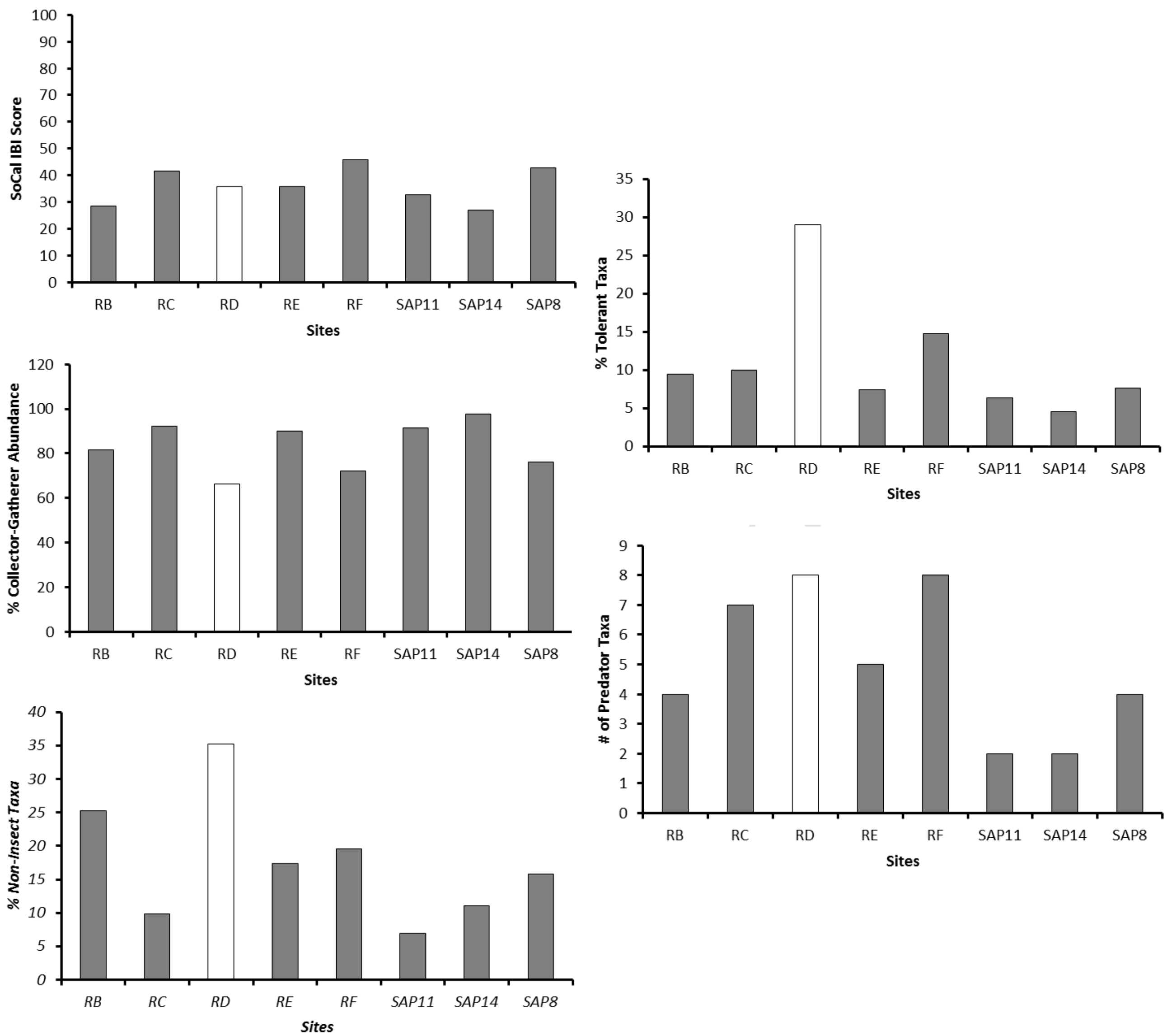


Figure 2. Southern California Index of Biotic Integrity (IBI) scores measured at the target and comparator sites in Fall 2006 (a), as well as the biological endpoints used in the stressor-response portions of the assessment (b – e).

Table 2. Inventory of the type of data and its original source used in the analyses of each candidate cause and their component proximate stressors for each line of evidence used in the causal assessment.

Candidate Cause /Conceptual Diagram	Proximate Stressor	Data Available	Data Source	Data Within the Case Lines of Evidence		Data From Outside the Case Lines of Evidence		
				Spatial Co-Occurrence	Stressor Response From the Field	Reference Condition	Stressor Response From the Field	S-R from lab
Elevated Conductivity	Increased Conductivity	Mean of monthly point measures made during quarter previous to biotic sampling (July-September).	NPDES Monitoring	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	Comparison of RD to environmentally similar reference sites	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	No Data Available
	Increased TDS	Mean of monthly point measures of TDS, chloride, and hardness made during quarter previous to biotic sampling (July-September).	NPDES Monitoring	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available
Increased Nutrients	Change in Algal Community	Bray-Curtis similarity to RD site based upon algal community structure.	Nitrogen Loading Special Study	Comparison of RD to comparator sites in multivariate space	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites.	No Data Available	No Data Available	No Data Available
	Increase in Toxic Algal Compounds			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
	Increased Frequency of Hypoxia	Frequency of mild hypoxia (2-5 mg O_2 L^{-1}) observed in in monthly daytime point measurements during quarter prior to biological sampling. Frequency of hypoxia (<2 mg O_2 L^{-1}) observed in daytime point measures during quarter prior to biological sampling. Frequency of mild hypoxia (2-5 mg O2 L-1) observed in diel data collected over 24 hr period during month of biological sampling. Frequency of hypoxia (<2 mg O2 L-1) observed in diel data collected over 24 hr period during month of biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available

Candidate Cause /Conceptual Diagram	Proximate Stressor	Data Available	Data Source	Data Within the Case Lines of Evidence		Data From Outside the Case Lines of Evidence		
				Spatial Co-Occurrence	Stressor Response From the Field	Reference Condition	Stressor Response From the Field	S-R from lab
Increased Nutrients (cont.)	Increased pH	Mean of monthly point measures made during quarter previous to biotic sampling (July - September). Mean of diel data collected over 24 hr period during the month of biotic sampling	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available
	Increased Ammonia Concentration	Mean of monthly point measures made during quarter previous to biotic sampling (July-September).	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available
Pesticides	Increased Other Sediment Pesticides			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
	Increased Other Water Column Pesticides	Maximum observed values of 4,4'-DDD, 4,4'-DDE, Acrolein, Acrylonitrile, Aldrin, alpha-BHC, cis-1,3-Dichloropropene, delta-BHC, Diazinon, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin aldehyde, Endrin, Heptachlor Epoxide (Isomer B), Heptachlor, Methoxychlor, o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDT, Technical Chlordane, and Toxaphene in 12 months prior to biological sampling Frequency of dectection of any compound above detection limit	NPDES Monitoring	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	Comparison of Diazinon concentrations observed at RD to species sensitivity distribution (SSD) curves developed by US EPA.
	Increased Water Column Pyrethroids			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
	Increased Sediment Pyrethroids			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
	Increased Water Column Herbicides	Maximum observed value of 2,3,7,8-TCDD, 2,4,5-TP (Silvex), and 2,4'-D in 12 months prior to biological sampling.	NPDES Monitoring	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available

Candidate Cause /Conceptual Diagram	Proximate Stressor	Data Available	Data Source	Data Within the Case Lines of Evidence		Data From Outside the Case Lines of Evidence		
				Spatial Co-Occurrence	Stressor Response From the Field	Reference Condition	Stressor Response From the Field	S-R from lab
Heavy Metals	Increase in Dissolved Metals	Mean of point measures of Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Hexavalent Chromium, Iron, Lead, Mercury, Nickel, Selenium, Silver, Thallium, and Zinc collected in quarter previous to biotic sampling (July-September).	NPDES Monitoring	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	Comparison of Arsenic, Cadmium, Chromium, Copper, Nickel, Selenium, and Zinc values observed at RD to species sensitivity distribution (SSD) curves developed by US EPA.
	Increase in Particulate Bound Metals			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
	Increased Concentration of Metals in Periphyton			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
Temperature	Increased Water Temperature	Mean of monthly point measures made during quarter previous to biotic sampling (July-September). Mean of diel data collected over 24 hr period during the month of biotic sampling	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available
	Decreased Variability in Water Temperature	Max - Min value of monthly point measures made during quarter previous to biotic sampling (July-September). Max - Min value of diel data collected over 24 hr period during the month of biotic sampling	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available

Candidate Cause /Conceptual Diagram	Proximate Stressor	Data Available	Data Source	Data Within the Case Lines of Evidence		Data From Outside the Case Lines of Evidence		
				Spatial Co-Occurrence	Stressor Response From the Field	Reference Condition	Stressor Response From the Field	S-R from lab
River Discontinuity	Decreased Recruitment of Fauna			No Data Available	No Data Available	No Data Available	No Data Available	No Data Available
	Decrease in Woody Debris	Length of reach (m) with woody debris during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	No Data Available
	Increase in Sands and Fines	Percent of reach with sand or fine sediment substrate during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	Comparison of RD to environmentally similar reference sites	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	No Data Available
	Decrease in Cobbles	Percent of reach with cobble substrate during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	No Data Available
	Burial of Cobbles	Mean percent embeddedness of cobbles observed during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	No Data Available

Candidate Cause /Conceptual Diagram	Proximate Stressor	Data Available	Data Source	Data Within the Case Lines of Evidence: Spatial Co-Occurrence	Data Within the Case Lines of Evidence: Stressor Response From the Field	Data From Outside the Case Lines of Evidence: Reference Condition	Data From Outside the Case Lines of Evidence: Stressor Response From the Field	Data From Outside the Case Lines of Evidence: S-R from lab
River Discontinuity (Cont.)	Increased Simplification of Habitat	Euclidean distance from RD location in nMDS comparison of sites based upon the presence of different substrates (artificial, boulders, roots, woody debris, sands+fines, gravel, cobbles, or bedrock), filamentous algae, overhanging vegetation, undercut banks, large woody debris, and mean thalweg depth.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to comparator sites in multivariate space	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites.	No Data Available	No Data Available	No Data Available
Habitat Simplification	Change in Food Source	Euclidean distance from RD location in nMDS comparison of sites based upon the occurrence of course particulate organic matter, macrophyte, filamentous algae, woody debris, and fine sediments.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to comparator sites in multivariate space	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites.	No Data Available	No Data Available	
	Increase in Channel Depth	Mean of thalweg depth (cm) measured at the transects and inter-transects of the reach during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	
	Decrease in the extent of Riffle Habitat					No Data Available	No Data Available	
	Decrease in Woody Debris	Length of reach (m) with woody debris during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	

Candidate Cause /Conceptual Diagram	Proximate Stressor	Data Available	Data Source	Data Within the Case Lines of Evidence		Data From Outside the Case Lines of Evidence		
				Spatial Co-Occurrence	Stressor Response From the Field	Reference Condition	Stressor Response From the Field	S-R from lab
Habitat Simplification (cont.)	Increase in Sands and Fines	Percent of reach with sand or fine sediment substrate during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	Comparison of RD to environmentally similar reference sites	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	
	Increase in Simplified Habitat	Euclidean distance from RD location in nMDS comparison of sites based upon the presence of different substrates (artificial, boulders, roots, woody debris, sands+fines,	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to comparator sites in multivariate space	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among the comparator sites.	No Data Available	No Data Available	
	Decrease in Cobbles	Percent of reach with cobble substrate during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	No Data Available	
	Decrease in Extent of Undercut Banks	Percent of reach with undercut banks during biological sampling.	NPDES Monitoring and Nitrogen Loading Special Study	Comparison of RD to individual comparator sites	Spearman's rank correlations with percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa among RD and the comparator sites.	No Data Available	Relative risk calculation at stressor level observed at RD for percent non-insect taxa, percent tolerant taxa, percent collector-gatherer abundance, and number of predator taxa using stressor and biological data from environmental similar sites to establish the expectation.	

Candidate Causes

The following list of candidate causes was developed as the outcome of discussions held among the data analyst and the local stakeholders at a workshop held February 2012. Stressors were proposed and eventually included/excluded for consideration based upon the local stakeholders' knowledge of the Santa Clara River watershed, the human activities therein, as well as its environmental, geological, and hydrological characteristics. Each candidate cause consists of a series of proximate stressors, the stressors that directly touch the in-stream biota.

Candidate Cause: Elevated Conductivity – Most freshwater streams have some degree of natural conductivity imparted by the underlying geology of the stream's watershed (i.e. CaO, MgO content). Alterations to that "natural" conductivity level can have adverse effects on macrobenthic community structure reducing the numbers of stenohaline taxa through outright toxicity or increased physiological/osmotic stress that consumes energy normally dedicated to growth and reproduction (Kinne 1971, Hassell et al. 2006). As noted in the conceptual diagram (Figure 3), there were two proximate stressors within the elevated conductivity candidate cause: 1.) Increased total dissolved solids (TDS); and 2.) Increased conductivity

Candidate Cause: Habitat Alteration – Most wadeable streams have a high degree of physical habitat heterogeneity (e.g., riffles vs. pools, woody debris, undercut banks) at small spatial scales (10's of meters) that produce a multitude of different niches, which are in turn occupied by different macroinvertebrate species. This habitat heterogeneity increases the overall diversity of the macrobenthic community because individual taxa are often dependent on specific habitat characteristics (e.g. complex structure, fast moving water, or deep pools). Habitat alteration can have negative effects on the macrobenthic community. Habitat alteration ranges from direct modification of the stream bed and channel walls for flood or erosion control (concrete or rip rap walls), to modification of the riparian corridor, or development within the stream's upland watershed. Habitat alteration reduces habitat complexity and heterogeneity, acting as a barrier for certain taxa to recruit or survive in-stream. In the conceptual diagram (Figure 4), habitat alteration has 10 potential proximate stressors: 1.) Change in available food; 2.) Increase in channel deepening, 3.) A decrease in the amount of riffle habitat, 4.) A decrease in the amount of instream wood debris; 5.) An increase in sands and fines; 6.) An increase in the extent of undercut banks; 7.) A decrease in the number of cobbles; and 8.) A decrease in overall substrate complexity.

Candidate Cause: Metals – While there are some natural sources of metals to streams due to the erosion of metal bearing soils in the underlying geology of a watershed (e.g., Aluminum or Iron), most metals observed in streams are related to anthropogenic activities. Most metals impact stream macroinvertebrates by causing cell wall failure, interference with ion transfer, and interference with respiratory function. Metals can be transferred to stream biota either through direct ingestion or absorption from the water column. Consequently, the conceptual model for increased metals (Figure 5) has three proximate stressors: 1.) increase in dissolved water column metals; 2.) increase in metal concentration of periphyton; and 3.) increase in particulate bound metals.

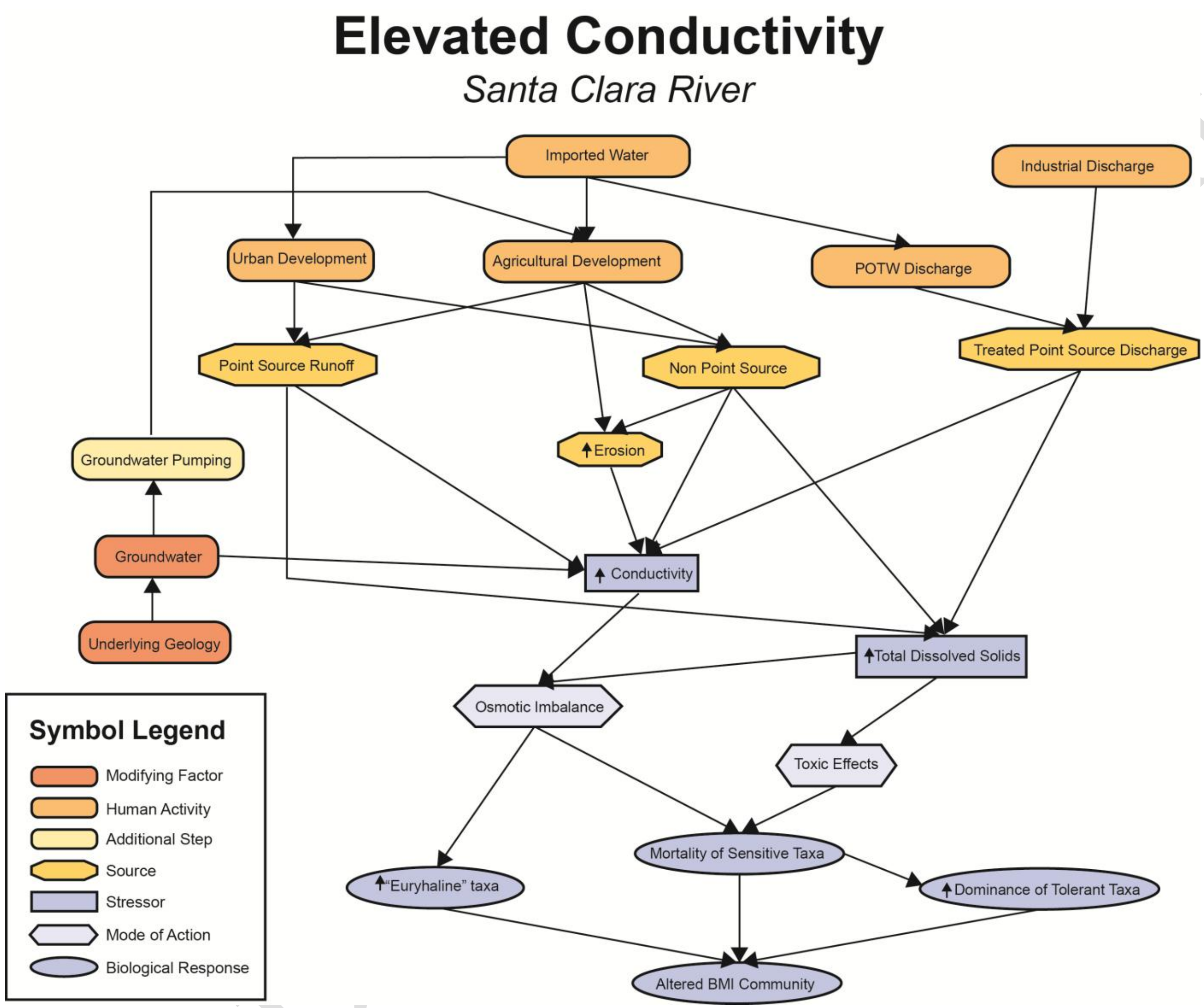


Figure 3. Elevated conductivity conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

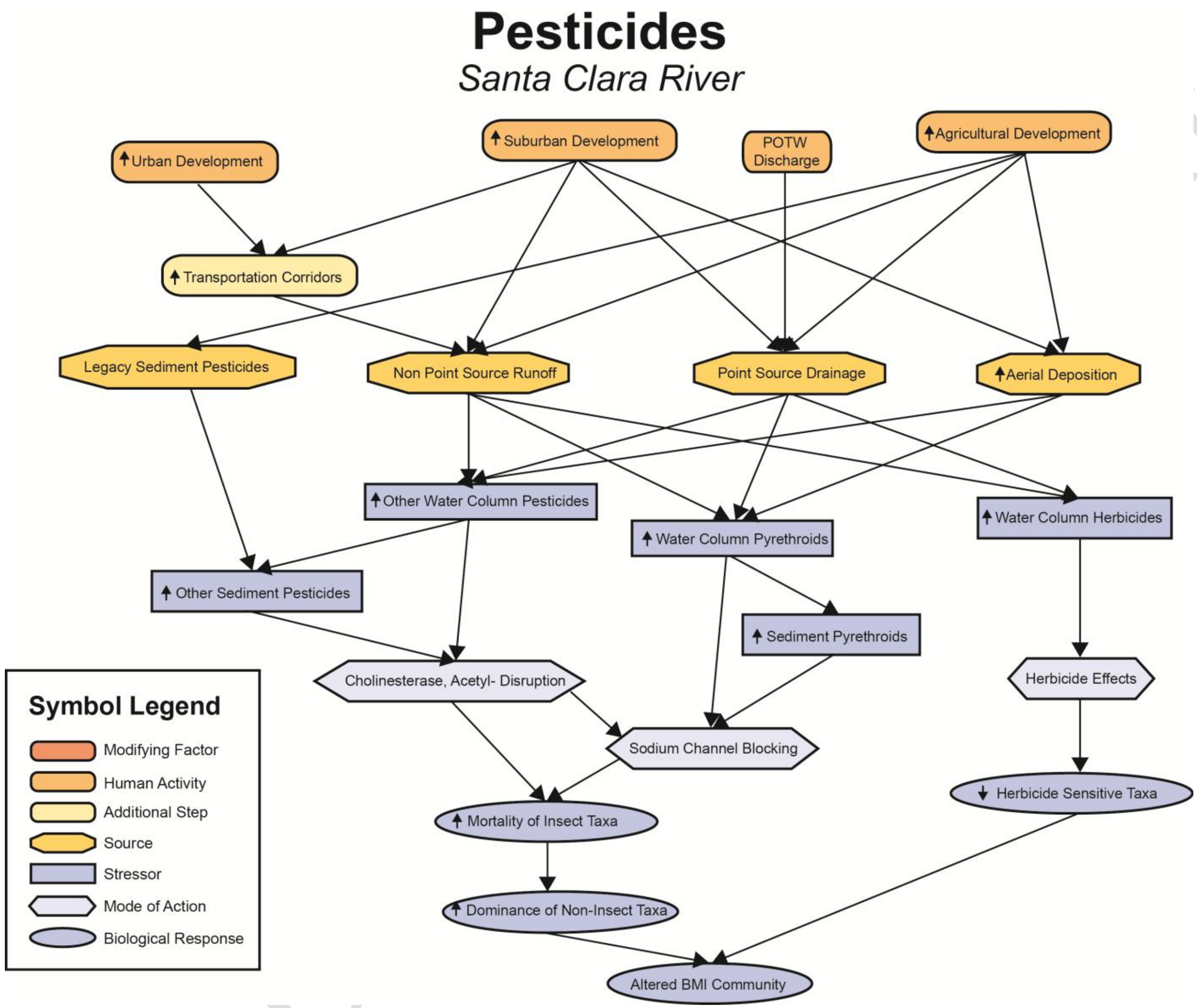


Figure 4. Pesticides conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

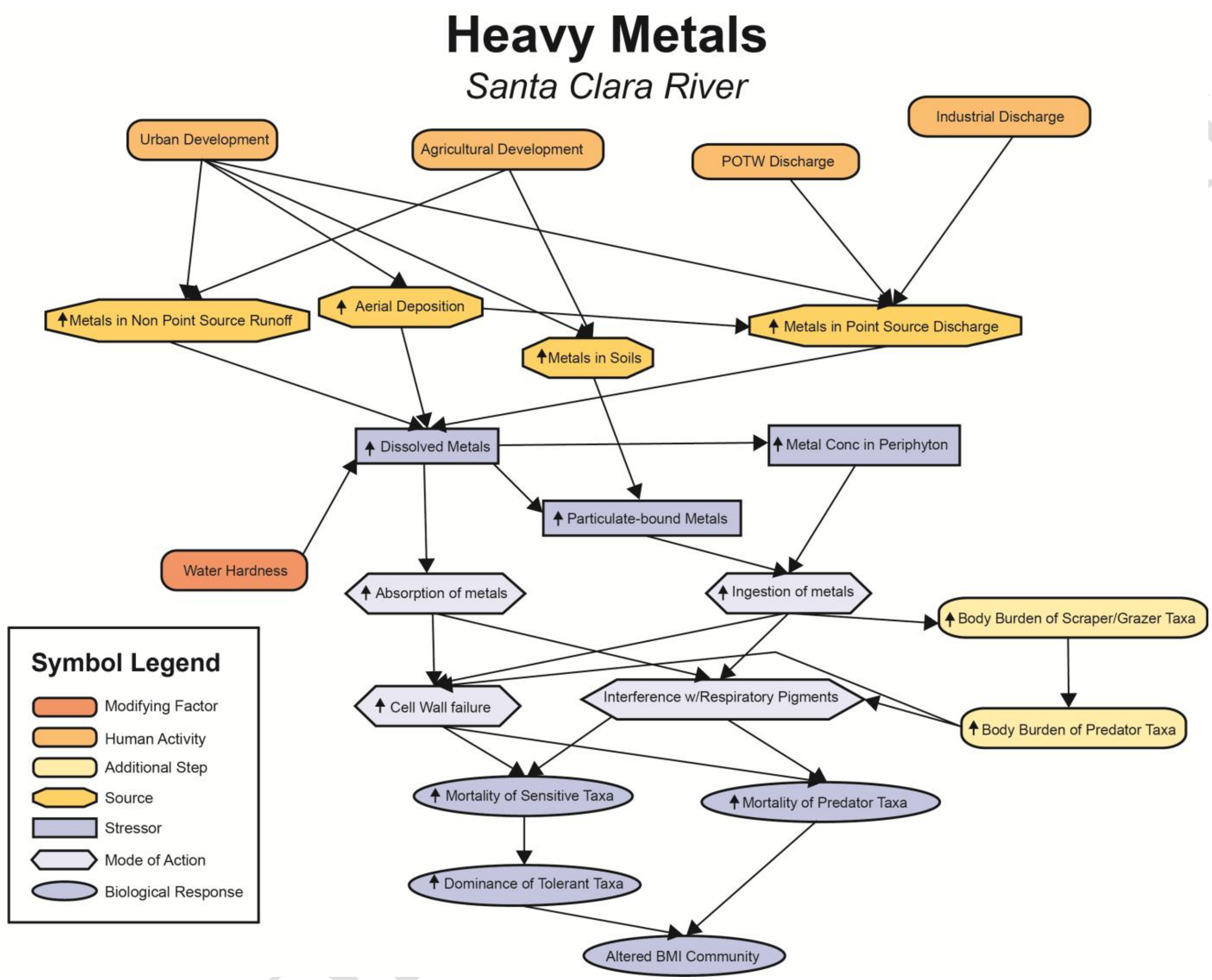


Figure 5. Heavy metals conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

Candidate Cause: Increased Nutrients – Stream macroinvertebrates typically experience problems from increasing concentrations of the different species of nitrogen and phosphorus as indirect effects, where the increased nutrients influence autotrophic community structure and primary production rates. These effects can include clogging of micro-habitats by algal mats, changes in algal taxa and their palatability to grazers, increased dominance of cyanobactieria and other toxic algae, or night time hypoxia. Ammonia toxicity is the primary direct effect that increased nutrients can have on stream macrobenthic community structure, with certain taxa being more sensitive than others (Arthur et al. 1987, Hickey and Vickers 1994). In the conceptual diagram (Figure 6), increased nutrients is comprised of five proximate stressors: 1.) A change in algal community structure; 2.) An increase in toxic compounds; 3.) An increase in water column pH; 4.) An increase in the frequency of hypoxia; and 5.) An increase in ammonia concentration.

Candidate Cause: Pesticides – Much like metals, there is a large amount of evidence about the negative effects of pesticides on stream macroinvertebrates (e.g. Hickey and Clements 1998, Pollard and Yuan 2006). Pesticides, especially insecticides, have acute and chronic toxic effects on stream macroinvertebrates. This candidate cause includes current-use pesticides (synthetic pyrethroids) and legacy pesticides (diazinon, DDT), which can be dissolved in the water column or adsorbed to sediments. There were five proximate stressors in the conceptual model (Figure 7): 1.) Increased water column synthetic pyrethroids; 2.) Increased sediment synthetic pyrethroids; 3.) Increased "other" water column pesticides; 4.) Increased "other" sediment pesticides; and 5.) Increased water column herbicides.

Candidate Cause: Temperature – Water temperature can be one of the key environmental variables setting community structure among stream macroinvertebrates, with certain taxa flourishing best in cold water conditions and others in warm water. In temperate climates like southern California, seasonal temperature fluctuations are an important reproductive or metamorphic cue for stream fauna (e.g., Harper and Peckarsky 2006). Point source discharges and non-point source runoff can increase mean stream temperatures and decrease the range in temperature flux over short and long timescales. To capture both of these aspects, the temperature conceptual diagram (Figure 8) had two proximate stressors: 1.) Elevated water temperature; and 2.) Decreased variability in water temperature.

Candidate Cause: River Discontinuity – Though likely connected by hyporheic flows, the surface waters of the Santa Clara River are disconnected by stretches of dry streambed between the RB and RC monitoring sites for most of the year due to the natural climate, permeability of the riverbed, groundwater pumping, and surface water diversions. This discontinuity could potentially impact community structure by, among other things, limiting downstream recruitment of juvenile invertebrates, a loss of large woody debris from the upper watershed, limiting the export of sand and other fine grain sediments. The conceptual diagram (Figure 9) contains six proximate stressors: 1.) Decreased recruitment; 2.) A decrease in woody debris; 3.) A decrease in cobbles; 4.) An increase in sands & fines; 5.) Burial of cobbles; and 6.) An increase in simplified habitat.

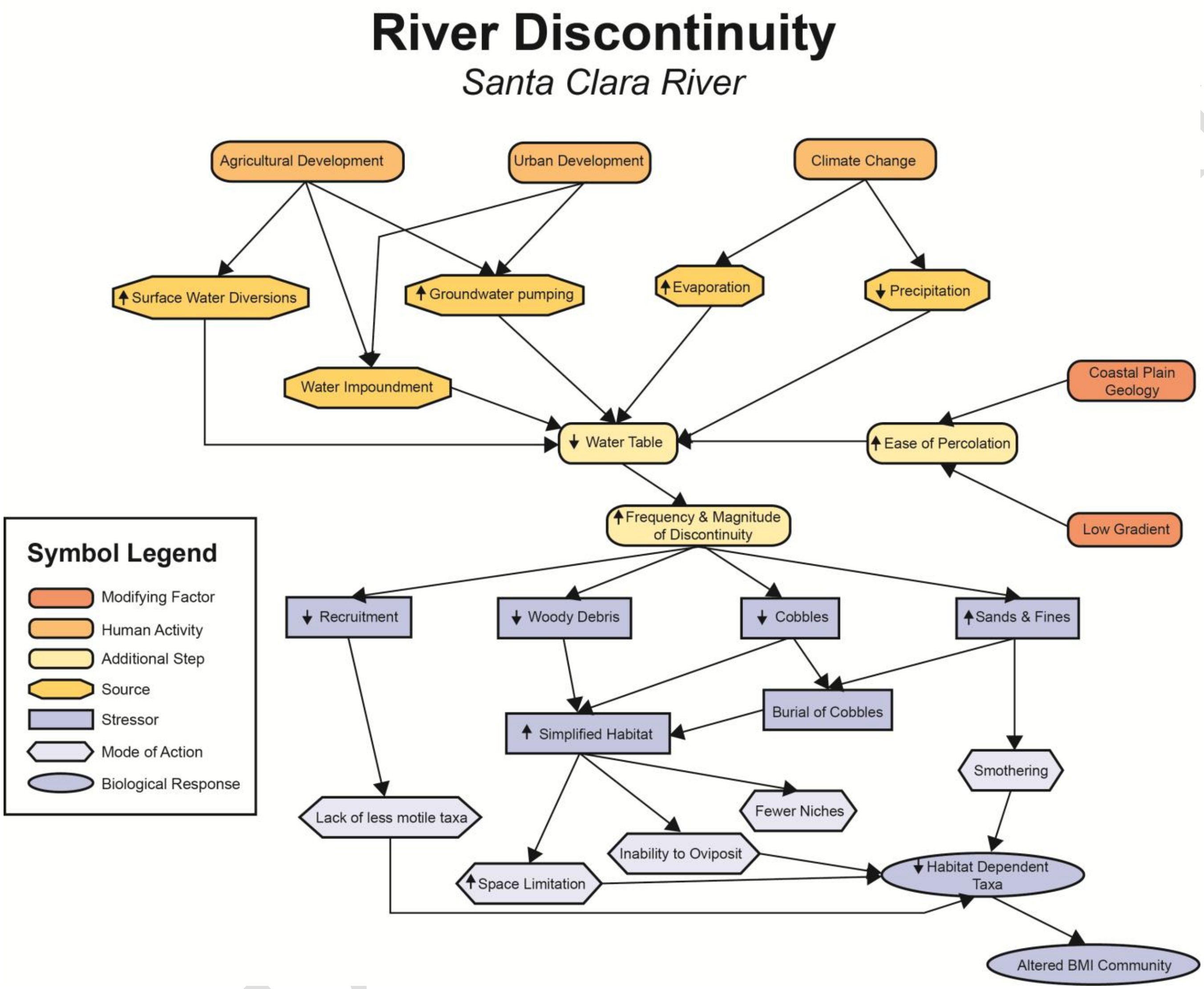


Figure 6. River discontinuity conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

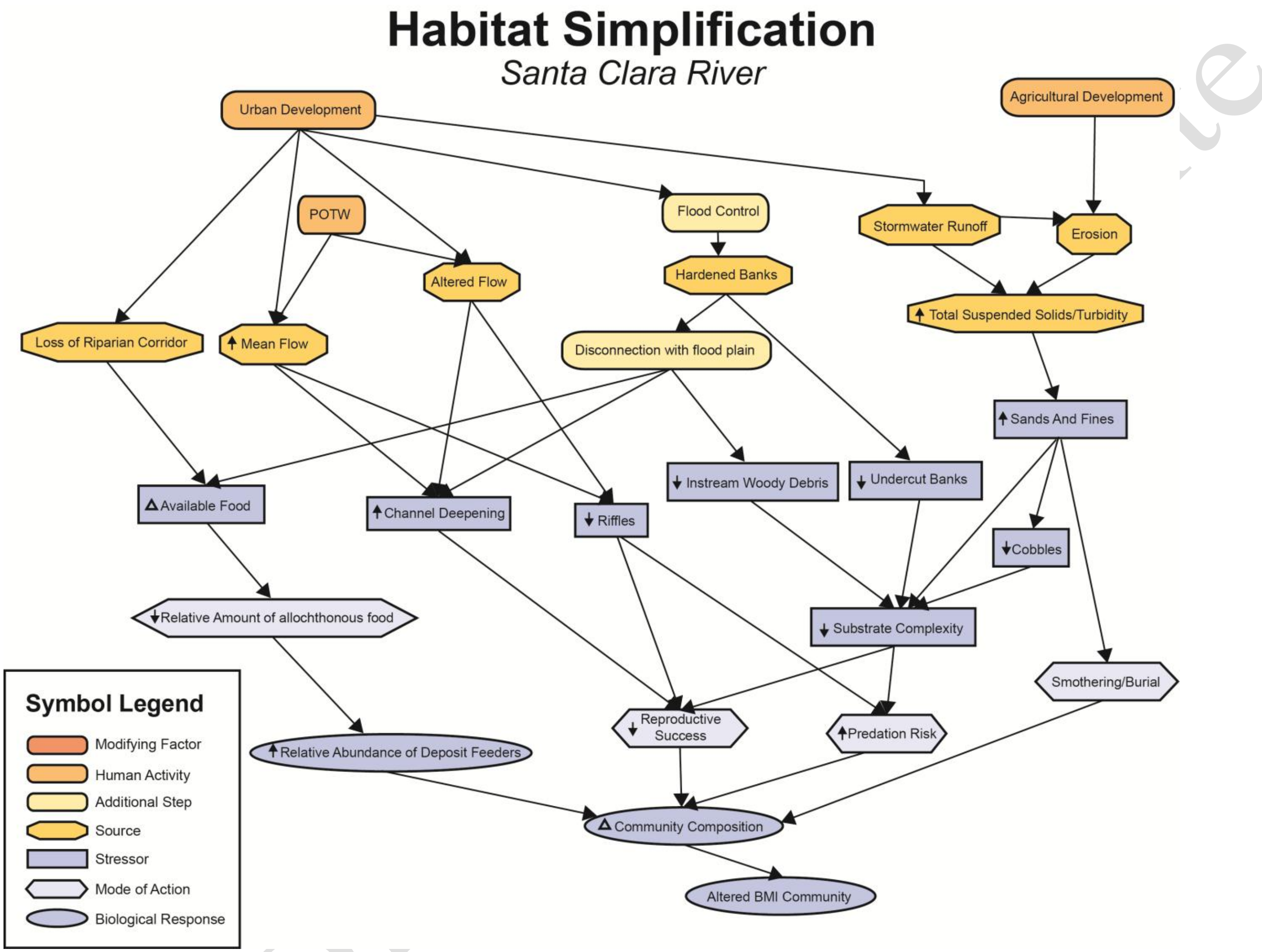


Figure 7. Habitat simplification conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

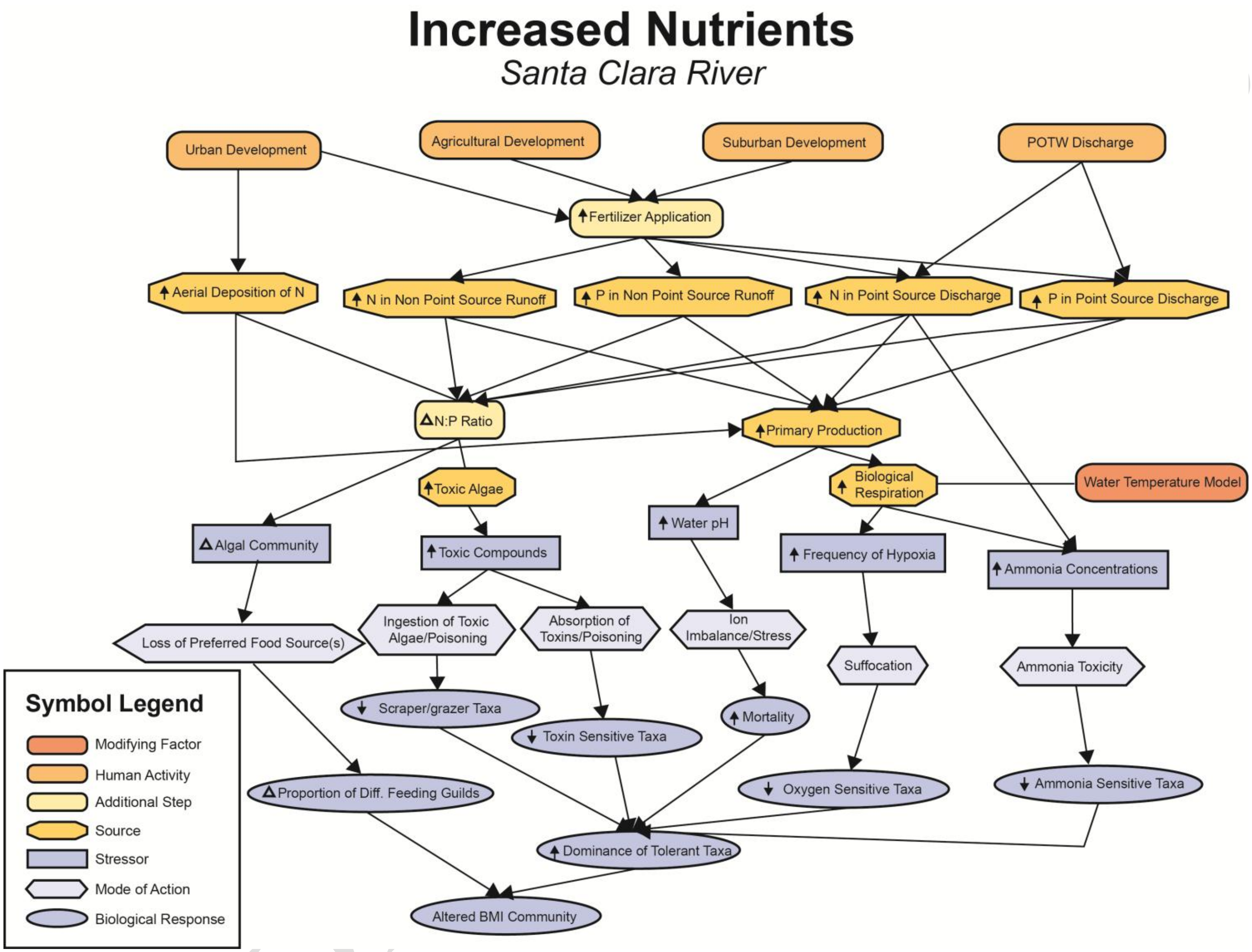


Figure 8. Increased nutrients conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

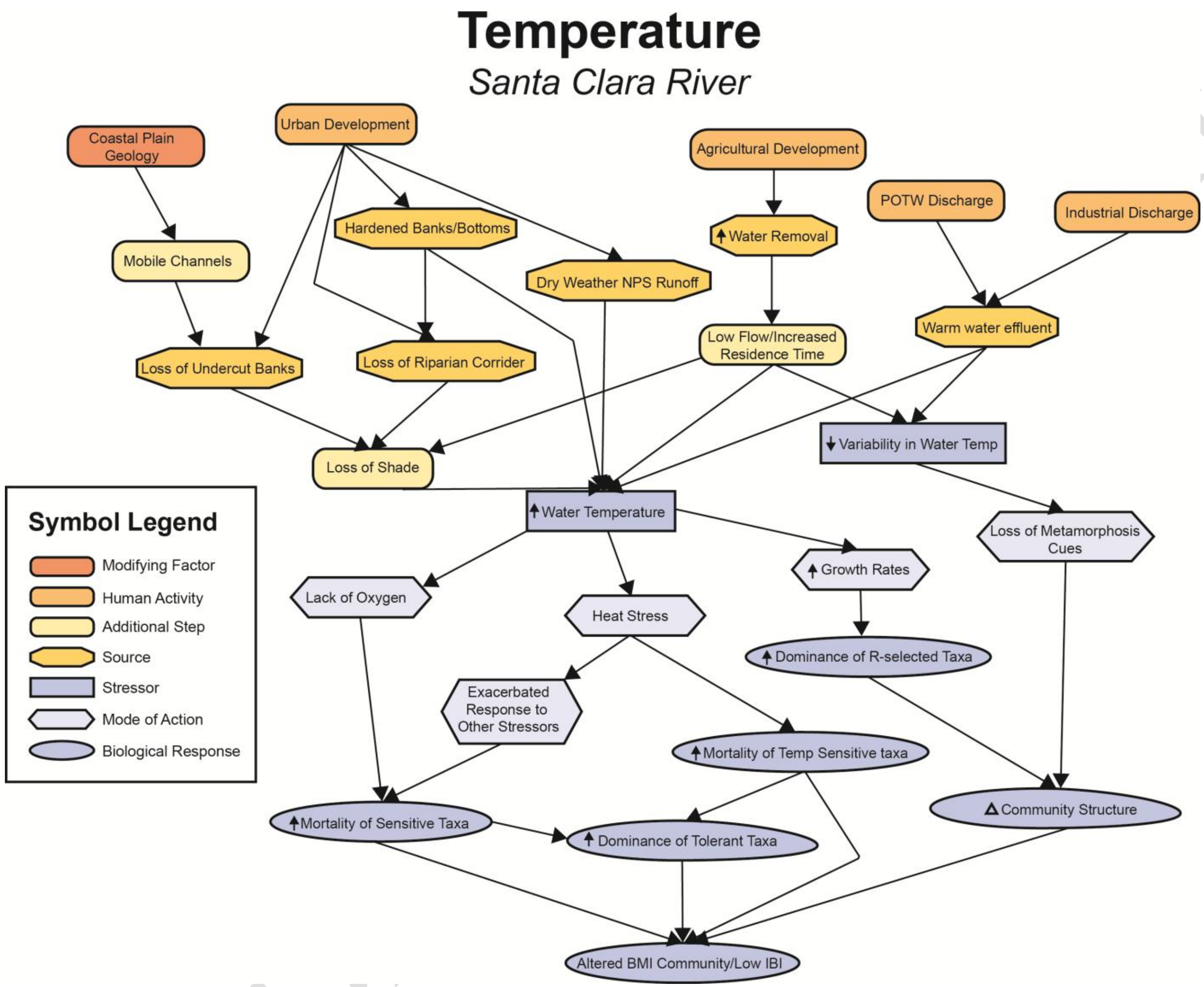


Figure 9. Temperature conceptual diagram detailing proximate stressors, potential sources, and potential modes of action to impacting the macrobenthic community.

Identifying the Cause

In this causal assessment of degraded biological condition observed at the RD site in the Santa Clara River, seven candidate causes were evaluated including conductivity, habitat simplification, river discontinuity, metals, increased nutrients, temperature, and pesticides. Based upon our review of the available data across seven comparator sites elevated conductivity and temperature were the two most likely causes behind the low IBI scores observed at RD in 2006. Metals, pesticides, and nutrients were likely not causes. Habitat simplification and river discontinuity could not be diagnosed or refuted due to conflicting evidence and lack of data. The summary of all scores for all evidence types are presented in Table 3.

Elevated conductivity was indicated as a likely stressor based on three lines of evidence. First, the quarterly mean observation of conductivity at the test site far exceeded the range of conductivity values measured at ecologically similar sites in the statewide reference network. Relative risk patterns of conductivity and macrobenthic invertebrates used in outside of the case stressor response line of evidence indicated that the levels of conductivity observed at RD were high enough to potentially produce the degraded levels of % non-insect taxa, # of predator taxa, and the % of tolerant taxa observed at the test site. Lastly, spatial co-occurrence indicated that mean quarterly conductivity, TDS, and hardness were elevated at RD relative to the RB site. It should be noted that no proximate stressor data were available for many of the comparator sites (RF, SAP8, SAP11, or SAP14 sites) and consequently the power of the within the case analyses were somewhat diminished.

Temperature was a likely stressor based on two lines of evidence, though this assessment is tempered based on consistency of evidence (i.e. mean temperature vs. temperature range). First, spatial temporal co-occurrence indicated that RD had elevated mean temperature and reduced temperature range compared to all of the comparator sites, with the exception of RB (RB is also located near a water reclamation plant outfall like RD). Second, there was a strong stressor-response relationship between increasing mean temperature (both monthly and diel) and increasing % of non-insect taxa. There were no stressor response relationships observed among temperature range and the different biological endpoints, which may imply that the temperature range may not be as important to the biota as the overall mean temperature. Unfortunately, there was no data from elsewhere to contextualize the magnitude of temperature range or mean against environmentally similar streams, so the diagnosis for temperature is weaker than for elevated conductivity.

Table 3. Table 3 Summary score sheets for RD and each of the comparator sites in the Santa Clara River assessment. Each candidate cause score is the integration of the component proximate stressor scores, which are detailed in the supplemental material. The continuity line of evidence evaluates the continuity of each line of evidence for each of the four biological endpoints: % collector-gatherer abundance/% non-insect taxa/% tolerant taxa/# of predator taxa..

RD vs. RB

Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		+	+	---	---	---	---	0
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		-/-/-/-	-/-/+/+	+/-/-/+	+/-/-/+	0/+/+/0	+/+/+/+	0/0/0/0

RD vs RC

Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		+	---	0	0	---	---	+
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		-/-/-/-	-/-/-/-	+/-/-/0	+/-/-/0	0+/+/0	+/+/+/+	0/+/0/0

§ Collector abundance were not at problematic levels and thusly were not scored for stressor response from the field and scored -- where there were data for stressor response from outside the case

RD vs RE

Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		---	---	0	---	---	---	+
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		+/-/-/-	-/-/-/-	+/-/-/0	+/-/-/0	0/+/+/0	+/+/+/+	0/+/0/0

RD vs RF

Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		NE	NE	0	0	+	NE	+
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		0/-/-/-	-/-/-/-	+/-/-/0	+/-/-/0	0/-/-/-	0/+/+/+	0/+/0/0

§ Collector abundance were not at problematic levels and thusly were not scored for stressor response from the field and scored - where there were data for stressor response from outside the case

RD vs. SAP8

Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		NE	NE	0	0	0	NE	+
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		+/-/-/-	-/-/-/-	+/-/-/0	+/-/-/0	0/0/0/0	+/+/+/+	0/+/0/0

RD vs SAP11

Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		NE	NE	0	+	0	NE	+
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		0-/-/-	-/-/+/+	+/-/-/0	0/+/+/-	0/0/0/0	+/+/+/+	0/+/0/0

§ Collector abundance were not at problematic levels and thusly were not scored for stressor response from the field and scored - where there were data for stressor response from outside the case

					RD vs SAP14			
Candidate Cause		Heavy Metals	Elevated Conductivity	River Discontinuity	Habitat Simplification	Increased Nutrients	Pesticides	Temperature
Spatial Co-Occurrence		NE	NE	---	0	---	NE	+
Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Non-Insect Taxa	+	-	0	0	-	--	+
	Tolerant Taxa	+	0	0	0	-	--	0
	Predator Taxa	+	0	0	0	0	--	0
Reference Condition Comparison		NE	+	-	-	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance §	--	--	--	--	NE	NE	NE
	Non-Insect Taxa	0	+	+	+	NE	NE	NE
	Tolerant Taxa	0	+	+	+	NE	NE	NE
	Predator Taxa	0	+	0	0	NE	NE	NE
Stressor Response From the Laboratory		--	NE	NE	NE	NE	-	NE
Continuity		+/-/-/-	-/-/+/+	+/-/-/+	+/-/-/0	0/+/+/0	+/+/+/+	0/+/0/0

§ Collector abundance were not at problematic levels and thusly were not scored for stressor response from the field and scored - where there were data for stressor response from outside the case

Metals, specifically dissolved metals in the water column, were not diagnosed as a potential cause for the observed biological degradation at RD. There were a few dissolved metals that were higher at RD than the comparator sites (e.g., copper or zinc) and there were strong correlations between different elements (arsenic, selenium, or zinc) and the biological endpoints. However, none of the correlations were consistent across the different biological endpoints (stressor response from the field) and none of the concentrations observed at the RD site were high enough to cause the biological degradation observed at the site (stressor response from laboratory studies). All of the evidence was based upon water column dissolved metals. No data were available to evaluate sediment-bound or periphyton-accumulated metals. The water column measurements were made in the three months (July-September) prior to biotic sampling. These dry season concentrations and loadings of metals are likely lower than during wet weather. However, the fauna observed at the target and comparator sites (Table 1) are primarily ephemeral, multivoltine taxa and the previous quarter's water measurements are probably a more accurate representation of their exposure than winter/wet season measurements.

Pesticides, specifically non-pyrethroid compounds in the water column, were likely not the cause of biological impacts because no detectable amounts of 24 different non-pyrethroid pesticides and 3 herbicides were observed at RD or the comparator sites where samples were collected (RB, RC, and RE) in the 12 months prior to collection of the macroinvertebrates. Synthetic pyrethroids were not measured at any of the sites, so that evidence could not be evaluated. Similarly, no measurements of any pesticide were made in sediments of the Santa Clara River. Consequently, investigation of sediment-bound compounds would be recommended in future analyses to more definitively rule out the influence of pesticides in the degraded benthic communities observed at RD.

Increased nutrients were not likely stressors at the RD site because none of the proximate stressors within the conceptual diagram were elevated at RD compared to the comparator sites and there were inverse relationships between all of the biological endpoints and the measures of nutrient impact. Nutrient-related stressors were difficult to tie into macroinvertebrate community structure as most of the effects of increased nutrients are indirect; translated through algal growth, primary production, and oxygen consumption. However, relatively high quality data were available for evaluating the presence and effects of potential low dissolved oxygen or altered pH, with the diel data that covered daytime periods of net productivity and night time periods of net respiration. Although these temporally detailed measurements were only available for a 24-hr period, they provide better insight than many daytime point measures made once a month.

River discontinuity and habitat simplification were unresolved candidate causes. These two candidate causes shared a number of component proximate stressors (e.g., loss of woody debris, loss of cobbles, etc.) that capture different aspects of stream physical habitat. The differences in the proximate stressors were small between test and comparator sites (often within the perceived error of the method). Similarly, there was no consistent stressor response relationship with any of the biological endpoints. However, none of the comparator sites had particularly good biological condition. Hence, all of the sites in the middle Santa Clara River may be impacted by sands and fine sediments. This ambiguity was further compounded by a lack of data, or inconsistent data, from elsewhere for many of the component proximate stressors to provide context to the conditions at RD. For example, the increase in sands and fine sediments observed at RD were within the range observed at similar low elevation, low gradient reference sites, but those same values of sands and fine sediments were also linked to degraded community structure in biogeographically similar non-reference sites. These kinds of ambiguities illustrate a need to better understand the influence physical habitat on community structure, a better characterization of expectation in low gradient/elevation streams, and the development of more precise measures of stream habitat.

There were several lessons learned from this causal assessment. First, diagnosing candidate cause in this assessment was difficult because much of the upper Santa Clara River was equally degraded. There were marginal differences among the biological endpoints at RD and comparator sites making traditional causal assessment approaches such as spatial temporal co-occurrence difficult. Second, since the use of within case evidence was hampered by widespread impacts at comparator sites, valuable evidence was gained by examining evidence from elsewhere. Additional data assessment tools should be developed utilizing the statewide data set for future causal assessments plagued with this same problem. Third, candidate causes comprised of complex interactions of proximate stressors such as nutrients or habitat alteration might be better served by separating into their respective stressors. For many of these stressors, additional research into the complex interactions with biological response should be explored. This research can then be used for future causal assessments as stressor response from elsewhere.

The Santa Clara River case study provides an instructive point about the careful and purposeful selection of biological endpoints. Four biological endpoints were originally selected when this case was constructed, but one of them - % collector-gatherer taxa – was actually not observed at a degraded level as measured by the Southern California IBI. Certain lines of evidence (i.e., stressor response from the field and stressor response from elsewhere) implicitly work upon the notion that the condition of the biological endpoints at the test case site are worse than the within case comparator sites. For the % collector-gatherer endpoint, this was not the case. This oversight speaks to the need to carefully consider what biological endpoints are selected for use in future causal analyses, with potential emphasis placed upon those endpoints which capture the biological degradation at the site and whose remediation may improve condition at the site.

Data Analysis from within the Case

Spatial Co-Occurrence

Spatial co-occurrence was one of the analyses with the most coverage of sites and proximate stressors for all of the different candidate causes in the Santa Clara River assessment. The analysis was set up as a comparison of the value of a potential stressor at the RD site versus each of the comparator sites (RB, RC, RE, RF, SAP8, SAP11, and SAP14). In scoring these comparisons, a series of guidelines were created to assist in making consistent evaluations across the large dataset. Summarized in Figure 10 and assuming the presence of a variable was considered as having a negative impact on a macrobenthic community structure: if the test site had a higher value than the comparator and that difference was greater than the detection limit of that variable, the data were scored "+"; if the test site had a higher value than the comparator site and the difference was less than the detection limit, the data were scored "0"; if the target and comparator sites had equal values, the data were scored "---"; if the test site had a lower value than the comparator site and the difference was less than the detection limit, the data were scored "---"; and if the test site had a lower value than the comparator site and that difference was greater than the detection limit, the data were scored as "---". If the variable was a positive variable, i.e., reducing its value would negatively affect macrobenthic community structure, the guidelines were reversed. The spatial co-occurrence comparisons (observed values, differences, and individual scores) between RD and the comparator sites for all of the individual analyses are presented in Table 4 and the scores for each candidate cause and their proximate stressors are summarized in Table 5.

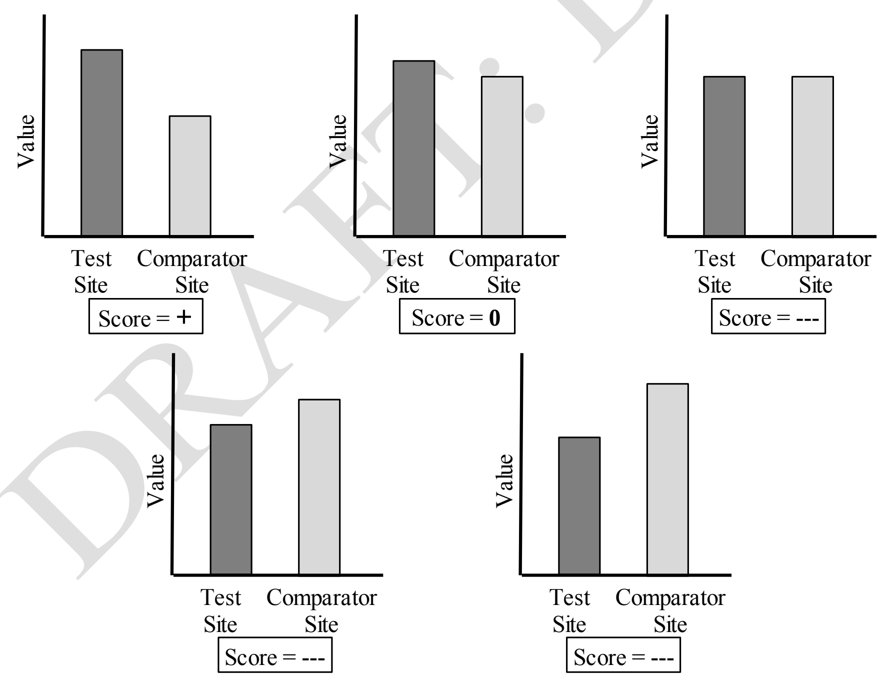


Figure 10. Illustration of scoring rules established during this case study for assessing spatial co-occurrence data assuming a negative variable. A + indicates supporting evidence, 0 indicates indeterminate evidence, and --- indicates strong contrary or weakening evidence.

Table 4. Detailed spatial co-occurrence score sheet for calculating and scoring the differences of each proximate stressor and the components therein between RD and each comparator site. Data are scored + for supporting evidence, --- for strongly weakening evidence, 0 for indeterminate evidence, or NE for no evidence. bdl = below detection limit nd = no data n/a = not applicable.

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RE Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							---	Antimony and Nickel were ambivilent
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony (µg L^{-1})	0.63	0.53	0.10	0		
			Arsenic (µg L^{-1})	0.82	1.36	-0.54	---		
			Barium (µg L^{-1})	41.70	47.50	-5.80	---		
			Beryllium (µg L^{-1})	0.13	0.13	0.00	---		
			Cadmium (µg L^{-1})	0.09	0.13	-0.04	---		
			Chromium (µg L^{-1})	0.23	0.70	-0.47	---		
			Copper (µg L^{-1})	3.42	3.72	-0.30	---		
			Hexavalent Chromium (mg L^{-1})	0.01	0.00	0.00	---		
			Iron (mg L^{-1})	0.10	0.53	-0.43	---		
			Lead (µg L^{-1})	0.10	0.31	-0.21	---		
			Mercury (µg L^{-1})	0.02	0.02	0.00	---		
			Nickel (µg L^{-1})	6.86	5.92	0.95	0		
			Selenium (µg L^{-1})	1.33	1.90	-0.57	---		
			Silver (µg L^{-1})	0.13	0.01	0.12	---		
			Thallium (µg L^{-1})	0.13	0.13	0.00	---		
			Zinc (µg L^{-1})	27.97	29.53	-1.57	---		
	Increase in Particulate Bound Metals							NE	
					No Data Available				
	Increase in Metals in Periphyton							NE	
					No Data Available				
Elevated Conductivity									
	Increase in Conductivity							---	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1207	1232.3	-25.00	---		
	Increase in Total Dissolved Solids							---	Lower TDS and Hardness, but elevated Chloride
		Mean of Previous Quarter							
			TDS (mg L^{-1})	788	815	-27.00	---		
			Chloride (mg L^{-1})	128.5	116.5	12.00	+		
			Hardness (mg L^{-1})	350	380.67	-30.67	---		
River Discontinuity									
	Decrease in Recruitment							NE	
					No Data Available				
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0.0	4.0	-4	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	23.3	-4.3	---		
	Burial of Cobbles							NE	Few if any cobbles observed, so mesurements unreliable
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)		No Data Available				
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RE Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food							0	
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				0		
	Increase in Channel Deepening							---	
			Mean Thalweg Depth (cm)	26.5	28.3	-1.7	---		
	Decrease in Riffles							NE	
					No Data Available				
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0.0	4.0	-4	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	23.3	-4.3	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		
Increased Nutrients									
	Change in Algal Community							---	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				---		
	Increase in Algal Toxins							NE	
					No Data Available				
	Increase in pH								
		Mean of Previous Quarter						---	
			pH	nd	8.10	n/a			Only based upon diel data
		Mean of 24 Hours							
			pH	7.77	8.64	-0.87	---		
	Increased Frequency of Hypoxia							---	
		Count of Observations in Daytime Point Measures							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
	Increased Ammonia Concentrations							+	
		Mean of Previous Quarter							
			Ammonia (mg L^{-1})	0.337	0.05	0.29	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RE Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Non-pyrethroid Pesticides							---	All measurements below detection limit at both sites
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	bdl	n/a	---		
			4,4'-DDE (μg L^{-1})	bdl	bdl	n/a	---		
			Acrolein (μg L^{-1})	bdl	bdl	n/a	---		
			Acrylonitrile (μg L^{-1})	bdl	bdl	n/a	---		
			Aldrin (μg L^{-1})	bdl	bdl	n/a	---		
			alpha-BHC (μg L^{-1})	bdl	bdl	n/a	---		
			cis-1,3-Dichloropropene (μg L^{-1})	bdl	bdl	n/a	---		
			delta-BHC (μg L^{-1})	bdl	bdl	n/a	---		
			Diazinon (μg L^{-1})	bdl	bdl	n/a	---		
			Dieldrin (μg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan I (μg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan II (μg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan sulfate (μg L^{-1})	bdl	bdl	n/a	---		
			Endrin aldehyde (μg L^{-1})	bdl	bdl	n/a	---		
			Endrin (μg L^{-1})	bdl	bdl	n/a	---		
			Heptachlor Epoxide (Isomer B) (μg L^{-1})	bdl	bdl	n/a	---		
			Heptachlor (μg L^{-1})	bdl	bdl	n/a	---		
			Methoxychlor (μg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDD (μg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDE (μg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDT (μg L^{-1})	bdl	bdl	n/a	---		
			p,p'-DDT (μg L^{-1})	bdl	bdl	n/a	---		
			Technical Chlordane (μg L^{-1})	bdl	bdl	n/a	---		
			Toxaphene (μg L^{-1})	bdl	bdl	n/a	---		
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	0	0	---		
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides							---	All measurements below detection limit at both sites
		Maximum Value of Previous Year							
			2,3,7,8-TCDD (pg L^{-1})	bdl	bdl	n/a	---		
			2,4,5-TP (Silvex) (μg L^{-1})	bdl	bdl	n/a	---		
			2,4'-D (μg L^{-1})	bdl	bdl	n/a	---		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RE Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature							0	Ambivilent in quarterly data, but higher in 24 hour diel data
		Mean of Previous Quarter							
			Water Temperature (C)	26.39	25.738	0.65	0		
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	24.6	23.2	1.4	+		
	Decreased Variability in Water Temperature							+	
		Range of Previous Quarter							
			Water Temperature (C)	9.06	18.61	-9.56	+		
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	6.37	-3.1	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RB Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							+	
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony (μg L^{-1})	0.63	0.30	0.33	0		
			Arsenic (μg L^{-1})	0.82	0.30	0.52	+		
			Barium (μg L^{-1})	41.70	16.00	25.70	+		
			Beryllium (μg L^{-1})	0.13	0.13	0.00	---		
			Cadmium (μg L^{-1})	0.09	0.02	0.07	0		
			Chromium (μg L^{-1})	0.23	0.23	0.00	---		
			Copper (μg L^{-1})	3.42	3.11	0.31	0		
			Hexavalent Chromium (mg L^{-1})	0.01	0.01	0.00	---		
			Iron (mg L^{-1})	0.10	0.10	0.00	---		
			Lead (μg L^{-1})	0.10	0.08	0.02	0		
			Mercury (μg L^{-1})	0.02	0.02	0.00	---		
			Nickel (μg L^{-1})	6.86	5.11	1.75	+		
			Selenium (μg L^{-1})	1.33	0.50	0.83	+		
			Silver (μg L^{-1})	0.13	0.13	0.00	---		
			Thallium (μg L^{-1})	0.13	0.13	0.00	---		
			Zinc (μg L^{-1})	27.97	40.40	-12.43	---		
	Increase in Particulate Bound Metals							NE	
					No Data Available				
	Increase in Metals in Periphyton							NE	
					No Data Available				
Elevated Conductivity									
	Increase in Conductivity							+	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1233.9	1076	158.23	+		
	Increase in Total Dissolved Solids								
		Mean of Previous Quarter						+	
			TDS (mg L^{-1})	788	631.3	156.67	+		
			Chloride (mg L^{-1})	128.5	126	2.50	+		
			Hardness (mg L^{-1})	350	195	155.00	+		
River Discontinuity									
	Decrease in Recruitment							NE	
					No Data Available				
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	4.1	0.9	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							---	
		% of Reach Area Where Present							
			Cobbles (%)	0.0	0.0	0	---		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	39.5	-20.4	---		
	Burial of Cobbles							NE	
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)		No Data Available				
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RB Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food							---	
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				---		
	Increase in Channel Deepening							---	
			Mean Thalweg Depth (cm)	26.5	28.5	-2	---		
	Decrease in Riffles							NE	
						No Data Available			
	Decrease in Woody Debris								
		Length of Reach Where Present						---	
			Small (<0.3m length) Woody Debris (m)	5	4.1	0.9	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							---	
		% of Reach Area Where Present							
			Cobbles (%)	0.0	0.0	0	---		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	39.5	-20.4	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		
Increased Nutrients									
	Change in Algal Community							0	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				0		
	Increase in Algal Toxins								
						No Data Available			
	Increase in pH							---	Only 24hr measurements available
		Mean of Previous Quarter							
			pH	nd	7.42	n/a		NE	
		Mean of 24 Hours						---	
			pH	7.77	7.24	0.53	---		
	Increased Frequency of Hypoxia							---	
		Count of Observations in Daytime Point Measures							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	7.4	-7.4	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
	Increased Ammonia Concentrations							---	
		Mean of Previous Quarter							
			Ammonia (mg L^{-1})	0.34	1.03	-0.69	---		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RB Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Non-pyrethroid Pesticides							---	
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	bdl	n/a	---		
			4,4'-DDE (μg L^{-1})	bdl	bdl	n/a	---		
			Acrolein (μg L^{-1})	bdl	bdl	n/a	---		
			Acrylonitrile (μg L^{-1})	bdl	bdl	n/a	---		
			Aldrin (μg L^{-1})	bdl	bdl	n/a	---		
			alpha-BHC (μg L^{-1})	bdl	bdl	n/a	---		
			cis-1,3-Dichloropropene (μg L^{-1})	bdl	bdl	n/a	---		
			delta-BHC (μg L^{-1})	bdl	bdl	n/a	---		
			Diazinon (μg L^{-1})	bdl	bdl	n/a	---		
			Dieldrin (μg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan I (μg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan II (μg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan sulfate (μg L^{-1})	bdl	bdl	n/a	---		
			Endrin aldehyde (μg L^{-1})	bdl	bdl	n/a	---		
			Endrin (μg L^{-1})	bdl	bdl	n/a	---		
			Heptachlor Epoxide (Isomer B) (μg L^{-1})	bdl	bdl	n/a	---		
			Heptachlor (μg L^{-1})	bdl	bdl	n/a	---		
			Methoxychlor (μg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDD (μg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDE (μg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDT (μg L^{-1})	bdl	bdl	n/a	---		
			p,p'-DDT (μg L^{-1})	bdl	bdl	n/a	---		
			Technical Chlordane (μg L^{-1})	bdl	bdl	n/a	---		
			Toxaphene (μg L^{-1})	bdl	bdl	n/a	---		
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	0	0	---		
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides								
		Maximum Value of Previous Year						---	
			2,3,7,8-TCDD (pg L^{-1})	bdl	bdl	n/a	---		
			2,4,5-TP (Silvex) (μg L^{-1})	bdl	bdl	n/a	---		
			2,4'-D (μg L^{-1})	bdl	bdl	n/a	---		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RB Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature							---	
		Mean of Previous Quarter							
			Water Temperature (C)	26.39	27.42	-1.03	---		
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	24.6	26.4	-1.8	---		
	Decreased Variability in Water Temperature							+	
		Range of Previous Quarter							
			Water Temperature (C)	9.06	6.72	2.33	+		
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	4.29	-1.02	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RC Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							+	Elevated levels of Copper and Zinc. Ambigious levels of Antimony
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony (µg L^{-1})	0.63	0.27	0.36	0		
			Arsenic (µg L^{-1})	0.82	1.51	-0.69	---		
			Barium (µg L^{-1})	41.70	79.00	-37.30	---		
			Beryllium (µg L^{-1})	0.13	0.13	0.00	---		
			Cadmium (µg L^{-1})	0.09	0.13	-0.04	---		
			Chromium (µg L^{-1})	0.23	0.25	-0.02	---		
			Copper (µg L^{-1})	3.42	2.48	0.94	+		
			Hexavalent Chromium (mg L^{-1})	0.01	0.01	0.00	---		
			Iron (mg L^{-1})	0.10	0.10	0.00	---		
			Lead (µg L^{-1})	0.10	0.07	0.03	---		
			Mercury (µg L^{-1})	0.02	0.02	0.00	---		
			Nickel (µg L^{-1})	6.86	11.40	-4.54	---		
			Selenium (µg L^{-1})	1.33	2.87	-1.54	---		
			Silver (µg L^{-1})	0.13	0.13	0.00	---		
			Thallium (µg L^{-1})	0.13	0.13	0.00	---		
			Zinc (µg L^{-1})	27.97	7.40	20.57	+		
	Increase in Particulate Bound Metals							NE	
					No Data Available				
	Increase in Metals in Periphyton							NE	
					No Data Available				
Elevated Conductivity									
	Increase in Conductivity							---	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1207.33	1295.7	-88.33	---		
	Increase in Total Dissolved Solids								
		Mean of Previous Quarter						---	Lower TDS and hardness, but higher chloride
			TDS (mg L^{-1})	788	866.67	-78.67	---		
			Chloride (mg L^{-1})	128.5	118.33	10.17	+		
			Hardness (mg L^{-1})	350	472.67	-122.67	---		
River Discontinuity									
	Decrease in Recruitment							NE	
					No Data Available				
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0.0	2.0	-2	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	45.1	-26.0	---		
	Burial of Cobbles							NE	Few if any cobbles observed, so mesurements unreliable
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)		No Data Available				
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RC Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food							---	
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				---		
	Increase in Channel Deepening							+	
			Mean Thalweg Depth (cm)	26.5	16.7	9.8	+		
	Decrease in Riffles							NE	
						No Data Available			
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles								
		% of Reach Area Where Present						+	
			Cobbles (%)	0.0	2.0	-2	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	45.1	-26.0	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		
Increased Nutrients									
	Change in Algal Community							---	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				---		
	Increase in Algal Toxins							NE	
						No Data Available			
	Increase in pH							---	Only 24 hour data available
		Mean of Previous Quarter							
			pH	nd	nd	n/a			
		Mean of 24 Hours							
			pH	7.77	7.72	0.05	---		
	Increased Frequency of Hypoxia								
		Count of Observations in Daytime Point Measures						---	
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
	Increased Ammonia Concentrations							+	
		Mean of Previous Quarter							
			Ammonia (mg L^{-1})	0.34	0.05	0.29	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RC Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Non-pyrethroid Pesticides							---	All measurements below detection limit at both sites
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	bdl	n/a	---		
			4,4'-DDE (µg L^{-1})	bdl	bdl	n/a	---		
			Acrolein (µg L^{-1})	bdl	bdl	n/a	---		
			Acrylonitrile (µg L^{-1})	bdl	bdl	n/a	---		
			Aldrin (µg L^{-1})	bdl	bdl	n/a	---		
			alpha-BHC (µg L^{-1})	bdl	bdl	n/a	---		
			cis-1,3-Dichloropropene (µg L^{-1})	bdl	bdl	n/a	---		
			delta-BHC (µg L^{-1})	bdl	bdl	n/a	---		
			Diazinon (µg L^{-1})	bdl	bdl	n/a	---		
			Dieldrin (µg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan I (µg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan II (µg L^{-1})	bdl	bdl	n/a	---		
			Endosulfan sulfate (µg L^{-1})	bdl	bdl	n/a	---		
			Endrin aldehyde (µg L^{-1})	bdl	bdl	n/a	---		
			Endrin (µg L^{-1})	bdl	bdl	n/a	---		
			Heptachlor Epoxide (Isomer B) (µg L^{-1})	bdl	bdl	n/a	---		
			Heptachlor (µg L^{-1})	bdl	bdl	n/a	---		
			Methoxychlor (µg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDD (µg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDE (µg L^{-1})	bdl	bdl	n/a	---		
			o,p'-DDT (µg L^{-1})	bdl	bdl	n/a	---		
			p,p'-DDT (µg L^{-1})	bdl	bdl	n/a	---		
			Technical Chlordane (µg L^{-1})	bdl	bdl	n/a	---		
			Toxaphene (µg L^{-1})	bdl	bdl	n/a	---		
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	0	0	---		
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides								
		Maximum Value of Previous Year						---	All measurements below detection limit at both sites
			2,3,7,8-TCDD (pg L^{-1})	bdl	bdl	n/a	---		
			2,4,5-TP (Silvex) (µg L^{-1})	bdl	bdl	n/a	---		
			2,4'-D (µg L^{-1})	bdl	bdl	n/a	---		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RC Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature							+	
		Mean of Previous Quarter							
			Water Temperature (C)	26.39	24.96	1.43	+		
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	24.6	18.36	6.24	+		
	Decreased Variability in Water Temperature							+	
		Range of Previous Quarter							
			Water Temperature (C)	9.06	13.83	-4.78	+		
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	4.73	-1.46	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RF Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							NE	
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony (µg L^{-1})	0.63	nd	n/a			
			Arsenic (µg L^{-1})	0.82	nd	n/a			
			Barium (µg L^{-1})	41.70	nd	n/a			
			Beryllium (µg L^{-1})	0.13	nd	n/a			
			Cadmium (µg L^{-1})	0.09	nd	n/a			
			Chromium (µg L^{-1})	0.23	nd	n/a			
			Copper (µg L^{-1})	3.42	nd	n/a			
			Hexavalent Chromium (mg L^{-1})	0.01	nd	n/a			
			Iron (mg L^{-1})	0.10	nd	n/a			
			Lead (µg L^{-1})	0.10	nd	n/a			
			Mercury (µg L^{-1})	0.02	nd	n/a			
			Nickel (µg L^{-1})	6.86	nd	n/a			
			Selenium (µg L^{-1})	1.33	nd	n/a			
			Silver (µg L^{-1})	0.13	nd	n/a			
			Thallium (µg L^{-1})	0.13	nd	n/a			
			Zinc (µg L^{-1})	27.97	nd	n/a			
	Increase in Particulate Bound Metals							NE	
						No Data Available			
	Increase in Metals in Periphyton							NE	
						No Data Available			
Elevated Conductivity									
	Increase in Conductivity							NE	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1207.33	nd	n/a			
	Increase in Total Dissolved Solids							NE	
		Mean of Previous Quarter							
			TDS (mg L^{-1})	788	nd	n/a			
			Chloride (mg L^{-1})	128.5	nd	n/a			
			Hardness (mg L^{-1})	350	nd	n/a			
River Discontinuity									
	Decrease in Recruitment							NE	
						No Data Available			
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0.5	0	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0	2.0	-2	+		
	Increase in Sands and Fines								
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	37.6	-18.6	---		
	Burial of Cobbles							NE	Few if any cobbles observed, so mesurements unreliable
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)			No Data Available			
	Increase in Simplified Habitat								
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RF Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food								
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				---		
	Increase in Channel Deepening								
			Mean Thalweg Depth (cm)	26.5	20.5	6	+		
	Decrease in Riffles								
					No Data Available				
	Decrease in Woody Debris								
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0.5	0	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0	2.0	-2	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	37.6	-18.6	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat								
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		
Increased Nutrients									
	Change in Algal Community							+	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				+		
	Increase in Algal Toxins							NE	
					No Data Available				
	Increase in pH							---	Only 24 hour diel data
		Mean of Previous Quarter							
			pH	nd	nd	n/a			
		Mean of 24 Hours							
			pH	7.77	9.3	-1.53	---		
	Increased Frequency of Hypoxia							---	Only 24 hour diel data
		Count of Observations in Daytime Point Measures							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	nd	n/a			
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	nd	n/a			
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
	Increased Ammonia Concentrations							+	
		Mean of Previous Quarter							
			Ammonia (mg L^{-1})	0.34	0.05	0.29	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RF Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Non-pyrethroid Pesticides							NE	
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	nd	n/a			
			4,4'-DDE (µg L^{-1})	bdl	nd	n/a			
			Acrolein (µg L^{-1})	bdl	nd	n/a			
			Acrylonitrile (µg L^{-1})	bdl	nd	n/a			
			Aldrin (µg L^{-1})	bdl	nd	n/a			
			alpha-BHC (µg L^{-1})	bdl	nd	n/a			
			cis-1,3-Dichloropropene (µg L^{-1})	bdl	nd	n/a			
			delta-BHC (µg L^{-1})	bdl	nd	n/a			
			Diazinon (µg L^{-1})	bdl	nd	n/a			
			Dieldrin (µg L^{-1})	bdl	nd	n/a			
			Endosulfan I (µg L^{-1})	bdl	nd	n/a			
			Endosulfan II (µg L^{-1})	bdl	nd	n/a			
			Endosulfan sulfate (µg L^{-1})	bdl	nd	n/a			
			Endrin aldehyde (µg L^{-1})	bdl	nd	n/a			
			Endrin (µg L^{-1})	bdl	nd	n/a			
			Heptachlor Epoxide (Isomer B) (µg L^{-1})	bdl	nd	n/a			
			Heptachlor (µg L^{-1})	bdl	nd	n/a			
			Methoxychlor (µg L^{-1})	bdl	nd	n/a			
			o,p'-DDD (µg L^{-1})	bdl	nd	n/a			
			o,p'-DDE (µg L^{-1})	bdl	nd	n/a			
			o,p'-DDT (µg L^{-1})	bdl	nd	n/a			
			p,p'-DDT (µg L^{-1})	bdl	nd	n/a			
			Technical Chlordane (µg L^{-1})	bdl	nd	n/a			
			Toxaphene (µg L^{-1})	bdl	nd	n/a			
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	nd	n/a			
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides							NE	
		Maximum Value of Previous Year							
			2,3,7,8-TCDD (pg L^{-1})	bdl	nd	n/a			
			2,4,5-TP (Silvex) (µg L^{-1})	bdl	nd	n/a			
			2,4'-D (µg L^{-1})	bdl	nd	n/a			

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RF Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature							+	
		Mean of Previous Quarter							Only 24 hour diel data
			Water Temperature (C)	26.39	nd	n/a			
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	24.6	21.18	3.42	+		
	Decreased Variability in Water Temperature							+	
		Range of Previous Quarter							Only 24 hour diel data
			Water Temperature (C)	9.06	nd	n/a			
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	9.2	-5.93	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP8 Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							NE	
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony ($\mu g\ L^{-1}$)	0.63	nd	n/a			
			Arsenic ($\mu g\ L^{-1}$)	0.82	nd	n/a			
			Barium ($\mu g\ L^{-1}$)	41.70	nd	n/a			
			Beryllium ($\mu g\ L^{-1}$)	0.13	nd	n/a			
			Cadmium ($\mu g\ L^{-1}$)	0.09	nd	n/a			
			Chromium ($\mu g\ L^{-1}$)	0.23	nd	n/a			
			Copper ($\mu g\ L^{-1}$)	3.42	nd	n/a			
			Hexavalent Chromium ($mg\ L^{-1}$)	0.01	nd	n/a			
			Iron ($mg\ L^{-1}$)	0.10	nd	n/a			
			Lead ($\mu g\ L^{-1}$)	0.10	nd	n/a			
			Mercury ($\mu g\ L^{-1}$)	0.02	nd	n/a			
			Nickel ($\mu g\ L^{-1}$)	6.86	nd	n/a			
			Selenium ($\mu g\ L^{-1}$)	1.33	nd	n/a			
			Silver ($\mu g\ L^{-1}$)	0.13	nd	n/a			
			Thallium ($\mu g\ L^{-1}$)	0.13	nd	n/a			
			Zinc ($\mu g\ L^{-1}$)	27.97	nd	n/a			
	Increase in Particulate Bound Metals							NE	
						No Data Available			
	Increase in Metals in Periphyton							NE	
						No Data Available			
Elevated Conductivity									
	Increase in Conductivity							NE	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1207.3	nd	n/a			
	Increase in Total Dissolved Solids							NE	
		Mean of Previous Quarter							
			TDS ($mg\ L^{-1}$)	788	nd	n/a			
			Chloride ($mg\ L^{-1}$)	128.5	nd	n/a			
			Hardness ($mg\ L^{-1}$)	350	nd	n/a			
River Discontinuity									
	Decrease in Recruitment							NE	
						No Data Available			
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	1.8	3.2	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0	2.0	-2	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	31.0	-11.9	---		
	Burial of Cobbles							NE	Few if any cobbles observed, so mesurements unreliable
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)			No Data Available			
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP8 Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food							---	
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				---		
	Increase in Channel Deepening							0	
			Mean Thalweg Depth (cm)	26.5	24.4	2.2	0		
	Decrease in Riffles							NE	
						No Data Available			
	Decrease in Woody Debris								
		Length of Reach Where Present						---	
			Small (<0.3m length) Woody Debris (m)	5	1.8	3.2	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0	0.5	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0	2.0	-2	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	31.0	-11.9	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat							0	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				0		
Increased Nutrients									
	Change in Algal Community							0	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				0		
	Increase in Algal Toxins							NE	
						No Data Available			
	Increase in pH							---	Only 24 hour diel data
		Mean of Previous Quarter							
			pH	nd	nd	n/a			
		Mean of 24 Hours							
			pH	7.77	8.71	-0.94	---		
	Increased Frequency of Hypoxia							---	Only 24 hour diel data
		Count of Observations in Daytime Point Measures							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	nd	n/a			
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	nd	n/a			
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
	Increased Ammonia Concentrations							+	
		Mean of Previous Quarter							
			Ammonia (mg L^{-1})	0.34	0.05	0.29	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP8 Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Non-pyrethroid Pesticides							NE	
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	nd	n/a			
			4,4'-DDE (μg L^{-1})	bdl	nd	n/a			
			Acrolein (μg L^{-1})	bdl	nd	n/a			
			Acrylonitrile (μg L^{-1})	bdl	nd	n/a			
			Aldrin (μg L^{-1})	bdl	nd	n/a			
			alpha-BHC (μg L^{-1})	bdl	nd	n/a			
			cis-1,3-Dichloropropene (μg L^{-1})	bdl	nd	n/a			
			delta-BHC (μg L^{-1})	bdl	nd	n/a			
			Diazinon (μg L^{-1})	bdl	nd	n/a			
			Dieldrin (μg L^{-1})	bdl	nd	n/a			
			Endosulfan I (μg L^{-1})	bdl	nd	n/a			
			Endosulfan II (μg L^{-1})	bdl	nd	n/a			
			Endosulfan sulfate (μg L^{-1})	bdl	nd	n/a			
			Endrin aldehyde (μg L^{-1})	bdl	nd	n/a			
			Endrin (μg L^{-1})	bdl	nd	n/a			
			Heptachlor Epoxide (Isomer B) (μg L^{-1})	bdl	nd	n/a			
			Heptachlor (μg L^{-1})	bdl	nd	n/a			
			Methoxychlor (μg L^{-1})	bdl	nd	n/a			
			o,p'-DDD (μg L^{-1})	bdl	nd	n/a			
			o,p'-DDE (μg L^{-1})	bdl	nd	n/a			
			o,p'-DDT (μg L^{-1})	bdl	nd	n/a			
			p,p'-DDT (μg L^{-1})	bdl	nd	n/a			
			Technical Chlordane (μg L^{-1})	bdl	nd	n/a			
			Toxaphene (μg L^{-1})	bdl	nd	n/a			
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	nd	n/a			
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides							NE	
		Maximum Value of Previous Year							
			2,3,7,8-TCDD (pg L^{-1})	bdl	nd	n/a			
			2,4,5-TP (Silvex) (μg L^{-1})	bdl	nd	n/a			
			2,4'-D (μg L^{-1})	bdl	nd	n/a			

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP8 Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature							+	Only 24 hour diel data
		Mean of Previous Quarter							
			Water Temperature (C)	26.39	nd	n/a			
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	6.71	7.86	-1.15	+		
	Decreased Variability in Water Temperature							+	Only 24 hour diel data
		Range of Previous Quarter							
			Water Temperature (C)	9.06	nd	n/a			
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	8.45	-5.18	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP11 Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							NE	
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony ($\mu g\ L^{-1}$)	0.63	nd	n/a			
			Arsenic ($\mu g\ L^{-1}$)	0.82	nd	n/a			
			Barium ($\mu g\ L^{-1}$)	41.70	nd	n/a			
			Beryllium ($\mu g\ L^{-1}$)	0.13	nd	n/a			
			Cadmium ($\mu g\ L^{-1}$)	0.09	nd	n/a			
			Chromium ($\mu g\ L^{-1}$)	0.23	nd	n/a			
			Copper ($\mu g\ L^{-1}$)	3.42	nd	n/a			
			Hexavalent Chromium ($mg\ L^{-1}$)	0.01	nd	n/a			
			Iron ($mg\ L^{-1}$)	0.10	nd	n/a			
			Lead ($\mu g\ L^{-1}$)	0.10	nd	n/a			
			Mercury ($\mu g\ L^{-1}$)	0.02	nd	n/a			
			Nickel ($\mu g\ L^{-1}$)	6.86	nd	n/a			
			Selenium ($\mu g\ L^{-1}$)	1.33	nd	n/a			
			Silver ($\mu g\ L^{-1}$)	0.13	nd	n/a			
			Thallium ($\mu g\ L^{-1}$)	0.13	nd	n/a			
			Zinc ($\mu g\ L^{-1}$)	27.97	nd	n/a			
	Increase in Particulate Bound Metals							NE	
						No Data Available			
	Increase in Metals in Periphyton							NE	
						No Data Available			
Elevated Conductivity									
	Increase in Conductivity							NE	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1207.3	nd	n/a			
	Increase in Total Dissolved Solids							NE	
		Mean of Previous Quarter							
			TDS ($mg\ L^{-1}$)	788	nd	n/a			
			Chloride ($mg\ L^{-1}$)	128.5	nd	n/a			
			Hardness ($mg\ L^{-1}$)	350	nd	n/a			
River Discontinuity									
	Decrease in Recruitment							NE	
						No Data Available			
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0.5	0	---		
	Decrease in Cobbles								
		% of Reach Area Where Present							
			Cobbles (%)	0.0	16.0	-16	+		
	Increase in Sands and Fines								
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	36.5	-17.4	---		
	Burial of Cobbles							NE	Few if any cobbles observed, so mesurements unreliable
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)			No Data Available			
	Increase in Simplified Habitat							+	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP11 Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food							+	
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				+		
	Increase in Channel Deepening							+	
			Mean Thalweg Depth (cm)	26.5	18.8	7.7	+		
	Decrease in Riffles							NE	
						No Data Available			
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0.5	0	---		
	Decrease in Cobbles							+	
		% of Reach Area Where Present							
			Cobbles (%)	0.0	16.0	-16	+		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	36.5	-17.4	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat							+	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				+		
Increased Nutrients									
	Change in Algal Community							+	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				+		
	Increase in Algal Toxins							NE	
						No Data Available			
	Increase in pH							---	Only 24 hour diel data
		Mean of Previous Quarter							
			pH	nd	nd	n/a			
		Mean of 24 Hours							
			pH	7.77	8.31	-0.54	---		
	Increased Frequency of Hypoxia							---	Only 24 hour diel data
		Count of Observations in Daytime Point Measures							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	nd	n/a			
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	nd	n/a			
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0	0	---		
	Increased Ammonia Concentrations							+	
		Mean of Previous Quarter							
			Ammonia (mg L^{-1})	0.34	0.05	0.29	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP11 Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Non-pyrethroid Pesticides							NE	
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	nd	n/a			
			4,4'-DDE (μg L^{-1})	bdl	nd	n/a			
			Acrolein (μg L^{-1})	bdl	nd	n/a			
			Acrylonitrile (μg L^{-1})	bdl	nd	n/a			
			Aldrin (μg L^{-1})	bdl	nd	n/a			
			alpha-BHC (μg L^{-1})	bdl	nd	n/a			
			cis-1,3-Dichloropropene (μg L^{-1})	bdl	nd	n/a			
			delta-BHC (μg L^{-1})	bdl	nd	n/a			
			Diazinon (μg L^{-1})	bdl	nd	n/a			
			Dieldrin (μg L^{-1})	bdl	nd	n/a			
			Endosulfan I (μg L^{-1})	bdl	nd	n/a			
			Endosulfan II (μg L^{-1})	bdl	nd	n/a			
			Endosulfan sulfate (μg L^{-1})	bdl	nd	n/a			
			Endrin aldehyde (μg L^{-1})	bdl	nd	n/a			
			Endrin (μg L^{-1})	bdl	nd	n/a			
			Heptachlor Epoxide (Isomer B) (μg L^{-1})	bdl	nd	n/a			
			Heptachlor (μg L^{-1})	bdl	nd	n/a			
			Methoxychlor (μg L^{-1})	bdl	nd	n/a			
			o,p'-DDD (μg L^{-1})	bdl	nd	n/a			
			o,p'-DDE (μg L^{-1})	bdl	nd	n/a			
			o,p'-DDT (μg L^{-1})	bdl	nd	n/a			
			p,p'-DDT (μg L^{-1})	bdl	nd	n/a			
			Technical Chlordane (μg L^{-1})	bdl	nd	n/a			
			Toxaphene (μg L^{-1})	bdl	nd	n/a			
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	n/a	nd			
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides							NE	
		Maximum Value of Previous Year							
			2,3,7,8-TCDD (pg L^{-1})	bdl	nd	n/a			
			2,4,5-TP (Silvex) (μg L^{-1})	bdl	nd	n/a			
			2,4'-D (μg L^{-1})	bdl	nd	n/a			

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP11 Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature								
		Mean of Previous Quarter						+	Only 24 hour diel data
			Water Temperature (C)	26.39	nd	n/a			
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	24.6	14.72	9.88	+		
	Decreased Variability in Water Temperature							+	Only 24 hour diel data
		Range of Previous Quarter							
			Water Temperature (C)	9.06	nd	n/a			
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	5.35	-2.08	+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP14 Value	Difference	Component Score	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals							NE	
		Mean of Previous Quarter (BDL = 1/2 MDL)							
			Antimony (µg L^{-1})	0.63	nd	n/a			
			Arsenic (µg L^{-1})	0.82	nd	n/a			
			Barium (µg L^{-1})	41.70	nd	n/a			
			Beryllium (µg L^{-1})	0.13	nd	n/a			
			Cadmium (µg L^{-1})	0.09	nd	n/a			
			Chromium (µg L^{-1})	0.23	nd	n/a			
			Copper (µg L^{-1})	3.42	nd	n/a			
			Hexavalent Chromium (mg L^{-1})	0.01	nd	n/a			
			Iron (mg L^{-1})	0.10	nd	n/a			
			Lead (µg L^{-1})	0.10	nd	n/a			
			Mercury (µg L^{-1})	0.02	nd	n/a			
			Nickel (µg L^{-1})	6.86	nd	n/a			
			Selenium (µg L^{-1})	1.33	nd	n/a			
			Silver (µg L^{-1})	0.13	nd	n/a			
			Thallium (µg L^{-1})	0.13	nd	n/a			
			Zinc (µg L^{-1})	27.97	nd	n/a			
	Increase in Particulate Bound Metals							NE	
						No Data Available			
	Increase in Metals in Periphyton							NE	
						No Data Available			
Elevated Conductivity									
	Increase in Conductivity							NE	
		Mean of Previous Quarter							
			Conductivity mmhos cm^{-1}	1207.33	nd	n/a			
	Increase in Total Dissolved Solids							NE	
		Mean of Previous Quarter							
			TDS (mg L^{-1})	788	nd	n/a			
			Chloride (mg L^{-1})	128.5	nd	n/a			
			Hardness (mg L^{-1})	350	nd	n/a			
River Discontinuity									
	Decrease in Recruitment							NE	
						No Data Available			
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0.5	0	---		
	Decrease in Cobbles							---	
		% of Reach Area Where Present							
			Cobbles (%)	0	0	0	---		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	45.7	-26.7	---		
	Burial of Cobbles							NE	Few if any cobbles observed, so mesurements unreliable
		Mean % of Cobbles Embeddedness							
			Cobble Embeddedness (%)			No Data Available			
	Increase in Simplified Habitat							+	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				+		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP14 Value	Difference	Component Score	Proximate Stressor Score	Comment
Habitat Simplification									
	Change in Available Food							+	
		nMDS Comparison of Sites Based Upon Food Type Availability							
			Euclidean Distance from RD				+		
	Increase in Channel Deepening							+	
			Mean Thalweg Depth (cm)	26.5	6.2	20.4	+		
	Decrease in Riffles							NE	
					No Data Available				
	Decrease in Woody Debris							---	
		Length of Reach Where Present							
			Small (<0.3m length) Woody Debris (m)	5	5	0	---		
			Large (>0.3m length) Woody Debris (m)	0.5	0.5	0	---		
	Decrease in Cobbles							---	
		% of Reach Area Where Present							
			Cobbles (%)	0	0	0	---		
	Increase in Sands and Fines							---	
		% of Reach Area Where Present							
			Sands and Fines (%)	19.1	45.7	-26.7	---		
	Decrease in Undercut Banks							---	
		Length of Reach Where Present							
			Undercut banks (m)	5	5	0	---		
	Increase in Simplified Habitat							+	
		nMDS Comparison of Sites Based on Habitat Types Present							
			Euclidean Distance from RD				+		
Increased Nutrients									
	Change in Algal Community							+	
		nMDS Comparison of Sites Based on Diatom Communty Structure							
			Bray-Curtis Similarity to RD				+		
	Increase in Algal Toxins							NE	
					No Data Available				
	Increase in pH							NE	
		Mean of Previous Quarter							
			pH	nd	nd	n/a			
		Mean of 24 Hours							
			pH	7.77	nd	n/a			
	Increased Frequency of Hypoxia							---	Only 24 hour diel data and data are questionable
		Count of Observations in Daytime Point Measures							
			Mild Hypoxia (2-5 $mg\ L^{-1}$ Dissolved Oxygen)	0	nd	n/a			
			Hypoxia (<2.0 $mg\ L^{-1}$ Dissolved Oxygen)	0	nd	n/a			
		Count of Observations in Diel Measures (24hrs)							
			Mild Hypoxia (2-5 $mg\ L^{-1}$ Dissolved Oxygen)	0	50.4	-50.4	---		
			Hypoxia (<2.0 $mg\ L^{-1}$ Dissolved Oxygen)	0	0.1	-0.1	---		
	Increased Ammonia Concentrations							---	
		Mean of Previous Quarter							
			Ammonia ($mg\ L^{-1}$)	0.34	0.55	-0.21	---		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP14 Value	Difference	Component Score	Proximate Stressor Score	Comment
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides							NE	
	Increased Water Column Non-pyrethroid Pesticides							NE	
		Maximum Value of Previous Year							
			4,4'-DDD (mg L^{-1})	bdl	nd	n/a			
			4,4'-DDE (µg L^{-1})	bdl	nd	n/a			
			Acrolein (µg L^{-1})	bdl	nd	n/a			
			Acrylonitrile (µg L^{-1})	bdl	nd	n/a			
			Aldrin (µg L^{-1})	bdl	nd	n/a			
			alpha-BHC (µg L^{-1})	bdl	nd	n/a			
			cis-1,3-Dichloropropene (µg L^{-1})	bdl	nd	n/a			
			delta-BHC (µg L^{-1})	bdl	nd	n/a			
			Diazinon (µg L^{-1})	bdl	nd	n/a			
			Dieldrin (µg L^{-1})	bdl	nd	n/a			
			Endosulfan I (µg L^{-1})	bdl	nd	n/a			
			Endosulfan II (µg L^{-1})	bdl	nd	n/a			
			Endosulfan sulfate (µg L^{-1})	bdl	nd	n/a			
			Endrin aldehyde (µg L^{-1})	bdl	nd	n/a			
			Endrin (µg L^{-1})	bdl	nd	n/a			
			Heptachlor Epoxide (Isomer B) (µg L^{-1})	bdl	nd	n/a			
			Heptachlor (µg L^{-1})	bdl	nd	n/a			
			Methoxychlor (µg L^{-1})	bdl	nd	n/a			
			o,p'-DDD (µg L^{-1})	bdl	nd	n/a			
			o,p'-DDE (µg L^{-1})	bdl	nd	n/a			
			o,p'-DDT (µg L^{-1})	bdl	nd	n/a			
			p,p'-DDT (µg L^{-1})	bdl	nd	n/a			
			Technical Chlordane (µg L^{-1})	bdl	nd	n/a			
			Toxaphene (µg L^{-1})	bdl	nd	n/a			
		Detection of Any Compound Above Detection Limit							
			Frequency of Detection (# observed/# measured)	0	nd	n/a			
	Increased Water Column Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Sediment Pyrethroid Pesticides							NE	
						No Data Available			
	Increased Water Column Herbicides							NE	
		Maximum Value of Previous Year							
			2,3,7,8-TCDD (pg L^{-1})	bdl	nd	n/a			
			2,4,5-TP (Silvex) (µg L^{-1})	bdl	nd	n/a			
			2,4'-D (µg L^{-1})	bdl	nd	n/a			

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	SAP 14 Value	Difference	Component Score	Proximate Stressor Score	Comment
Temperature									
	Increased Water Temperature							+	Only 24 hour diel data
		Mean of Previous Quarter							
			Water Temperature (C)	26.39	nd	n/a			
		Mean of Diel Measurements (24hr)							
			Water Temperature (C)	24.6	18.7	5.9	+		
	Decreased Variability in Water Temperature							+	Only 24 hour diel data
		Range of Previous Quarter							
			Water Temperature (C)	9.06	nd	n/a			
		Range of Diel Measurements (24hr)							
			Water Temperature (C)	3.27	16.04	-12.77	+		

Table 5. Summary of spatial co-occurrence comparisons between RD and each comparator site for the candidate causes and their component proximate stressors. Data are scored + for supporting evidence, --- for strongly weakening evidence, 0 for indeterminate evidence, or NE for no evidence.

Candidate Cause	Proximate Stressor	RB vs RD Proximate Stressor Score	RB vs RD Comment	RC vs RD Proximate Stressor Score	RC vs RD Comment
Heavy Metals					
	Increase in Dissolved Metals	+		+	Elevated levels of Copper and Zinc. Ambigious levels of Antimony
	Increase in Particulate Bound Metals	NE		NE	
	Increase in Metals in Periphyton	NE		NE	
Elevated Conductivity					
	Increase in Conductivity	+		---	
	Increase in Total Dissolved Solids	+		---	Lower TDS and hardness, but higher chloride
River Discontinuity					
	Decrease in Recruitment	NE		NE	
	Decrease in Woody Debris	---		---	
	Decrease in Cobbles	---		+	
	Increase in Sands and Fines	---		---	
	Burial of Cobbles	NE	Few if any cobbles observed, so mesurements unreliable	NE	Few if any cobbles observed, so mesurements unreliable
	Increase in Simplified Habitat	0		0	
Habitat Simplification					
	Change in Available Food	---		---	
	Increase in Channel Deepening	---		+	
	Decrease in Riffles	NE		NE	
	Decrease in Woody Debris	---		---	
	Decrease in Cobbles	---		+	
	Increase in Sands and Fines	---		---	
	Decrease in Undercut Banks	---		---	
	Increase in Simplified Habitat	0		0	
Increased Nutrients					
	Change in Algal Community	0		---	
	Increase in Algal Toxins	NE		NE	
	Increase in pH	---	Only 24hr measurements availabl	---	Only 24 hour data available
	Increased Frequency of Hypoxia	---		---	
	Increased Ammonia Concentrations	---		+	
Pesticides					
	Increased Sediment Non-pyrethroid Pesticides	NE		NE	
	Increased Water Column Non-pyrethroid Pesticides	---	All measurements below detection limit at both sites	---	All measurements below detection limit at both sites
	Increased Water Column Pyrethroid Pesticides	NE		NE	
	Increased Sediment Pyrethroid Pesticides	NE		NE	
	Increased Water Column Herbicides	---	All measurements below detection limit at both sites	---	All measurements below detection limit at both sites
Temperature					
	Increased Water Temperature	---		+	
	Decreased Variability in Water Temperature	+		+	

Candidate Cause	Proximate Stressor	RE vs RD		RF vs RD	
		Proximate Stressor Score	Comment	Proximate Stressor Score	Comment
Heavy Metals					
	Increase in Dissolved Metals	---	Antimony and Nickel were ambibilent	NE	
	Increase in Particulate Bound Metals	NE		NE	
	Increase in Metals in Periphyton	NE		NE	
Elevated Conductivity					
	Increase in Conductivity	---		NE	
	Increase in Total Dissolved Solids	---	Lower TDS and Hardness, but elevated Chloride	NE	
River Discontinuity					
	Decrease in Recruitment	NE		NE	
	Decrease in Woody Debris	---		---	
	Decrease in Cobbles	+		+	
	Increase in Sands and Fines	---		---	
	Burial of Cobbles	NE	Few if any cobbles observed, so mesurements unreliable	NE	Few if any cobbles observed, so mesurements unreliable
	Increase in Simplified Habitat	0		0	
Habitat Simplification					
	Change in Available Food	0		---	
	Increase in Channel Deepening	---		+	
	Decrease in Riffles	NE		NE	
	Decrease in Woody Debris	---		---	
	Decrease in Cobbles	+		+	
	Increase in Sands and Fines	---		---	
	Decrease in Undercut Banks	---		---	
	Increase in Simplified Habitat	0		0	
Increased Nutrients					
	Change in Algal Community	---		+	
	Increase in Algal Toxins	NE		NE	
	Increase in pH	---	Only based upon diel data	---	Only 24 hour diel data
	Increased Frequency of Hypoxia	---		---	Only 24 hour diel data
	Increased Ammonia Concentrations	+		+	
Pesticides					
	Increased Sediment Non-pyrethroid Pesticides	NE		NE	
	Increased Water Column Non-pyrethroid Pesticides	---	All measurements below detection limit at both sites	NE	
	Increased Water Column Pyrethroid Pesticides	NE		NE	
	Increased Sediment Pyrethroid Pesticides	NE		NE	
	Increased Water Column Herbicides	---	All measurements below detection limit at both sites	NE	
Temperature					
	Increased Water Temperature	0	Ambivilent in quarterly data, but higher in 24 hour diel data	+	Only 24 hour diel data
	Decreased Variability in Water Temperature	+		+	Only 24 hour diel data

Candidate Cause	Proximate Stressor	SAP8 vs RD		SAP11 vs. RD	
		Proximate Stressor Score	Comment	Proximate Stressor Score	Comment
Heavy Metals					
	Increase in Dissolved Metals	NE		NE	
	Increase in Particulate Bound Metals	NE		NE	
	Increase in Metals in Periphyton	NE		NE	
Elevated Conductivity					
	Increase in Conductivity	NE		NE	
	Increase in Total Dissolved Solids	NE		NE	
River Discontinuity					
	Decrease in Recruitment	NE		NE	
	Decrease in Woody Debris	---		---	
	Decrease in Cobbles	+		+	
	Increase in Sands and Fines	---		---	
	Burial of Cobbles	NE	Few if any cobbles observed, so mesurements unreliable	NE	Few if any cobbles observed, so mesurements unreliable
	Increase in Simplified Habitat	0		+	
Habitat Simplification					
	Change in Available Food	---		+	
	Increase in Channel Deepening	0		+	
	Decrease in Riffles	NE		NE	
	Decrease in Woody Debris	---		---	
	Decrease in Cobbles	+		+	
	Increase in Sands and Fines	---		---	
	Decrease in Undercut Banks	---		---	
	Increase in Simplified Habitat	0		+	
Increased Nutrients					
	Change in Algal Community	0		+	
	Increase in Algal Toxins	NE		NE	
	Increase in pH	---	Only 24 hour diel data	---	Only 24 hour diel data
	Increased Frequency of Hypoxia	---	Only 24 hour diel data	---	Only 24 hour diel data
	Increased Ammonia Concentrations	+		+	
Pesticides					
	Increased Sediment Non-pyrethroid Pesticides	NE		NE	
	Increased Water Column Non-pyrethroid Pesticides	NE		NE	
	Increased Water Column Pyrethroid Pesticides	NE		NE	
	Increased Sediment Pyrethroid Pesticides	NE		NE	
	Increased Water Column Herbicides	NE		NE	
Temperature					
	Increased Water Temperature	+	Only 24 hour diel data	+	Only 24 hour diel data
	Decreased Variability in Water Temperature	+	Only 24 hour diel data	+	Only 24 hour diel data

Candidate Cause	Proximate Stressor	SAP14 vs. RD	
		Proximate Stressor Score	Comment
Heavy Metals			
	Increase in Dissolved Metals	NE	
	Increase in Particulate Bound Metals	NE	
	Increase in Metals in Periphyton	NE	
Elevated Conductivity			
	Increase in Conductivity	NE	
	Increase in Total Dissolved Solids	NE	
River Discontinuity			
	Decrease in Recruitment	NE	
	Decrease in Woody Debris	---	
	Decrease in Cobbles	---	
	Increase in Sands and Fines	---	
	Burial of Cobbles	NE	Few if any cobbles observed, so mesurements unreliable
	Increase in Simplified Habitat	+	
Habitat Simplification			
	Change in Available Food	+	
	Increase in Channel Deepening	+	
	Decrease in Riffles	NE	
	Decrease in Woody Debris	---	
	Decrease in Cobbles	---	
	Increase in Sands and Fines	---	
	Decrease in Undercut Banks	---	
	Increase in Simplified Habitat	+	
Increased Nutrients			
	Change in Algal Community	+	
	Increase in Algal Toxins	NE	
	Increase in pH	NE	
	Increased Frequency of Hypoxia	---	Only 24 hour diel data and SAP 14 data are questionable
	Increased Ammonia Concentrations	---	
Pesticides			
	Increased Sediment Non-pyrethroid Pesticides	NE	
	Increased Water Column Non-pyrethroid Pesticides	NE	
	Increased Water Column Pyrethroid Pesticides	NE	
	Increased Sediment Pyrethroid Pesticides	NE	
	Increased Water Column Herbicides	NE	
Temperature			
	Increased Water Temperature	+	Only 24 hour diel data
	Decreased Variability in Water Temperature	+	Only 24 hour diel data

Stressor-Response from the Field

The stressor-response line of evidence also had relatively good coverage across all of the candidate causes and nearly all of the proximate stressors could be evaluated. Stressor response relationships were evaluated by calculating Spearman's rank correlations between the different proximate stressors and the four biological response variables: % non-insect taxa, % tolerant taxa, % collector-gatherer abundance, and the number of predator taxa observed at RD and the seven comparator sites. The % non-insect taxa, % tolerant taxa, and % collector-gatherer abundance are negative measures of community structure and habitat quality, where as a habitat is degraded these biological measures would be expected to increase. Conversely, the number of predator taxa is a positive measure of community structure and habitat quality, where as a habitat is degraded the number of predator taxa would be expected to decrease.

Data were scored based upon the rho (ρ) value of the correlation and the direction of the expected relationship between the biological endpoints and the different proximate stressors – a negative variable (e.g., % sands and fines) with negative biology would be a direct relationship, while a positive variable (% woody debris) with a negative biology would be an inverse relationship. As an example of an expected direct relationship: ρ= -1 – -0.9 would be scored --, ρ <-0.9 – -0.75 would be scored -, ρ <-0.75 – <0.75 would be scored 0, ρ= 0.75 - <0.9 would be scored +, and ρ = 0.9 – 1.0 would be scored ++. This pattern would be reversed for any expected inverse relationship. Any relationship scored ++ or -- was investigated visually by plotting the proximate stressor and the biological endpoint and looking for spurious or less compelling relationships. If there was a question about the pattern of the correlation versus the ρ-value, the ++ or -- was changed to + or -. Additionally, if a chemical compound (i.e., metals or pesticides) was below detection limit at RD, it was scored --.

The % abundance of collector-gatherers observed at the test site was not at levels typically thought to be indicative of degraded biological conditions. Consequently, though originally targeted as a potential biological endpoint of interest, it was excluded from evaluation in the stressor-response line of evidence. The other three biological endpoints (% tolerant taxa, % of non-insect taxa, and # of predator taxa) observed at the RD site were at levels typically associated with degraded conditions and were retained for the stressor-response evaluation. The correlation coefficients for the three biological endpoints and the different components of each candidate cause are presented in Table 6. The scores from these evaluations are presented in Table 7.

Table 6. Detailed correlation and scoring of within the case stressor-response data across the four biological endpoints for each proximate stressors and their candidate causes. Data are scored ++ for a strongly supporting response, + for a supporting response, 0 for ambivalent response, - for a weakening response, -- for a strongly weakening response, and NE for no evidence. bdl = below detection limit. Collector-gather abundance at RD was not at a level indicative of degradation, so the stressor-response relationships were not used in the assessment.

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Collector-Gatherer Abundance Rho	Score	Proximate Stressor Score	comment	% Non- Insect Taxa Rho	Score	Proximate Stressor Score	comment
Heavy Metals							Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment				
	Increase in Dissolved Metals					n/a				+	Support for Antimony, counter suport for Arsenic, Barium, Beryllium, and Mercury
		Mean of Previous Quarter (BDL = 1/2 MDL)									
			Antimony ($\mu g\ L^{-1}$)	-0.800				0.800	+		
			Arsenic ($\mu g\ L^{-1}$)	0.800				-0.800	-		
			Barium ($\mu g\ L^{-1}$)	bdl				bdl	--		
			Beryllium ($\mu g\ L^{-1}$)	bdl				bdl	--		
			Cadmium ($\mu g\ L^{-1}$)	0.738				-0.738	0		
			Chromium ($\mu g\ L^{-1}$)	0.738				-0.738	0		
			Copper ($\mu g\ L^{-1}$)	-0.400				0.400	0		
			Hexavalent Chromium ($mg\ L^{-1}$)	-0.258				0.258	0		
			Iron ($mg\ L^{-1}$)	0.258				-0.258	0		
			Lead ($\mu g\ L^{-1}$)	-0.400				0.400	0		
			Mercury ($\mu g\ L^{-1}$)	bdl				bdl	--		
			Nickel ($\mu g\ L^{-1}$)	0.400				-0.400	0		
			Selenium ($\mu g\ L^{-1}$)	0.800				-0.800	-		
			Silver ($\mu g\ L^{-1}$)	-0.258				0.258	0		
			Thallium ($\mu g\ L^{-1}$)								
			Zinc ($\mu g\ L^{-1}$)	-0.400				0.400	0		
	Increase in Particulate Bound Metals					NE				NE	
				No Data Available				No Data Available			
	Increase in Metals in Periphyton					NE				NE	
				No Data Available				No Data Available			
Elevated Conductivity							Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment				
	Increase in Conductivity					n/a				-	
		Mean of Previous Quarter									
			Conductivity mmhos cm^{-1}	0.800				-0.800	-		
	Increase in Total Dissolved Solids					n/a				-	
		Mean of Previous Quarter									
			TDS ($mg\ L^{-1}$)	0.800				-0.800	-		
			Chloride ($mg\ L^{-1}$)	-0.800				0.800	+		
			Hardness ($mg\ L^{-1}$)	0.800				-0.800	-		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Collector-Gatherer Abundance Rho	Score	Proximate Stressor Score	comment	% Non- Insect Taxa Rho	Score	Proximate Stressor Score	comment
River Discontinuity							Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment				
	Decrease in Recruitment			No Data Available				No Data Available			
	Decrease in Woody Debris										
		Length of Reach Where Present				n/a				0	
			Small (<0.3m length) Woody Debris (m)	0.265				-0.203	0		
			Large (>0.3m length) Woody Debris (m)	-0.109				0.000	0		
	Decrease in Cobbles					n/a				0	
		% of Reach Area Where Present									
			Cobbles (%)	0.175				-0.576	0		
	Increase in Sands and Fines					n/a				0	
		% of Reach Area Where Present									
			Sands and Fines (%)	0.690				-0.429	0		
	Burial of Cobbles					NE				NE	
		Mean % of Cobbles Embeddedness									
			Cobble Embeddedness (%)	0.342				-0.559	0		
	Increase in Simplified Habitat					n/a				0	
		nMDS Comparison of Sites Based on Habitat Types Present									
			Euclidean Distance from RD	0.714				-0.464	0		
Habitat Simplification							Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment				
	Change in Available Food					n/a				0	
		nMDS Comparison of Sites Based Upon Food Type Availability									
			Euclidean Distance from RD	0.464				-0.500	0		
	Increase in Channel Deepening					n/a				0	
			Mean Thalweg Depth (cm)	-0.619				0.738	0		
	Decrease in Riffles					NE				NE	
				No Data Available				No Data Available			
	Decrease in Woody Debris					n/a				0	
		Length of Reach Where Present									
			Small (<0.3m length) Woody Debris (m)	0.265				-0.203	0		
			Large (>0.3m length) Woody Debris (m)	-0.109				0.000	0		
	Decrease in Cobbles					n/a				0	
		% of Reach Area Where Present									
			Cobbles (%)	0.175				-0.576	0		
	Increase in Sands and Fines					n/a				0	
		% of Reach Area Where Present									
			Sands and Fines (%)	0.690				-0.429	0		
	Decrease in Undercut Banks					n/a				--	
		Length of Reach Where Present									
			Undercut banks (m)	0				0	--		
	Increase in Simplified Habitat					n/a				0	
		nMDS Comparison of Sites Based on Habitat Types Present									
			Euclidean Distance from RD	0.714				-0.464	0		

				% Collector-Gatherer Abundance				% Non- Insect Taxa			
Candidate Cause	Proximate Stressor	Measurement	Components (units)	Rho	Score	Proximate Stressor Score	comment	Rho	Score	Proximate Stressor Score	comment
Increased Nutrients							Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment				
	Change in Algal Community					n/a				0	
		nMDS Comparison of Sites Based on Diatom Communty Structure									
			Bray-Curtis Similarity to RD	0.214				-0.179	0		
	Increase in Algal Toxins					NE				NE	
	Increase in pH					n/a				0	based primarily on 24 hour data
		Mean of Previous Quarter									
			pH	1.000				-1.000	0		
		Mean of 24 Hours									
			pH	-0.357				-0.143	0		
	Increased Frequency of Hypoxia					n/a				0	based primarily on 24 hour data
		Count of Observations in Daytime Point Measures									
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0				0	--		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0				0	--		
		Count of Observations in Diel Measures (24hrs)									
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0.436				0.062	0		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0.577				-0.247	0		
	Increased Ammonia Concentrations					n/a				0	
		Mean of Previous Quarter									
			Ammonia (mg L^{-1})	0.027				0.464	0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Collector-Gatherer Abundance Rho	Score	Proximate Stressor Score	comment	% Non- Insect Taxa Rho	Score	Proximate Stressor Score	comment
Pesticides							Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment				
	Increased Sediment Non-pyrethroid Pesticides			No Data Available		NE		No Data Available		NE	
	Increased Water Column Non-pyrethroid Pesticides					n/a				--	
		Maximum Value of Previous Year									
			4,4'-DDD (mg L^{-1})	bdl				bdl	--		
			4,4'-DDE (µg L^{-1})	bdl				bdl	--		
			Acrolein (µg L^{-1})	bdl				bdl	--		
			Acrylonitrile (µg L^{-1})	bdl				bdl	--		
			Aldrin (µg L^{-1})	bdl				bdl	--		
			alpha-BHC (µg L^{-1})	bdl				bdl	--		
			cis-1,3-Dichloropropene (µg L^{-1})	bdl				bdl	--		
			delta-BHC (µg L^{-1})	bdl				bdl	--		
			Diazinon (µg L^{-1})	bdl				bdl	--		
			Dieldrin (µg L^{-1})	bdl				bdl	--		
			Endosulfan I (µg L^{-1})	bdl				bdl	--		
			Endosulfan II (µg L^{-1})	bdl				bdl	--		
			Endosulfan sulfate (µg L^{-1})	bdl				bdl	--		
			Endrin aldehyde (µg L^{-1})	bdl				bdl	--		
			Endrin (µg L^{-1})	bdl				bdl	--		
			Heptachlor Epoxide (Isomer B) (µg L^{-1})	bdl				bdl	--		
			Heptachlor (µg L^{-1})	bdl				bdl	--		
			Methoxychlor (µg L^{-1})	bdl				bdl	--		
			o,p'-DDD (µg L^{-1})	bdl				bdl	--		
			o,p'-DDE (µg L^{-1})	bdl				bdl	--		
			o,p'-DDT (µg L^{-1})	bdl				bdl	--		
			p,p'-DDT (µg L^{-1})	bdl				bdl	--		
			Technical Chlordane (µg L^{-1})	bdl				bdl	--		
			Toxaphene (µg L^{-1})	bdl				bdl	--		
		Detection of Any Compound Above Detection Limit									
			Frequency of Detection (# observed/# measured)	nd				nd	0		
	Increased Water Column Pyrethroid Pesticides			No Data Available		NE		No Data Available		NE	
	Increased Sediment Pyrethroid Pesticides			No Data Available		NE		No Data Available		NE	
	Increased Water Column Herbicides					n/a				--	
		Maximum Value of Previous Year									
			2,3,7,8-TCDD (pg L^{-1})	bdl				bdl	--		
			2,4,5-TP (Silvex) (µg L^{-1})	bdl				bdl	--		
			2,4'-D (µg L^{-1})	bdl				bdl	--		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Collector-Gatherer Abundance Rho	Score	Proximate Stressor Score	comment	% Non- Insect Taxa Rho	Score	Proximate Stressor Score	comment
Temperature											
	Increased Water Temperature					n/a	Collector-gatherers at RD were not at a level indicative of degradation and not used in the final assessment			+	
		Mean of Previous Quarter									
			Water Temperature (C)	-0.800				0.800	+		
		Mean of Diel Measurements (24hr)									
			Water Temperature (C)	-0.619				0.905	++		
	Decreased Variability in Water Temperature					n/a				0	
		Range of Previous Quarter									
			Water Temperature (C)	0.600				-0.600	0		
		Range of Diel Measurements (24hr)									
			Water Temperature (C)	0.310				-0.357	0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Tolerant Taxa Rho	Score	Proximate Stressor Score	comment	Predator Taxa Rho	Score	Proximate Stressor Score	comment
Heavy Metals											
	Increase in Dissolved Metals					+	Support for Chromium (VI) and Selenium, but counter support for Barium, Beryllium, Iron, and Mercury			+	Supporting evidence for Zinc, but weakening evidece for Beryllium, Mercury, Nickel, and Thallium
		Mean of Previous Quarter (BDL = 1/2 MDL)									
			Antimony (μg L^{-1})	0.200	0			0.400	0		
			Arsenic (μg L^{-1})	0.000	0			0.400	0		
			Barium (μg L^{-1})	bdl	--			0.400	0		
			Beryllium (μg L^{-1})	bdl	--				--		
			Cadmium (μg L^{-1})	-0.211	0			0.316	0		
			Chromium (μg L^{-1})	-0.632	0			-0.105	0		
			Copper (μg L^{-1})	-0.400	0			0.000	0		
			Hexavalent Chromium (mg L^{-1})	0.775	+			0.258	0		
			Iron (mg L^{-1})	-0.775	-			-0.258	0		
			Lead (μg L^{-1})	-0.400	0			0.000	0		
			Mercury (μg L^{-1})	bdl	--				--		
			Nickel (μg L^{-1})	0.600	0			0.800	-		
			Selenium (μg L^{-1})	0.000	0			0.400	0		
			Silver (μg L^{-1})	0.775	+			0.258	0		
			Thallium (μg L^{-1})						--		
			Zinc (μg L^{-1})	-0.600	0			-0.800	+		
	Increase in Particulate Bound Metals					NE				NE	
				No Data Available				No Data Available			
	Increase in Metals in Periphyton					NE				NE	
				No Data Available				No Data Available			
Elevated Conductivity											
	Increase in Conductivity					0				0	
		Mean of Previous Quarter									
			Conductivity mmhos cm^{-1}	0.000	0			0.400	0		
	Increase in Total Dissolved Solids					0				0	
		Mean of Previous Quarter									
			TDS (mg L^{-1})	0.000	0			0.400	0		
			Chloride (mg L^{-1})	0.800	+			0.400	0		
			Hardness (mg L^{-1})	0.000	0			0.400	0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Tolerant Taxa Rho	% Tolerant Taxa Score	% Tolerant Taxa Proximate Stressor Score	% Tolerant Taxa comment	Predator Taxa Rho	Predator Taxa Score	Predator Taxa Proximate Stressor Score	Predator Taxa comment
River Discontinuity											
	Decrease in Recruitment					NE				NE	
				No Data Available				No Data Available			
	Decrease in Woody Debris									0	
		Length of Reach Where Present				0					
			Small (<0.3m length) Woody Debris (m)	0.016	0			0.254	0		
			Large (>0.3m length) Woody Debris (m)	0.000	0			0.000	0		
	Decrease in Cobbles					0				0	
		% of Reach Area Where Present									
			Cobbles (%)	-0.300	0			-0.127	0		
	Increase in Sands and Fines					0				0	
		% of Reach Area Where Present									
			Sands and Fines (%)	-0.310	0			-0.376	0		
	Burial of Cobbles					NE				0	
		Mean % of Cobbles Embeddedness									
			Cobble Embeddedness (%)	-0.667	0			-0.257	0		
	Increase in Simplified Habitat					0				0	
		nMDS Comparison of Sites Based on Habitat Types Present									
			Euclidean Distance from RD	-0.571	0			-0.673	0		
Habitat Simplification											
	Change in Available Food					0				0	
		nMDS Comparison of Sites Based Upon Food Type Availability									
			Euclidean Distance from RD	-0.536	0			-0.327	0		
	Increase in Channel Deepening					0				0	
			Mean Thalweg Depth (cm)	0.333	0			0.279	0		
	Decrease in Riffles					NE					
				No Data Available				No Data Available			
	Decrease in Woody Debris					0				0	
		Length of Reach Where Present									
			Small (<0.3m length) Woody Debris (m)	0.016	0			0.254	0		
			Large (>0.3m length) Woody Debris (m)	0.000	0			0.000	0		
	Decrease in Cobbles					0				0	
		% of Reach Area Where Present									
			Cobbles (%)	-0.300	0			-0.127	0		
	Increase in Sands and Fines					0				0	
		% of Reach Area Where Present									
			Sands and Fines (%)	-0.310	0			-0.376	0		
	Decrease in Undercut Banks					--				--	
		Length of Reach Where Present									
			Undercut banks (m)	0	--				--		
	Increase in Simplified Habitat					0				0	
		nMDS Comparison of Sites Based on Habitat Types Present									
			Euclidean Distance from RD	-0.571	0			-0.673	0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Tolerant Taxa				Predator Taxa			
				Rho	Score	Proximate Stressor Score	comment	Rho	Score	Proximate Stressor Score	comment
Increased Nutrients											
	Change in Algal Community					0				0	
		nMDS Comparison of Sites Based on Diatom Communty Structure									
			Bray-Curtis Similarity to RD	0.107	0			0.218	0		
	Increase in Algal Toxins					NE				NE	
	Increase in pH					0	based primarily on 24 hour data			0	
		Mean of Previous Quarter									
			pH	-1.000	0			1.000	NE		
		Mean of 24 Hours									
			pH	-0.107	0			0.164	0		
	Increased Frequency of Hypoxia					0	based primarily on 24 hour data			0	based primarily on 24 hour data
		Count of Observations in Daytime Point Measures									
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0	0				--		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0	0				--		
		Count of Observations in Diel Measures (24hrs)									
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	-0.436	0			-0.540	0		
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	-0.577	0			-0.504	0		
	Increased Ammonia Concentrations					0				0	
		Mean of Previous Quarter									
			Ammonia (mg L^{-1})	-0.027	0			-0.222	0		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Tolerant Taxa Rho	% Tolerant Taxa Score	% Tolerant Taxa Proximate Stressor Score	% Tolerant Taxa comment	Predator Taxa Rho	Predator Taxa Score	Predator Taxa Proximate Stressor Score	Predator Taxa comment
Pesticides											
	Increased Sediment Non-pyrethroid Pesticides					NE				NE	
				No Data Available				No Data Available			
	Increased Water Column Non-pyrethroid Pesticides					--				--	
		Maximum Value of Previous Year									
			4,4'-DDD (mg L^{-1})	bdl	--				--		
			4,4'-DDE (μg L^{-1})	bdl	--				--		
			Acrolein (μg L^{-1})	bdl	--				--		
			Acrylonitrile (μg L^{-1})	bdl	--				--		
			Aldrin (μg L^{-1})	bdl	--				--		
			alpha-BHC (μg L^{-1})	bdl	--				--		
			cis-1,3-Dichloropropene (μg L^{-1})	bdl	--				--		
			delta-BHC (μg L^{-1})	bdl	--				--		
			Diazinon (μg L^{-1})	bdl	--				--		
			Dieldrin (μg L^{-1})	bdl	--				--		
			Endosulfan I (μg L^{-1})	bdl	--				--		
			Endosulfan II (μg L^{-1})	bdl	--				--		
			Endosulfan sulfate (μg L^{-1})	bdl	--				--		
			Endrin aldehyde (μg L^{-1})	bdl	--				--		
			Endrin (μg L^{-1})	bdl	--				--		
			Heptachlor Epoxide (Isomer B) (μg L^{-1})	bdl	--				--		
			Heptachlor (μg L^{-1})	bdl	--				--		
			Methoxychlor (μg L^{-1})	bdl	--				--		
			o,p'-DDD (μg L^{-1})	bdl	--				--		
			o,p'-DDE (μg L^{-1})	bdl	--				--		
			o,p'-DDT (μg L^{-1})	bdl	--				--		
			p,p'-DDT (μg L^{-1})	bdl	--				--		
			Technical Chlordane (μg L^{-1})	bdl	--				--		
			Toxaphene (μg L^{-1})	bdl	--				--		
		Detection of Any Compound Above Detection Limit									
			Frequency of Detection (# observed/# measured)	nd	0				--		
	Increased Water Column Pyrethroid Pesticides					NE				NE	
				No Data Available				No Data Available			
	Increased Sediment Pyrethroid Pesticides					NE				NE	
				No Data Available				No Data Available			
	Increased Water Column Herbicides					--				--	
		Maximum Value of Previous Year									
			2,3,7,8-TCDD (pg L^{-1})	bdl	--				--		
			2,4,5-TP (Silvex) (μg L^{-1})	bdl	--				--		
			2,4'-D (μg L^{-1})	bdl	--				--		

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Tolerant Taxa Rho	% Tolerant Taxa Score	% Tolerant Taxa Proximate Stressor Score	% Tolerant Taxa comment	Predator Taxa Rho	Predator Taxa Score	Predator Taxa Proximate Stressor Score	Predator Taxa comment
Temperature											
	Increased Water Temperature					0				0	
		Mean of Previous Quarter									
			Water Temperature (C)	0.000	0			-0.400	0		
		Mean of Diel Measurements (24hr)									
			Water Temperature (C)	0.405	0			0.339	0		
	Decreased Variability in Water Temperature					0				0	
		Range of Previous Quarter									
			Water Temperature (C)	-0.400	0			0.200	0		
		Range of Diel Measurements (24hr)									
			Water Temperature (C)	-0.524	0			-0.315	0		

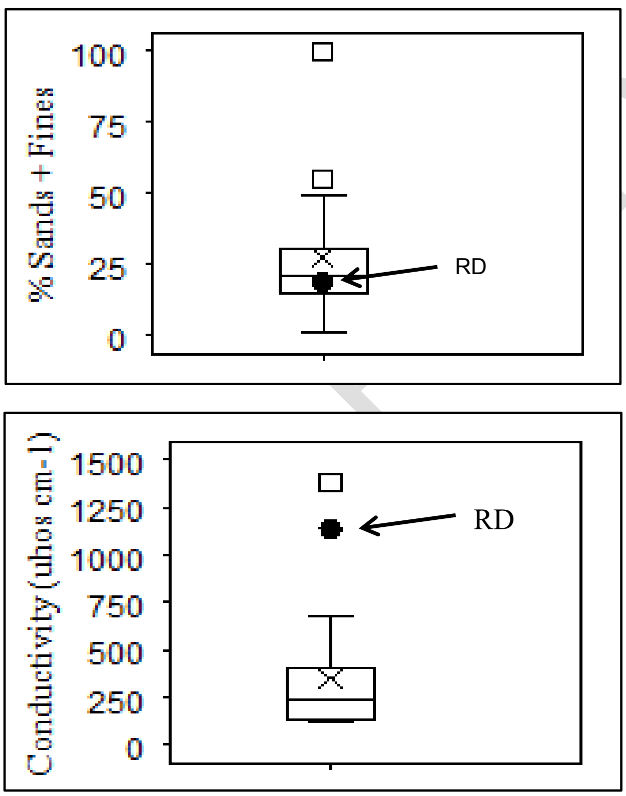
Table 7. Summary within the case stressor-response scores across the three biological endpoints for each proximate stressor in the candidate causes.

Candidate Cause / Conceptual Model	Proximate Stressor	% Non- Insect Taxa		% Tolerant Taxa		Predator Taxa	
		Proximate Stressor Score	Comment	Proximate Stressor Score	Comment	Proximate Stressor Score	Comment
Heavy Metals							
	Increase in Dissolved Metals	+	Supporting evidence for Antimony, counter suport for Arsenic, Barium, Beryllium, and Mercury	+	Supporting evidence for Chromium (VI) and Selenium, but counter support for Barium, Beryllium, Iron, and Mercury	+	Supporting evidence for Zinc, but weakening evidece for Beryllium, Mercury, Nickel, and Thallium
	Increase in Particulate Bound Metals	NE		NE		NE	
	Increase in Metals in Periphyton	NE		NE		NE	
Elevated Conductivity							
	Increase in Conductivity	-		0		0	
	Increase in Total Dissolved Solids	-		0			
River Discontinuity							
	Decrease in Recruitment	NE		NE		NE	
	Decrease in Woody Debris	0		0		0	
	Decrease in Cobbles	0		0		0	
	Increase in Sands and Fines	0		0		0	
	Burial of Cobbles	NE		NE		0	
	Increase in Simplified Habitat	0		0		0	
Habitat Simplification							
	Change in Available Food	0		0		0	
	Increase in Channel Deepening	0		0		0	
	Decrease in Riffles	NE		NE		NE	
	Decrease in Woody Debris	0		0		0	
	Decrease in Cobbles	0		0		0	
	Increase in Sands and Fines	0		0		0	
	Decrease in Undercut Banks	--		--		--	
	Increase in Simplified Habitat	0		0		0	
Increased Nutrients							
	Change in Algal Community	0		0		0	
	Increase in Algal Toxins	NE		NE		NE	
	Increase in pH	0	based primarily on 24 hour data	0	based primarily on 24 hour data	0	based primarily on 24 hour data
	Increased Frequency of Hypoxia	-	based primarily on 24 hour data	-	based primarily on 24 hour data	0	based primarily on 24 hour data
	Increased Ammonia Concentrations	0		0		0	
Pesticides							
	Increased Sediment Non-pyrethroid Pesticides	NE		NE		NE	
	Increased Water Column Non-pyrethroid Pesticides	--		--		--	
	Increased Water Column Pyrethroid Pesticides	NE		NE		NE	
	Increased Sediment Pyrethroid Pesticides	NE		NE		NE	
	Increased Water Column Herbicides	--		--		--	
Temperature							
	Increased Water Temperature	+		0		0	
	Decreased Variability in Water Temperature	0		0		0	

Data Analysis from Outside the Case

Reference Condition Comparison

The idea of this line of evidence was to provide context for the level of a given proximate stressor at the test site and to determine how different the observed value was from that seen in geographically similar reference sites. This comparison was made by characterizing the distribution of the proximate stressor values in the pool of reference sites, calculating the median, upper quartile, lower quartile, upper fence values (the upper quartile + 1.75X the interquartile range), and lower fence values. These types of data can be plotted in a schematic box and whisker plot (Tukey 1977) overlaid with the RD value for ease of display and interpretation (Figure 11). Reference sites from the large bioassessment database available in California. (see Ode et al in prep for reference definition) were selected as similar based upon slope (<1.5%) and elevation (<333 m). Data from the RD site were scored as follows (assuming a negative stressor): if the RD value was less than the upper quartile, then score = -; if the RD value was between the upper quartile and the upper fence, then score = 0; and if the RD value was greater than the upper fence, then score = +. If the proximate stressor was the loss of a positive variable, then the same rules would apply, but with reference to the lower quartile and fence values.



a

b

Figure 11. Examples of reference condition comparisons for outside of the case portions of the assessment. The box plot describes the reference site distribution of conductivity (a), and % Sands + Fines (b). The components of the plot are the solid line representing the median, the span of the box illustrating the upper and lower quartile, the whiskers are 1.75X the interquartile range, the cross representing the mean, and the hollow squares show outlier values. The dark circle overlaid represents the observed value at the test site.

Not every bioassessment program has collected the same data and after filtering from the larger pool of sites the only variables where there was enough data coverage were conductivity and % sands&fines,. Within the elevated conductivity candidate cause, the monthly mean conductivity value at RD from the previous quarter (1207 µmhos cm^{-1}) was well above the upper fence value (683 µmhos cm^{-1}), scoring the proximate stressor +. Consequently, the overall candidate cause score for elevated conductivity was also scored +. Data were available to evaluate % sands&fines, which was part of both the river discontinuity and habitat simplification candidate causes. The observed % sands&fines (19.1) at RD was between the 1st and 3rd quartile value of the reference sites (15.2 – 30.5), was scored -. As % sands&fines were the only proximate stressor that could be evaluated in either candidate cause, both river discontinuity and habitat simplification were scored - as well.

Stressor-Response from Other Field Studies

A relative risk approach (Van Sickle et al. 2006, Agresti 2007) was used to characterize and provide context to the observed relationships between the different biological endpoints and different proximate stressors at RD. These analyses were designed to assess whether the degraded biological condition captured in each biological endpoint could be the result of the observed level of the proximate stressor based upon patterns seen in other, environmentally similar sites within the State of California. Like the reference condition comparisons, sites were selected based upon slope (<1.5%) and elevation (<333 m) from the large bioassessment database available in California. An important difference however, was that both reference and non-reference sites (540 samples from 515 sites) were selected to span the range of potential biological and stressor conditions.

For these analyses, semi-continuous relative risk values were calculated for all proximate stressors where enough data were available. The relative risk of observing degraded biology with 95% confidence intervals was calculated at 50+ increments of the proximate stressors observed across the environmentally similar sites from the state's biomonitoring database. Proximate stressor data from the RD site were scored based upon the risk (+/- the 95% confidence interval) of the observed level of the stressor causing the degraded biological conditions (Figure 12). If the observed biological endpoint was not at impaired levels (a SoCal IBI metric score of 4 in this case), the line of evidence was scored "--" regardless of the level of stressor observed. If impaired biology was observed and the relative risk +/- CI was less than 1, then the data would be scored as -. If impaired biology was observed and relative risk +/- CI was greater than 1.2, then the data would be scored as +. If impaired biology was observed and the relative risk +/- CI was between 1 or 1.2 then the data would be scored 0.

Data for calculation of relative risks were not available for any of the proximate stressors associated with the increased nutrients, pesticides, or temperature candidate causes (consequently scored NE). Values of the different proximate stressors observed at RD and the relative risk associated with that value to each of the four biological endpoints are presented in Table 8. A summary of all the scores for each proximate stressor are presented in Table 9.

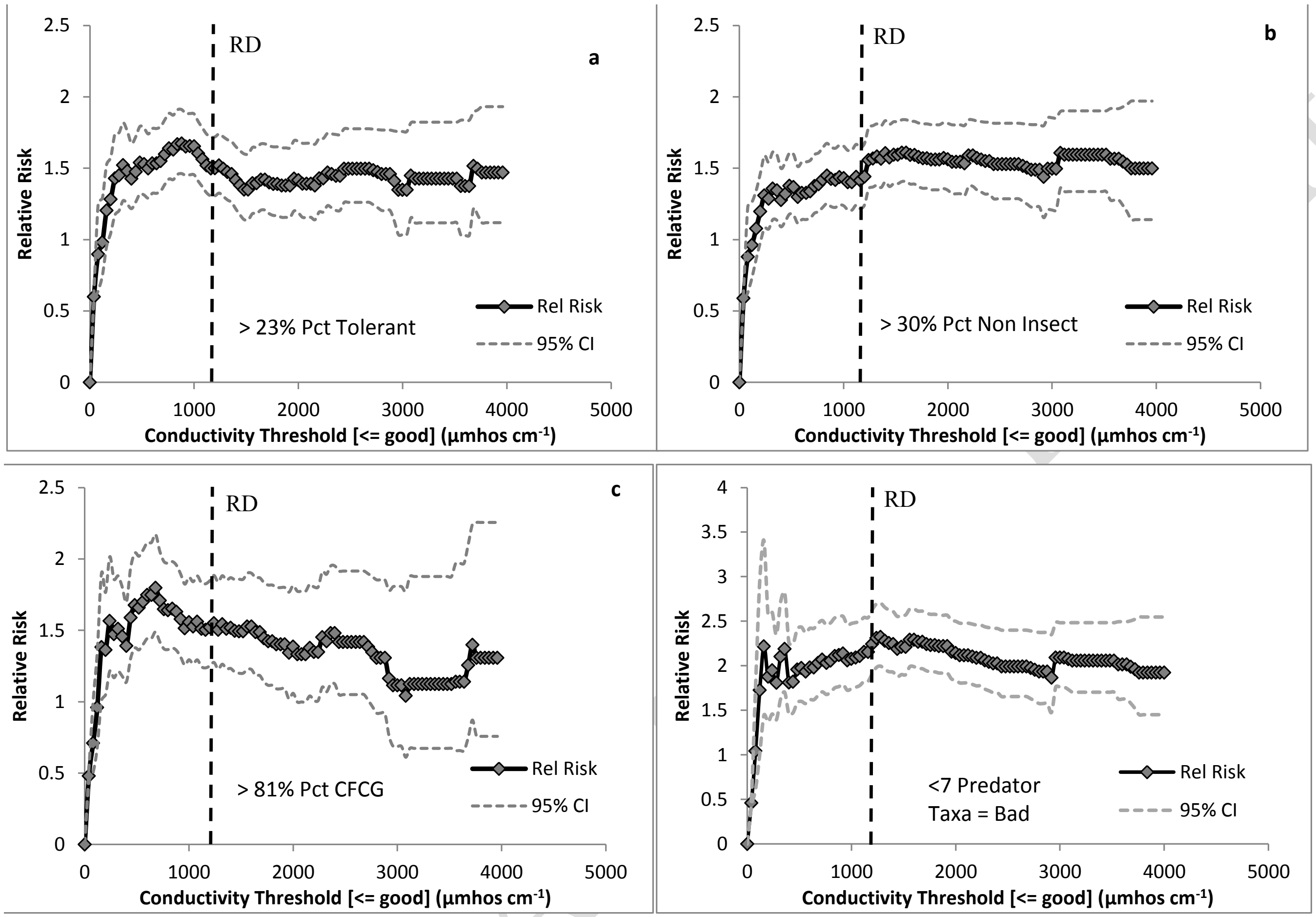


Figure 12. Examples of continuous relative risk plots using conductivity as the stressor and % tolerant taxa (a), % non-insect taxa (b), % abundance of collector-gatherers (c) and number of predator taxa (d) as biological endpoints. The solid dark line with grey diamonds represent the relative risk of observing biological impact at each respective value of the stressor, the dashed line represents the 95% confidence interval in that relative risk estimate, and the vertical dashed line represents the observed level of the stressor at the test site. Each panel describes the level of each biological endpoint above which was considered indicative of impaired conditions.

Table 8. Detailed scoring sheet for the outside of the case stressor-response from other field studies across each of the four biological endpoints for each proximate stressors and the components therein. For those components where they could be calculated, relative risk (Rel Risk) and 95% confidence intervals (UCI and LCI) are provided. Collector-gather abundance at RD was not at a level indicative of degradation, so this line of evidence was scored "--".

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Non Insect Taxa				Proximate Stressor Score	Comment	% Tolerant Taxa				Proximate Stressor Score
					Rel Risk	LCI	UCI	Score			Rel Risk	LCI	UCI	Score	
Heavy Metals															
	Increase in Dissolved Metals								0	Only evaluated Copper, Lead, and Zinc					0
		Mean of Previous Quarter (BDL = 1/2 MDL)													
			Antimony (µg L^{-1})	0.63											
			Arsenic (µg L^{-1})	0.82											
			Barium (µg L^{-1})	41.70											
			Beryllium (µg L^{-1})	0.13											
			Cadmium (µg L^{-1})	0.09											
			Chromium (µg L^{-1})	0.23											
			Copper (µg L^{-1})	3.42	1.00	0.73	1.38	0			0.94	0.75	1.19	0	
			Hexavalent Chromium (mg L^{-1})	0.01											
			Iron (mg L^{-1})	0.10											
			Lead (µg L^{-1})	0.10	1.40	0.48	4.04	0			1.07	0.56	2.03	0	
			Mercury (µg L^{-1})	0.02											
			Nickel (µg L^{-1})	6.86											
			Selenium (µg L^{-1})	1.33											
			Silver (µg L^{-1})	0.13											
			Thallium (µg L^{-1})	0.13											
			Zinc (µg L^{-1})	27.97	1.08	0.72	1.61	0			0.94	0.65	1.37	0	
	Increase in Particulate Bound Metals			No Data Available					NE						NE
	Increase in Metals in Periphyton			No Data Available					NE						NE
Elevated Conductivity															
	Increase in Conductivity								+						+
		Mean of Previous Quarter													
			Conductivity mmhos cm^{-1}	1233.88	1.44	1.24	1.67	+			1.50	1.31	1.72	+	
	Increase in Total Dissolved Solids								NE						NE
		Mean of Previous Quarter													
			TDS (mg L^{-1})	788											
			Chloride (mg L^{-1})	128.5											
			Hardness (mg L^{-1})	350											

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Non Insect Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment	% Tolerant Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score
River Discontinuity															
	Decrease in Recruitment								NE						NE
				No Data Available											
	Decrease in Woody Debris								0						0
		Length of Reach Where Present													
			Length w/ Small + Large Woody Debris	5.45	0.71	0.48	1.05	0			0.86	0.62	1.19	0	
	Decrease in Cobbles								NE						NE
		% of Reach Area Where Present													
			Cobbles (%)	0.0											
	Increase in Sands and Fines								+						+
		% of Reach Area Where Present													
			Sands and Fines (%)	19.1	1.86	1.39	2.50	+			1.68	1.28	2.20	+	
	Burial of Cobbles								NE						NE
		Mean % of Cobbles Embeddedness													
			Cobble Embeddedness (%)	0											
	Increase in Simplified Habitat								NE						NE
		nMDS Comparison of Sites Based on Habitat Types Present													
			Euclidean Distance from RD												
Habitat Simplification															
	Change in Available Food								NE						NE
		nMDS Comparison of Sites Based Upon Food Type Availability													
			Euclidean Distance from RD												
	Increase in Channel Deepening								0						0
			Mean Thalweg Depth (cm)	26.5	1.35	0.98	1.86	0			1.03	0.77	1.37	0	
	Decrease in Riffles								NE						
				No Data Available											
	Decrease in Woody Debris								0						0
		Length of Reach Where Present													
			Length w/ Small + Large Woody Debris	5.5	0.71	0.48	1.05	0			0.86	0.62	1.19	0	
	Decrease in Cobbles								0						
		% of Reach Area Where Present													
			Cobbles (%)	0.0											
	Increase in Sands and Fines								+						+
		% of Reach Area Where Present													
			Sands and Fines (%)	19.1	1.86	1.39	2.50	+			1.68	1.28	2.20	+	
	Decrease in Undercut Banks								-						0
		Length of Reach Where Present													
			Undercut banks (m)	5	0.65	0.49	0.87	-			0.82	0.59	1.13	0	
	Increase in Simplified Habitat								NE						NE
		nMDS Comparison of Sites Based on Habitat Types Present													
			Euclidean Distance from RD												

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Non Insect Taxa				Proximate Stressor Score	Comment	% Tolerant Taxa				Proximate Stressor Score
					Rel Risk	LCI	UCI	Score			Rel Risk	LCI	UCI	Score	
Increased Nutrients															
	Change in Algal Community								NE						NE
		nMDS Comparison of Sites Based on Diatom Communty Structure													
			Bray-Curtis Similarity to RD												
	Increase in Algal Toxins								NE						NE
				No Data Available											
	Increase in pH								NE						NE
		Mean of Previous Quarter													
			pH	No Data Available											
		Mean of 24 Hours													
			pH	7.77											
	Increased Frequency of Hypoxia								NE						NE
		Count of Observations in Daytime Point Measures													
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0											
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0											
		Count of Observations in Diel Measures (24hrs)													
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0											
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0											
	Increased Ammonia Concentrations								NE						NE
		Mean of Previous Quarter													
			Ammonia (mg L^{-1})	0.34											

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Non Insect Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment	% Tolerant Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score
Pesticides															
	Increased Sediment Non-pyrethroid Pesticides								NE						NE
				No Data Available											
	Increased Water Column Non-pyrethroid Pesticides								NE						NE
		Maximum Value of Previous Year													
			4,4'-DDD (mg L^{-1})	bdl											
			4,4'-DDE (µg L^{-1})	bdl											
			Acrolein (µg L^{-1})	bdl											
			Acrylonitrile (µg L^{-1})	bdl											
			Aldrin (µg L^{-1})	bdl											
			alpha-BHC (µg L^{-1})	bdl											
			cis-1,3-Dichloropropene (µg L^{-1})	bdl											
			delta-BHC (µg L^{-1})	bdl											
			Diazinon (µg L^{-1})	bdl											
			Dieldrin (µg L^{-1})	bdl											
			Endosulfan I (µg L^{-1})	bdl											
			Endosulfan II (µg L^{-1})	bdl											
			Endosulfan sulfate (µg L^{-1})	bdl											
			Endrin aldehyde (µg L^{-1})	bdl											
			Endrin (µg L^{-1})	bdl											
			Heptachlor Epoxide (Isomer B) (µg L^{-1})	bdl											
			Heptachlor (µg L^{-1})	bdl											
			Methoxychlor (µg L^{-1})	bdl											
			o,p'-DDD (µg L^{-1})	bdl											
			o,p'-DDE (µg L^{-1})	bdl											
			o,p'-DDT (µg L^{-1})	bdl											
			p,p'-DDT (µg L^{-1})	bdl											
			Technical Chlordane (µg L^{-1})	bdl											
			Toxaphene (µg L^{-1})	bdl											
		Detection of Any Compound Above Detection Limit													
			Frequency of Detection (# observed/# measured)	0											
	Increased Water Column Pyrethroid Pesticides								NE						NE
				No Data Available											
	Increased Sediment Pyrethroid Pesticides								NE						NE
				No Data Available											
	Increased Water Column Herbicides								NE						NE
		Maximum Value of Previous Year													
			2,3,7,8-TCDD (pg L^{-1})	bdl											
			2,4,5-TP (Silvex) (µg L^{-1})	bdl											
			2,4'-D (µg L^{-1})	bdl											

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Non Insect Taxa				Proximate Stressor Score	Comment	% Tolerant Taxa				Proximate Stressor Score
					Rel Risk	LCI	UCI	Score			Rel Risk	LCI	UCI	Score	
Temperature															
	Increased Water Temperature								NE						NE
		Mean of Previous Quarter													
			Water Temperature (C)	26.39											
		Mean of Diel Measurements (24hr)													
			Water Temperature (C)	24.6											
	Decreased Variability in Water Temperature								NE						NE
		Range of Previous Quarter													
			Water Temperature (C)	9.06											
		Range of Diel Measurements (24hr)													
			Water Temperature (C)	3.27											

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Collector-Gatherer Individuals				Proximate Stressor Score	Comment	# of Predator Taxa				Proximate Stressor Score	Comment
					Rel Risk	LCI	UCI	Score			Rel Risk	LCI	UCI	Score		
Heavy Metals																
	Increase in Dissolved Metals								--	Only evaluated Copper, Lead, and Zinc					0	Only evaluated Copper and Zinc
		Mean of Previous Quarter (BDL = 1/2 MDL)														
			Antimony (µg L^{-1})	0.63												
			Arsenic (µg L^{-1})	0.82												
			Barium (µg L^{-1})	41.70												
			Beryllium (µg L^{-1})	0.13												
			Cadmium (µg L^{-1})	0.09												
			Chromium (µg L^{-1})	0.23												
			Copper (µg L^{-1})	3.42	0.98	0.77	1.26	--			1.09	0.97	1.22	0		
			Hexavalent Chromium (mg L^{-1})	0.01												
			Iron (mg L^{-1})	0.10												
			Lead (µg L^{-1})	0.10	1.20	0.66	2.19	--								
			Mercury (µg L^{-1})	0.02												
			Nickel (µg L^{-1})	6.86												
			Selenium (µg L^{-1})	1.33												
			Silver (µg L^{-1})	0.13												
			Thallium (µg L^{-1})	0.13												
			Zinc (µg L^{-1})	27.97	0.97	0.66	1.43	--			1.09	0.99	1.21	0		
	Increase in Particulate Bound Metals			No Data Available					NE						NE	
	Increase in Metals in Periphyton			No Data Available					NE						NE	
Elevated Conductivity																
	Increase in Conductivity								--						+	
		Mean of Previous Quarter														
			Conductivity mmhos cm^{-1}	1233.9	1.52	1.25	1.85	--			2.24	1.91	2.63	+		
	Increase in Total Dissolved Solids								NE							
		Mean of Previous Quarter														
			TDS (mg L^{-1})	788												
			Chloride (mg L^{-1})	128.5												
			Hardness (mg L^{-1})	350												

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Collector-Gatherer Individuals				Proximate Stressor Score	Comment	# of Predator Taxa				Proximate Stressor Score	Comment
					Rel Risk	LCI	UCI	Score			Rel Risk	LCI	UCI	Score		
River Discontinuity																
	Decrease in Recruitment								NE						NE	
				No Data Available												
	Decrease in Woody Debris								0						0	
		Length of Reach Where Present														
			Length w/ Small + Large Woody Debris	5.45	1.19	0.75	1.87	--			1.23	0.78	1.93	0		
	Decrease in Cobbles								NE						NE	
		% of Reach Area Where Present														
			Cobbles (%)	0.0												
	Increase in Sands and Fines								0						0	
		% of Reach Area Where Present														
			Sands and Fines (%)	19.1	1.30	0.98	1.73	--			1.00	0.77	1.28	0		
	Burial of Cobbles								NE						NE	
		Mean % of Cobbles Embeddedness														
			Cobble Embeddedness (%)	0												
	Increase in Simplified Habitat								NE						NE	
		nMDS Comparison of Sites Based on Habitat Types Present														
			Euclidean Distance from RD													
Habitat Simplification																
	Change in Available Food								NE						NE	
		nMDS Comparison of Sites Based Upon Food Type Availability														
			Euclidean Distance from RD													
	Increase in Channel Deepening								-						0	
			Mean Thalweg Depth (cm)	26.5	0.66	0.46	0.95	-			0.90	0.61	1.32	0		
	Decrease in Riffles								NE						NE	
				No Data Available												
	Decrease in Woody Debris								NE						0	
		Length of Reach Where Present														
			Length w/ Small + Large Woody Debris	5.5	1.19	0.75	1.87	--			1.23	0.78	1.93	0		
	Decrease in Cobbles								NE						NE	
		% of Reach Area Where Present														
			Cobbles (%)	0.0												
	Increase in Sands and Fines								--						0	
		% of Reach Area Where Present														
			Sands and Fines (%)	19.1	1.30	0.98	1.73	--			1.00	0.77	1.28	0		
	Decrease in Undercut Banks								--						-	
		Length of Reach Where Present														
			Undercut banks (m)	5	0.46	0.32	0.67	--			0.56	0.38	0.81	-		
	Increase in Simplified Habitat								NE							
		nMDS Comparison of Sites Based on Habitat Types Present														
			Euclidean Distance from RD													

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Collector-Gatherer Individuals Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment	# of Predator Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment
Increased Nutrients																
	Change in Algal Community								NE						NE	
		nMDS Comparison of Sites Based on Diatom Communty Structure														
			Bray-Curtis Similarity to RD													
	Increase in Algal Toxins								NE						NE	
				No Data Available												
	Increase in pH								NE						NE	
		Mean of Previous Quarter														
			pH	No Data Available												
		Mean of 24 Hours														
			pH	7.77												
	Increased Frequency of Hypoxia								NE						NE	
		Count of Observations in Daytime Point Measures														
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0												
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0												
		Count of Observations in Diel Measures (24hrs)														
			Mild Hypoxia (2-5 mg L^{-1} Dissolved Oxygen)	0												
			Hypoxia (<2.0 mg L^{-1} Dissolved Oxygen)	0												
	Increased Ammonia Concentrations								NE						NE	
		Mean of Previous Quarter														
			Ammonia (mg L^{-1})	0.34												

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Collector-Gatherer Individuals Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment	# of Predator Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment
Pesticides																
	Increased Sediment Non-pyrethroid Pesticides								NE						NE	
				No Data Available												
	Increased Water Column Non-pyrethroid Pesticides								NE						NE	
		Maximum Value of Previous Year														
			4,4'-DDD (mg L^{-1})	bdl												
			4,4'-DDE (μg L^{-1})	bdl												
			Acrolein (μg L^{-1})	bdl												
			Acrylonitrile (μg L^{-1})	bdl												
			Aldrin (μg L^{-1})	bdl												
			alpha-BHC (μg L^{-1})	bdl												
			cis-1,3-Dichloropropene (μg L^{-1})	bdl												
			delta-BHC (μg L^{-1})	bdl												
			Diazinon (μg L^{-1})	bdl												
			Dieldrin (μg L^{-1})	bdl												
			Endosulfan I (μg L^{-1})	bdl												
			Endosulfan II (μg L^{-1})	bdl												
			Endosulfan sulfate (μg L^{-1})	bdl												
			Endrin aldehyde (μg L^{-1})	bdl												
			Endrin (μg L^{-1})	bdl												
			Heptachlor Epoxide (Isomer B) (μg L^{-1})	bdl												
			Heptachlor (μg L^{-1})	bdl												
			Methoxychlor (μg L^{-1})	bdl												
			o,p'-DDD (μg L^{-1})	bdl												
			o,p'-DDE (μg L^{-1})	bdl												
			o,p'-DDT (μg L^{-1})	bdl												
			p,p'-DDT (μg L^{-1})	bdl												
			Technical Chlordane (μg L^{-1})	bdl												
			Toxaphene (μg L^{-1})	bdl												
		Detection of Any Compound Above Detection Limit														
			Frequency of Detection (# observed/# measured)	0												
	Increased Water Column Pyrethroid Pesticides								NE						NE	
				No Data Available												
	Increased Sediment Pyrethroid Pesticides								NE						NE	
				No Data Available												
	Increased Water Column Herbicides								NE						NE	
		Maximum Value of Previous Year														
			2,3,7,8-TCDD (pg L^{-1})	bdl												
			2,4,5-TP (Silvex) (μg L^{-1})	bdl												
			2,4'-D (μg L^{-1})	bdl												

Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	% Collector-Gatherer Individuals Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment	# of Predator Taxa Rel Risk	LCI	UCI	Score	Proximate Stressor Score	Comment
Temperature																
	Increased Water Temperature								NE						NE	
		Mean of Previous Quarter														
			Water Temperature (C)	26.39												
		Mean of Diel Measurements (24hr)														
			Water Temperature (C)	24.6												
	Decreased Variability in Water Temperature								NE						NE	
		Range of Previous Quarter														
			Water Temperature (C)	9.06												
		Range of Diel Measurements (24hr)														
			Water Temperature (C)	3.27												

Table 9. Summary of scores for outside the case stressor-response from other field studies across the four biological endpoints for each proximate stressor in the candidate causes. Data are scored + for supporting evidence, - for weakening evidence, 0 for indeterminate evidence, -- if the biological endpoint is not below the degradation threshold, or NE for no evidence.

Candidate Cause	Proximate Stressor	% Non Insect Taxa		% Tolerant Taxa		% CFCG Individuals		Number of Predator Taxa	
		Proximate Stressor Score	Comment	Proximate Stressor Score	Comment	Proximate Stressor Score	Comment	Proximate Stressor Score	Comment
Heavy Metals									
	Increase in Dissolved Metals	0	Only evaluated Copper, Lead, and Zinc	0	Only evaluated Copper, Lead, and Zinc	--	Only evaluated Copper, Lead, and Zinc	0	Only evaluated Copper and Zinc
	Increase in Particulate Bound Metals	NE		NE		NE		NE	
	Increase in Metals in Periphyton	NE		NE		NE		NE	
Elevated Conductivity									
	Increase in Conductivity	+		+		--		+	
	Increase in Total Dissolved Solids	NE		NE		NE		NE	
River Discontinuity									
	Decrease in Recruitment	NE		NE		NE		NE	
	Decrease in Woody Debris	0		0		--		0	
	Decrease in Cobbles	NE		NE		NE		NE	
	Increase in Sands and Fines	+		+		--		0	
	Burial of Cobbles	NE		NE		NE		NE	
	Increase in Simplified Habitat	NE		NE		NE		NE	
Habitat Simplification									
	Change in Available Food	NE		NE		NE		NE	
	Increase in Channel Deepening	0		0		--		0	
	Decrease in Riffles	NE		NE		NE		NE	
	Decrease in Woody Debris	0		0		--		0	
	Decrease in Cobbles	NE		NE		NE		NE	
	Increase in Sands and Fines	+		+		--		0	
	Decrease in Undercut Banks	-		0		--		-	
	Increase in Simplified Habitat	NE		NE		NE		NE	
Increased Nutrients									
	Change in Algal Community	NE		NE		NE		NE	
	Increase in Algal Toxins	NE		NE		NE		NE	
	Increase in pH	NE		NE		NE		NE	
	Increased Frequency of Hypoxia	NE		NE		NE		NE	
	Increased Ammonia Concentrations	NE		NE		NE		NE	
Pesticides									
	Increased Sediment Non-pyrethroid Pesticides	NE		NE		NE		NE	
	Increased Water Column Non-pyrethroid Pesticides	NE		NE		NE		NE	
	Increased Water Column Pyrethroid Pesticides	NE		NE		NE		NE	
	Increased Sediment Pyrethroid Pesticides	NE		NE		NE		NE	
	Increased Water Column Herbicides	NE		NE		NE		NE	
Temperature									
	Increased Water Temperature	NE		NE		NE		NE	
	Decreased Variability in Water Temperature	NE		NE		NE		NE	

Laboratory Data from Outside the Case

The laboratory data from outside the case line of evidence was evaluated by using species sensitivity distribution (SSD) curves to assess the relative toxicity of the observed heavy metal and pesticide compounds measured at the RD site. Species sensitivity distribution curves synthesize compound-specific laboratory toxicity tests, expressing the number of different taxa that show a toxic effect at different concentrations of that compound (e.g., Figure 13). Curves were available for Arsenic, Cadmium, Chromium, Copper, Nickel, Selenium, Zinc, and diazinon. Data were scored -- if the observed RD concentration was below any observed toxic level, - if the concentration produced less than a 10% species loss, 0 if the concentration was equivalent to between 10 – 30% species loss, + if the concentration was between 30 – 60% species loss, and ++ if the concentration produced greater than 60% species loss. All of the elements observed at RD that had applicable SSD curves were scored --, so dissolved metals were scored -- and consequently, so was the heavy metal candidate cause. The pesticides candidate cause was scored -- based upon the scores of water column non-pyrethroid pesticides. Increased water column non-pyrethroid pesticides was scored --, with diazinon scoring -- (Table 10). It should be noted that all of the SSD curves constructed for pesticides were still in draft form and have yet to undergo formal peer review (S. Hagerthey, *pers comm*).

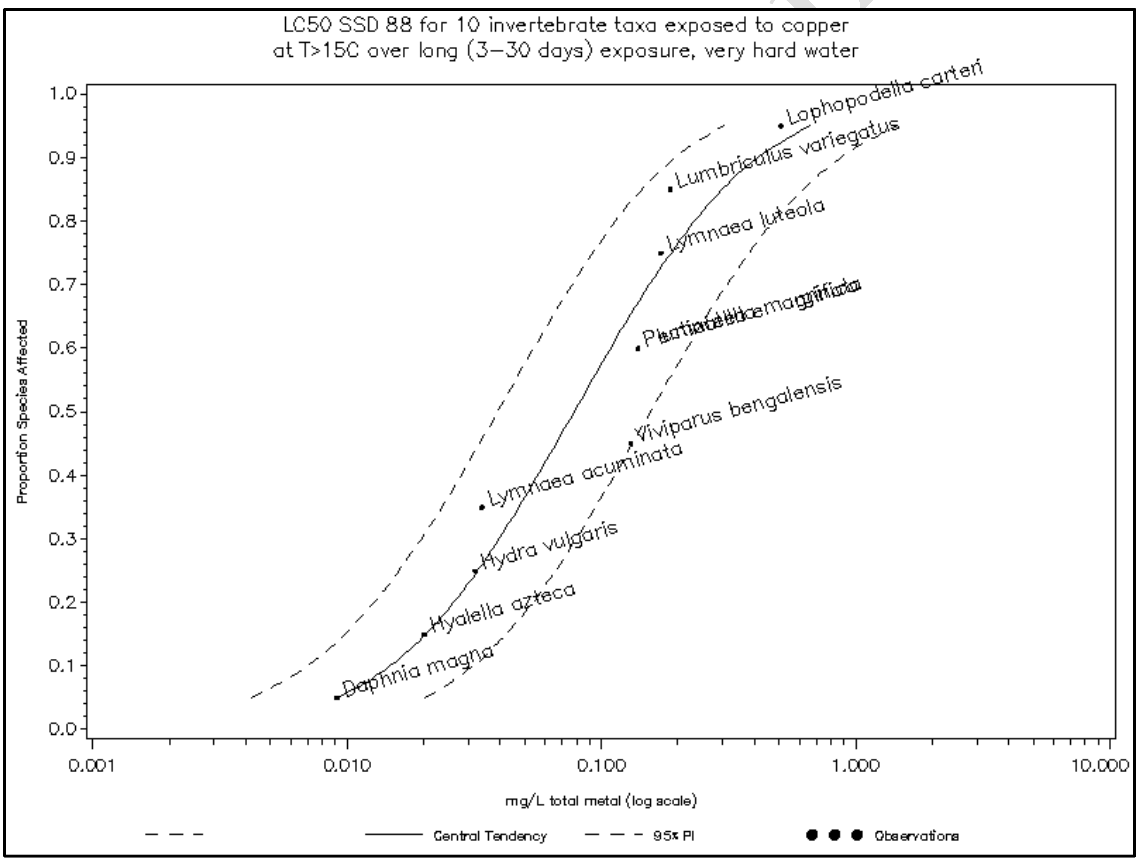


Figure 13. An example of a species sensitivity distribution curve (USEPA 2013) illustrating the different taxa where potential mortality would be expected from different concentrations of copper in water >15°C and >180 mg L^{-1} $CaCO_3$ (i.e., warm, very hard water). The dashed line represents the mean monthly observed concentration of copper at the RD site (3.42 μg L^{-1}).

Table 10 Scoring of the laboratory data from outside the case line of evidence. Data from the test site were compared to published (metals) or draft (pesticides) species sensitivity distribution curves. Data are scored ++ for moderately strong supporting evidence, + for strongly supporting evidence, -- for moderately weakening evidence, - for weakening evidence, 0 for indeterminate evidence, or NE for no evidence. bdl = below detection limit.

Candidate Cause	Proximate Stressor	Components (units)	RD Value	Component Score	Comment	Proximate Stressor Score
Heavy Metals						
	Increase in Dissolved Metals					--
		Mean of Previous Quarter (BDL = 1/2 MDL)				
		Antimony ($\mu g\ L^{-1}$)	0.63	NE		
		Arsenic ($\mu g\ L^{-1}$)	0.82	--	Not Hardness corrected	
		Barium ($\mu g\ L^{-1}$)	41.70	NE		
		Beryllium ($\mu g\ L^{-1}$)	0.13	NE		
		Cadmium ($\mu g\ L^{-1}$)	0.09	--		
		Chromium ($\mu g\ L^{-1}$)	0.23	-		
		Copper ($\mu g\ L^{-1}$)	3.42	--		
		Hexavalent Chromium ($mg\ L^{-1}$)	0.01	NE		
		Iron ($mg\ L^{-1}$)	0.10	NE		
		Lead ($\mu g\ L^{-1}$)	0.10	NE		
		Mercury ($\mu g\ L^{-1}$)	0.02	--		
		Nickel ($\mu g\ L^{-1}$)	6.86	-		
		Selenium ($\mu g\ L^{-1}$)	1.33	-	Not Hardness corrected	
		Silver ($\mu g\ L^{-1}$)	0.13	NE		
		Thallium ($\mu g\ L^{-1}$)	0.13	NE		
		Zinc ($\mu g\ L^{-1}$)	27.97	-		
	Increase in Particulate Bound Metals					NE
			No Data Available			
	Increase in Metals in Periphyton					NE
			No Data Available			
Pesticides						
	Increased Sediment Non-pyrethroid Pesticides					NE
			No Data Available			
	Increased Water Column Non-pyrethroid Pesticides					--
		Maximum Value of Previous Year				
		4,4'-DDD ($\mu g\ L^{-1}$)	bdl	NE		
		4,4'-DDE ($\mu g\ L^{-1}$)	bdl	NE		
		Acrolein ($\mu g\ L^{-1}$)	bdl	NE		
		Acrylonitrile ($\mu g\ L^{-1}$)	bdl	NE		
		Aldrin ($\mu g\ L^{-1}$)	bdl	NE		
		alpha-BHC ($\mu g\ L^{-1}$)	bdl	NE		
		cis-1,3-Dichloropropene ($\mu g\ L^{-1}$)	bdl	NE		
		delta-BHC ($\mu g\ L^{-1}$)	bdl	NE		
		Diazinon ($\mu g\ L^{-1}$)	bdl	--		
		Dieldrin ($\mu g\ L^{-1}$)	bdl	NE		
		Endosulfan I ($\mu g\ L^{-1}$)	bdl	NE		
		Endosulfan II ($\mu g\ L^{-1}$)	bdl	NE		
		Endosulfan sulfate ($\mu g\ L^{-1}$)	bdl	NE		
		Endrin aldehyde ($\mu g\ L^{-1}$)	bdl	NE		
		Endrin ($\mu g\ L^{-1}$)	bdl	NE		
		Heptachlor Epoxide (Isomer B) ($\mu g\ L^{-1}$)	bdl	NE		
		Heptachlor ($\mu g\ L^{-1}$)	bdl	NE		
		Methoxychlor ($\mu g\ L^{-1}$)	bdl	NE		
		o,p'-DDD ($\mu g\ L^{-1}$)	bdl	NE		
		o,p'-DDE ($\mu g\ L^{-1}$)	bdl	NE		
		o,p'-DDT ($\mu g\ L^{-1}$)	bdl	NE		
		p,p'-DDT ($\mu g\ L^{-1}$)	bdl	NE		
		Technical Chlordane ($\mu g\ L^{-1}$)	bdl	NE		
		Toxaphene ($\mu g\ L^{-1}$)	bdl	NE		
	Increased Water Column Pyrethroid Pesticides					NE
			No Data Available			
	Increased Sediment Pyrethroid Pesticides					NE
			No Data Available			
	Increased Water Column Herbicides					NE
		Maximum Value of Previous Year				
		2,3,7,8-TCDD ($pg\ L^{-1}$)	bdl	NE		
		2,4,5-TP (Silvex) ($\mu g\ L^{-1}$)	bdl	NE		
		2,4'-D ($\mu g\ L^{-1}$)	bdl	NE		

Multi-Year Assessments

Traditionally, causal assessments using the CADDIS framework have focused on a spatially and temporally constrained case definition (i.e., one test site and a single sampling event). These constraints have been both practical and philosophical. Practically, many sites that may need a causal assessment often have a limited amount of data at the test and comparator sites; especially data that are collected uniformly and concurrently at all of the sites. Philosophically, the constrained case definition can reduce complexity in the assessment as well as limit the number of candidate causes and their potential interaction. It can also make data management easier.

For all of the benefits, constraining the case definition in an assessment to a single point in time can also be problematic. Any biotic measurement used as the endpoint to an assessment is going to be prone to year-to-year variation independent of anthropogenic disturbance (e.g., variable recruitment, predation, or productivity rates). This natural biotic variability can be further exacerbated in environmentally variable systems like small streams in Mediterranean climates found through much of coastal southern California. The natural biotic variability may potentially obscure or distort the perceived impacts of stressors on stream biota, especially if the stressor-response dynamics are subtle and non-acute. Given the chronic, non-point source nature of the impacts experienced by many of the streams throughout California, as well as the inherent year-to-year variability in stream macrobenthos, defining the case for a causal assessment so as to incorporate multiple years of data could potentially improve the accuracy of an assessment and improve the confidence in the results of the causal assessment.

Following convention, a spatially-temporally constrained framework was used for the assessment of the Santa Clara River (RD site in 2006). However, as noted in the main body of this report, the biomonitoring efforts along the upper Santa Clara River were part of their NPDES monitoring efforts. Consequently there was biological, chemical, water quality, and physical habitat data collected at multiples sites regularly for almost a decade. As such, the stakeholders and analysts felt that the Santa Clara River causal assessment provided a great opportunity for preliminary investigation into the utility of using a multi-year case definition in diagnosing the biotic conditions in a stream.

Conducting a meaningful causal assessment over multiple years will be dependent upon at least two assumptions. First is that all of the years under consideration are similar and free of natural stochastic events (i.e., anomalously wet or dry years or fires) that may also impact the biology observed at a site. If those events can be detected, the data from those years should not be included in a multi-year assessment. There are number of potential approaches for the detection of these kinds of anomalies including plotting of fire occurrence, rainfall, or flow data through time to look for outliers (e.g., Fig 14). From the biological perspective, plots of multivariate (e.g., non-metric Multi-Dimensional Scaling [nMDS]) or univariate (e.g., species richness, diversity, dominance) community characterizations from the test and comparator sites over the multiple years can be used to highlight any potentially anomalous years and to ensure relative comparability (e.g., Figures 15 and 16). A second assumption is that there is relatively consistent pressure from the same stressor(s) and a relatively similar biological response over the time period of interest. This assumption is probably best tested after the data analysis of the assessment has been conducted. If there is a lack of consistency in the stressor-biology patterns through the years or a large amount of variance in year-to-year data, then the assessment should not be done in the multi-year framework.

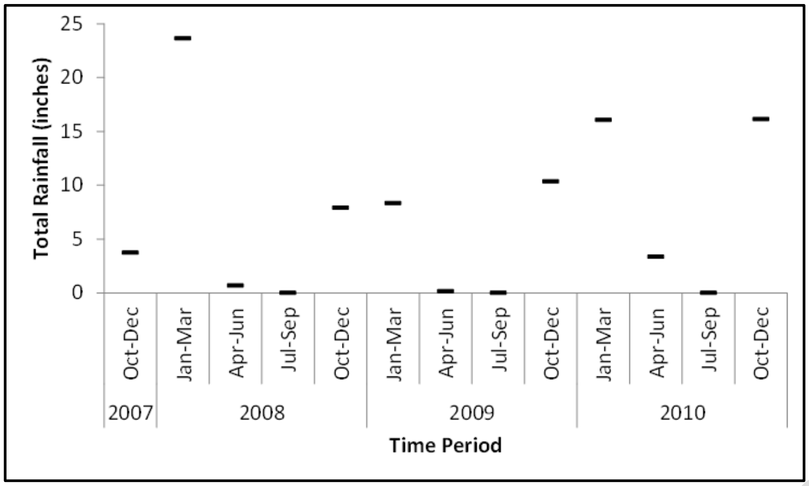


Figure 14 Total rainfall at US Geological Survey rain gauge located near the upper Santa Clara River (Fillmore, CA; Station ID 343120118533301) from October 2007-Decmeber 2010. No value was deemed anomalous and consequently no associated data were excluded from the assessment.

Once appropriate data are gathered and organized, there are a number of potential approaches to utilizing the stressor and biological data from multiple years. The goal of any of these approaches would be to incorporate the year-to-year variability in all of the data and the relationships between the biology and the stressors. The basic unit of data will vary from assessment to assessment, but uniformity should be used across all of the different years being incorporated into the assessment. As an example, for the Santa Clara River assessment it was decided among the stakeholders and analysts to use the biological and physical habitat data collected at the time of bioassessment and the mean or maximum observed values over the three months prior to bioassessment for water quality and chemistry data (where available). These data can then be synthesized across multiple years using an estimate of central tendency (e.g., means or median values across years), estimates of the distribution (e.g., 25th, 50th, and 75th percentiles or absolute range across years), or the most frequently observed relationships from the individual years across the period of interest. The choice of which approach to use could vary from assessment to assessment, but should be a decision made by the data analyst in conjunction with the stakeholders involved in the case during the case definition process.

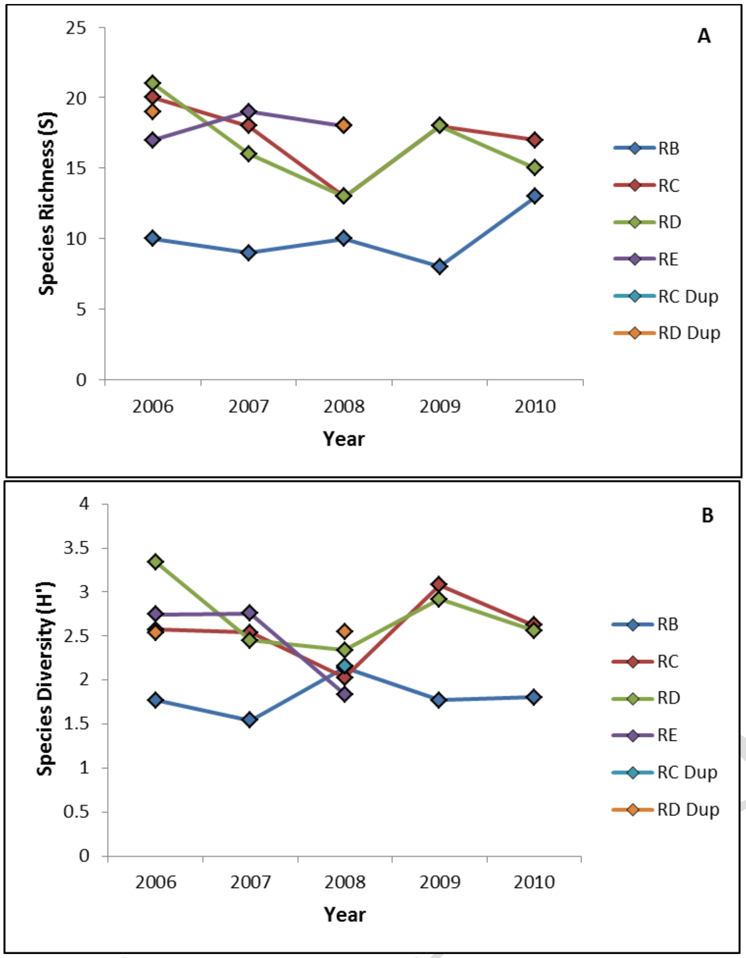


Figure 15 Species richness (A) and Shannon Weiner Diversity (B) of the macrobenthic community collected at the test site RD and comparator sites RB, RC, and RE in 2006 -2010. No particular year appears to be an outlier, so no data were excluded from the assessment. Note that a duplicate sample was collected at RC in 2008 and RD in 2006 and 2008

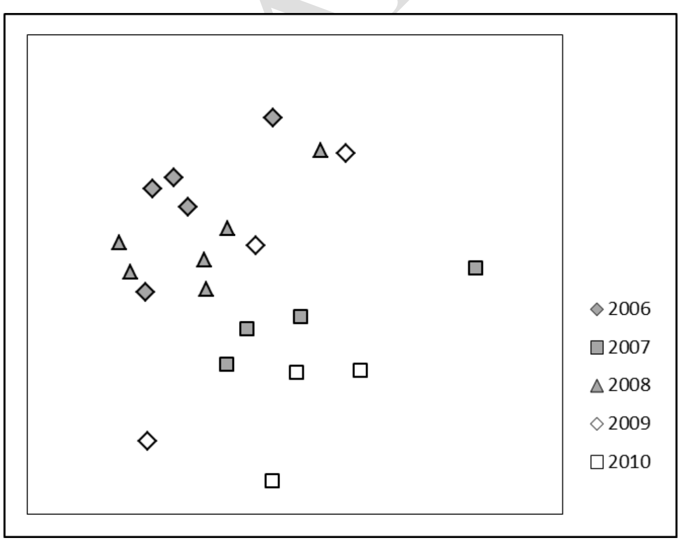


Figure 16 Non-metric multidimensional scaling (n-MDS) plot based upon Bray-Curtis similarity of macrobenthic community structure at the test site RD and the comparator sites RB, RC, and RE from 2006-2010. No single year appears to be an outlier, so no data were excluded from the assessment.

Synthesizing and scoring data using measures of central tendency is relatively straight forward and most similar to the traditional evidence evaluation/scoring process. The arithmetic mean or median value for the appropriate time periods should be calculated from all of the data observations for each proximate stressor and biological endpoint used in the assessment. These mean or median values can then be evaluated using the different lines of evidence in the assessment and scored like any other data. It may be useful to look at the variance and heteroscedasticity of each proximate stressor/biotic endpoint to ensure that the data are indeed relatively comparable and therefore appropriate to be combined.

Several estimates of data distributions can be used, some are calculated relatively simply, but the lines of evidence using these data will have to be scored in a modified process. Example data distribution metrics can include the maximum and minimum observation, 25th, 50th, and 75th percentiles of all observations across the time period of interest. Once these values are calculated for each proximate stressor and biotic endpoint, they are scored individually for each line of evidence in the assessment (e.g., a separate score for each percentile). These individual scores will then be synthesized into a single score for each candidate cause.

Using the most frequently observed pattern across years will also require an additional scoring of evidence step. In this approach, stressor and biology data from each year are evaluated and scored independently for each time period of record. The scores are then synthesized by evaluating the frequency of supporting evidence across all time periods for that line of evidence. Frequent support can lead towards diagnosing the candidate cause and infrequency leads towards weakening the cause.

The Santa Clara River causal assessment provided a good opportunity to test these approaches for using multiple years of data in an assessment and to evaluate if they produced a different result than the single-year approach. The results of the single-year approach (Fall 2006) indicated elevated conductivity and temperature as potential causes to the biological impairment observed in the Santa Clara River (Figs 3 and 9). However, data for biological condition, conductivity, and temperature collected over a five year period (2006-2010). We used these data to evaluate the frequency approach to using multi-year data in a Causal Assessment. This analysis focused on assessing the temperature and elevated conductivity candidate causes from the test (RD) and comparator sites (RB, RC, and RE). The details of the frequency scoring and synthesis are presented, and then used to compare to the single year assessment (2006). Finally, we repeat the assessment using the mean of measures across years (mean), the median of measures observed across years (median), and the 25th, 50th, and 75th percentile measurements observed across years (percentiles), to compare assessments across the four different approaches to using multi-year data.

The 2006-2010 data synthesized with the frequency approach were used for within case lines of evidence (spatial co-occurrence and stressor response) and outside the case lines of evidence (reference comparison and stressor-response) in an evaluation of the biological impairment observed at the RD site in the upper Santa Clara River (Table 11). Both elevated conductivity and temperature were evaluated as likely causes for the degraded biologic condition observed at the RD site of the Santa Clara River. Elevated conductivity was a likely cause based upon multiple lines of evidence. Levels of conductivity observed at the RD site in each year were higher than measures observed at environmentally similar reference sites. Furthermore, these levels were high enough to potentially cause degraded levels of three of the four biological endpoints based upon a relative risk approach to outside of the case stressor response. There was mixed evidence supporting elevated conductivity as a cause at some comparator sites and for some biological endpoints but weakening for others (Table 11). Though there were no outside of the case data available for evaluation for the temperature candidate cause, the spatial co-occurrence data at two sites and the stressor response relationships with non-insect taxa indicated that temperature was a likely candidate cause. It should be noted that both aspects of the temperature candidate cause, elevated mean temperature and decreased temperature range, tended to score in the same fashion across the different lines of evidence.

One of the primary differences between this multi-year assessment and the single year assessment is the use of comparator sites. Beyond the "baseline" comparator sites (RB, RC, and RE) used in the multi-year assessment, the single year assessment took advantage of a special study that occurred only in 2006 that provided an additional four comparator sites. In fact, that is why 2006 was originally chosen; data were not available for these additional sites for the 2007-2010 time period. As a result the additional comparator sites were not utilized for the multi-year assessment. Data completeness is another variable to consider when deciding if multi-year assessment is warranted.

Table 12 provides an example scoresheet for conductivity when applying spatial co-occurrence lines of evidence using the frequency-based approach to multi-year assessments. For the spatial co-occurrence line of evidence, elevated conductivity was scored "+" for RD vs. RB, "---" for RD vs. RC, and "0" for RD vs. RE. Conductivity and RD was always higher than at RB (scored "+") and lower or equivalent to measurements at RC and RE (scored "---" or "0"). Total dissolved solids (TDS) at RD – measured as TDS, hardness, and chloride – were most frequently higher than at RB and RE, while most frequently lower than measures from RC.

Table 13 provides an example scoresheet for conductivity when applying stressor-response lines of evidence using the frequency-based approach to multi-year assessments. Within the case stressor response was scored "+" for % abundance of collector-gatherers, "-" for % non-insect taxa, and "0" for % tolerant taxa and number of predator taxa. The individual proximate stressor of conductivity was most frequently scored "+" for collector-gatherer abundance, "-" for non-insect taxa, and "0" for tolerant and predator taxa. The proximate stressor of TDS was most frequently scored 0 for all four of the biological endpoints.

For the reference comparison and outside the case stressor response lines of evidence, data were only available for the proximate stressor of conductivity, so all elevated conductivity scores were the same as those for the proximate stressor. Conductivity at RD was greater in all years than the outer fence value of similar reference sites (683 µmhos cm^{-1}) and were consequently scored "+" (Table 14). Stressor response from outside the case was most frequently scored "--" for abundance of collector-gatherers, as this biological endpoint was most frequently not at a level indicative of degradation. Non-insect taxa, tolerant taxa, and predator taxa were all most frequently scored "+" (Table E).

Table 11 Comparison of summary score sheets for RD and each of the comparator sites in the Santa Clara River assessment using a single year and multiple years of data. Each candidate cause score is the integration of the component proximate stressor scores. The continuity line of evidence evaluates the continuity of each line of evidence for each of the four biological endpoints: % collector-gatherer abundance/% non-insect taxa/% tolerant taxa/# of predator taxa.

			RD vs RB		RD vs RC		RD vs RE	
	Candidate Cause		Elevated Conductivity	Temperature	Elevated Conductivity	Temperature	Elevated Conductivity	Temperature
Single Year (2006)	Spatial Co-Occurrence		+	0	---	+	---	+
	Stressor Response	Collector Abundance §	n/a	n/a	n/a	n/a	n/a	n/a
		Non-Insect Taxa	-	+	-	+	-	+
		Tolerant Taxa	0	0	0	0	0	0
		Predator Taxa	0	0	0	0	0	0
	Reference Condition Comparison		+	NE	+	NE	+	NE
	Stressor Response From Outside the Case	Collector Abundance §	--	NE	--	NE	--	NE
		Non-Insect Taxa	+	NE	+	NE	+	NE
		Tolerant Taxa	+	NE	+	NE	+	NE
		Predator Taxa	+	NE	+	NE	+	NE
	Continuity		-/-/+/+	0/0/0/0	-/-/-/-	0/+/0/0	-/-/-/-	0/+/0/0
			RD vs RB		RD vs RC		RD vs RE	
	Candidate Cause		Elevated Conductivity	Temperature	Elevated Conductivity	Temperature	Elevated Conductivity	Temperature
Multi-Year (2006-2010)	Spatial Co-Occurrence		+	---	---	+	0	+
	Stressor Response	Collector Abundance	+	-	+	-	+	-
		Non-Insect Taxa	-	+	-	+	-	+
		Tolerant Taxa	0	0	0	0	0	0
		Predator Taxa	0	0	0	0	0	0
	Reference Condition Comparison		+	NE	+	NE	+	NE
	Stressor Response From Outside the Case	Collector Abundance	--	NE	--	NE	--	NE
		Non-Insect Taxa	+	NE	+	NE	+	NE
		Tolerant Taxa	+	NE	+	NE	+	NE
		Predator Taxa	+	NE	+	NE	+	NE
	Continuity		-/-/-/-	+/-/0/0	-/-/-/-	0/+/0/0	-/-/+/+	-/+/0/0

§ Collector abundance in 2006 was not at a problematic level and thusly were not scored for stressor response from the field and scored -- where there were data for stressor response from outside the case

Table 12. Detailed spatial-co-occurrence scoring sheet using the multi-year frequency approach for the increased conductivity and temperature candidate causes.

Candidate Cause	Proximate Stressor	Measure	Component	year	RD	RB	Difference	Score	Most Frequent Score	Proximate Stressor Score
Increased Conductivity										
	Elevated Conductivity									+
		Mean of previous quarter point measures								
			Conductivity (umhos/cm @25C)	2006	1207.3	1031.7	175.7	+	+	
			Conductivity (umhos/cm @25C)	2007	1236.7	1056.7	180.0	+		
			Conductivity (umhos/cm @25C)	2008	1210.0	1140.0	70.0	+		
			Conductivity (umhos/cm @25C)	2009	1230.0	1196.7	33.3	+		
			Conductivity (umhos/cm @25C)	2010	1240.0	1151.7	88.3	+		
	Elevated TDS									+
		Mean of previous quarter point measures								
			TDS (mg/l)	2005	758.3	626.0	132.3	+	+	
			TDS (mg/l)	2006	788.0	631.3	156.7	+		
			TDS (mg/l)	2007	761.0	620.7	140.3	+		
			TDS (mg/l)	2008	773.3	710.3	63.0	+		
			TDS (mg/l)	2009	787.3	726.0	61.3	+		
			TDS (mg/l)	2010	789.3	742.0	47.3	+		
			TDS (mg/l)	2011	743.3	724.7	18.7	+		
			Hardness (mg/l)	2005	306.7	204.0	102.7	+	+	
			Hardness (mg/l)	2006	350.0	195.0	155.0	+		
			Hardness (mg/l)	2007	336.0	182.0	154.0	+		
			Hardness (mg/l)	2008	342.3	259.0	83.3	+		
			Hardness (mg/l)	2009	317.7	219.0	98.7	+		
			Hardness (mg/l)	2010	344.2	249.3	94.9	+		
			Hardness (mg/l)	2011	351.2	228.5	122.7	+		
			Chloride (mg/l)	2005	128.9	130.2	-1.3	---	---	
			Chloride (mg/l)	2006	128.5	124.4	4.1	+		
			Chloride (mg/l)	2007	146.0	144.7	1.3	+		
			Chloride (mg/l)	2008	135.8	152.4	-16.6	---		
			Chloride (mg/l)	2009	127.7	146.2	-18.5	---		
			Chloride (mg/l)	2010	120.3	131.3	-11.0	---		
			Chloride (mg/l)	2011	107.3	118.3	-11.0	---		

Candidate Cause	Proximate Stressor	Measure	Component	year	RD	RB	Difference	Score	Most Frequent Score	Proximate Stressor Score
Temperature										
	Increased Mean Temperature									---
		Mean of previous quarter point measures								
			Water Temperature (deg F)	2005	79.2	80.1	-0.9	---	---	
			Water Temperature (deg F)	2006	79.5	81.4	-1.9	---		
			Water Temperature (deg F)	2007	78.2	82.3	-4.1	---		
			Water Temperature (deg F)	2008	75.2	76.5	-1.3	---		
			Water Temperature (deg F)	2009	73.4	74.2	-0.7	---		
			Water Temperature (deg F)	2010	72.6	72.9	-0.3	---		
			Water Temperature (deg F)	2011	71.6	73.5	-1.8	---		
	Decreased Range									---
		Range of previous quarter point measures								
			Water Temperature (deg F)	2005	4.1	6.3	-2.2	+	---	
			Water Temperature (deg F)	2006	6.9	3.1	3.8	---		
			Water Temperature (deg F)	2007	4.1	3.7	0.4	---		
			Water Temperature (deg F)	2008	15.1	9.2	5.9	---		
			Water Temperature (deg F)	2009	12.3	6.3	6.0	---		
			Water Temperature (deg F)	2010	9.0	7.9	1.1	---		
			Water Temperature (deg F)	2011	10.2	5.7	4.5	---		

Candidate Cause	Proximate Stressor	Measure	Component	year	RD	RC	Difference	Score	Most Frequent Score	Proximate Stressor Score
Increased Conductivity										
	Elevated Conductivity									---
		Mean of previous quarter point measures								
			Conductivity (umhos/cm @25C)	2006	1207.3	1295.7	-88.3	---	---	
			Conductivity (umhos/cm @25C)	2007	1236.7	1383.3	-146.7	---		
			Conductivity (umhos/cm @25C)	2008	1210.0	1256.7	-46.7	---		
			Conductivity (umhos/cm @25C)	2009	1230.0	1293.3	-63.3	---		
			Conductivity (umhos/cm @25C)	2010	1240.0	1250.0	-10.0	---		
	Elevated TDS									---
		Mean of previous quarter point measures								
			TDS (mg/l)	2005	758.3	890.0	-131.7	---	---	
			TDS (mg/l)	2006	788.0	866.7	-78.7	---		
			TDS (mg/l)	2007	761.0	917.0	-156.0	---		
			TDS (mg/l)	2008	773.3	867.0	-93.7	---		
			TDS (mg/l)	2009	787.3	846.0	-58.7	---		
			TDS (mg/l)	2010	789.3	828.7	-39.3	---		
			TDS (mg/l)	2011	743.3	783.3	-40.0	---		
			Hardness (mg/l)	2005	306.7	443.3	-136.7	---	---	
			Hardness (mg/l)	2006	350.0	472.7	-122.7	---		
			Hardness (mg/l)	2007	336.0	503.3	-167.3	---		
			Hardness (mg/l)	2008	342.3	465.7	-123.3	---		
			Hardness (mg/l)	2009	317.7	427.7	-110.0	---		
			Hardness (mg/l)	2010	344.2	437.3	-93.2	---		
			Hardness (mg/l)	2011	351.2	390.8	-39.7	---		
			Chloride (mg/l)	2005	128.9	118.5	10.4	+	+	
			Chloride (mg/l)	2006	128.5	118.3	10.2	+		
			Chloride (mg/l)	2007	146.0	115.0	31.0	+		
			Chloride (mg/l)	2008	135.8	110.3	25.6	+		
			Chloride (mg/l)	2009	127.7	106.3	21.3	+		
			Chloride (mg/l)	2010	120.3	101.4	18.9	+		
			Chloride (mg/l)	2011	107.3	97.1	10.2	+		

Candidate Cause	Proximate Stressor	Measure	Component	year	RD	RC	Difference	Score	Most Frequent Score	Proximate Stressor Score
Temperature										
	Increased Mean Temperature									+
		Mean of previous quarter point measures								
			Water Temperature (deg F)	2005	79.2	76.7	2.5	+	+	
			Water Temperature (deg F)	2006	79.5	76.9	2.6	+		
			Water Temperature (deg F)	2007	78.2	70.6	7.6	+		
			Water Temperature (deg F)	2008	75.2	73.2	2.0	+		
			Water Temperature (deg F)	2009	73.4	72.7	0.8	+		
			Water Temperature (deg F)	2010	72.6	70.7	1.8	+		
			Water Temperature (deg F)	2011	71.6	73.0	-1.4	---		
	Decreased Temperature Range									+
		Range of previous quarter point measures								
			Water Temperature (deg F)	2005	4.1	11.2	-7.1	+	+	
			Water Temperature (deg F)	2006	6.9	15.6	-8.7	+		
			Water Temperature (deg F)	2007	4.1	7.8	-3.7	+		
			Water Temperature (deg F)	2008	15.1	12.6	2.5	---		
			Water Temperature (deg F)	2009	12.3	16.2	-3.9	+		
			Water Temperature (deg F)	2010	9	15.9	-6.9	+		
			Water Temperature (deg F)	2011	10.2	16.5	-6.3	+		

Candidate Cause	Proximate Stressor	Measure	Component	year	RD	RE	Difference	Score	Most Frequent Score	Proximate Stressor Score
Increased Conductivity										
	Elevated Conductivity									---
		Mean of previous quarter point measures								
			Conductivity (umhos/cm @25C)	2006	1207.3	1232.3	-25.0	---	---	
			Conductivity (umhos/cm @25C)	2007	1236.7	1243.3	-6.7	---		
			Conductivity (umhos/cm @25C)	2008	1210.0	1253.3	-43.3	---		
			Conductivity (umhos/cm @25C)	2009	1230.0	1213.3	16.7	0		
			Conductivity (umhos/cm @25C)	2010	1240.0	717.2	522.8	+		
	Elevated TDS									+
		Mean of previous quarter point measures								
			TDS (mg/l)	2005	758.3	716.7	41.7	+	+	
			TDS (mg/l)	2006	788.0	815.0	-27.0	---		
			TDS (mg/l)	2007	761.0	781.7	-20.7	---		
			TDS (mg/l)	2008	773.3	711.3	62.0	+		
			TDS (mg/l)	2009	787.3	767.3	20.0	+		
			TDS (mg/l)	2010	789.3	550.0	239.3	+		
			TDS (mg/l)	2011	743.3	573.3	170.0	+		
			Hardness (mg/l)	2005	306.7	326.3	-19.7	---	---	
			Hardness (mg/l)	2006	350.0	380.7	-30.7	---		
			Hardness (mg/l)	2007	336.0	354.0	-18.0	---		
			Hardness (mg/l)	2008	342.3	401.0	-58.7	---		
			Hardness (mg/l)	2009	317.7	343.0	-25.3	---		
			Hardness (mg/l)	2010	344.2	215.0	129.2	+		
			Hardness (mg/l)	2011	351.2	220.3	130.8	+		
			Chloride (mg/l)	2005	128.9	97.8	31.1	+	+	
			Chloride (mg/l)	2006	128.5	116.5	12.0	+		
			Chloride (mg/l)	2007	146.0	126.7	19.3	+		
			Chloride (mg/l)	2008	135.8	108.8	27.0	+		
			Chloride (mg/l)	2009	127.7	115.0	12.7	+		
			Chloride (mg/l)	2010	120.3	92.3	28.0	+		
			Chloride (mg/l)	2011	107.3	86.0	21.3	+		

Candidate Cause	Proximate Stressor	Measure	Component	year	RD	RE	Difference	Score	Most Frequent Score	Proximate Stressor Score
Temperature										
	Increased Mean Temperature									+
		Mean of previous quarter point measures								
			Water Temperature (deg F)	2005	79.2	76.5	2.6	+	+	
			Water Temperature (deg F)	2006	79.5	78.3	1.2	+		
			Water Temperature (deg F)	2007	78.2	76.3	1.8	+		
			Water Temperature (deg F)	2008	75.2	72.4	2.8	+		
			Water Temperature (deg F)	2009	73.4	68.2	5.2	+		
			Water Temperature (deg F)	2010	72.6	65.5	7.1	+		
			Water Temperature (deg F)	2011	71.6	65.4	6.2	+		
	Decreased Range									+
		Range of previous quarter point measures								
			Water Temperature (deg F)	2005	4.1	13.18	-9.1	+	+	
			Water Temperature (deg F)	2006	6.9	12.5	-5.6	+		
			Water Temperature (deg F)	2007	4.1	6.2	-2.1	+		
			Water Temperature (deg F)	2008	15.1	21.1	-6.0	+		
			Water Temperature (deg F)	2009	12.3	18.5	-6.2	+		
			Water Temperature (deg F)	2010	9	14.8	-5.8	+		
			Water Temperature (deg F)	2011	10.2	16.2	-6.0	+		

Table 13. Detailed within the case stressor-response scoring sheet using the multi-year frequency approach for the increased conductivity and temperature candidate causes and the four biological endpoints.

Candidate Cause	Proximate Stressor	Measure	Component	year	% Collector Abundance			Proximate Stressor Score	% Tolerant Taxa			Proximate Stressor Score
					rho	score	freq score		rho	score	freq score	
Increased Conductivity												
	Elevated Conductivity							+				0
		Mean of previous quarter point measures										
			Conductivity (umhos/cm @25C)	2006	0.82	+	+		-0.15	0	0	
				2007	0.20	0			0.95	+		
				2008	0.79	+			-0.72	0		
				2009	1.00	+			-0.50	0		
				2010	0.50	0			-1.00	-		
	Elevated TDS							0				0
		Mean of previous quarter point measures										
			TDS (mg/l)	2006	0.82	+	0		-0.15	0	0	
				2007	0.20	0			0.95	+		
				2008	0.44	0			-0.33	0		
				2009	1.00	+			-0.50	0		
				2010	0.50	0			-1.00	-		
			Hardness (mg/l)	2006	0.82	+	+		-0.15	0	0	
				2007	0.20	0			0.95	+		
				2008	0.79	+			-0.72	0		
				2009	1.00	+			-0.50	0		
				2010	0.50	0			-1.00	-		
			Chloride (mg/l)	2006	-0.72	0	0		0.87	+	+	
				2007	0.40	0			-0.95	-		
				2008	-0.79	-			0.93	+		
				2009	-1.00	-			0.50	0		
				2010	-0.50	0			1.00	+		
Temperature												
	Increased Mean Temperature							-				0
		Mean of previous quarter point measures										
			Water Temperature (deg F)	2006	-0.82	-	-		0.15	0	0	
				2007	-0.20	0			-0.95	-		
				2008	-0.79	-			0.93	+		
				2009	-1.00	-			0.50	0		
				2010	-0.50	0			1.00	+		
	Decreased Range							0				0
		Range of previous quarter point measures										
			Water Temperature (deg F)	2006	0.82	-	0		-0.15	0	0	
				2007	0.20	0			0.95	-		
				2008	0.09	0			-0.57	0		
				2009	1.00	-			-0.50	0		
				2010	0.50	0			-1.00	+		

Candidate Cause	Proximate Stressor	Measure	Component	year	% Non-Insect Taxa rho	% Non-Insect Taxa score	% Non-Insect Taxa freq score	% Non-Insect Taxa Proximate Stressor Score	# of Predator Taxa rho	# of Predator Taxa score	# of Predator Taxa freq score	# of Predator Taxa Proximate Stressor Score
Increased Conductivity												
	Elevated Conductivity							-				0
		Mean of previous quarter point measures										
			Conductivity (umhos/cm @25C)	2006	-0.82	-	-		0.50	0	0	
				2007	-0.40	0			0.95	-		
				2008	-0.72	0			-0.38	0		
				2009	-1.00	-			1.00	-		
				2010	-1.00	-			0.50	0		
	Elevated TDS							0				0
		Mean of previous quarter point measures										
			TDS (mg/l)	2006	-0.82	-	-		0.50	0	0	
				2007	-0.40	0			0.95	-		
				2008	-0.33	0			-0.38	0		
				2009	-1.00	-			1.00	-		
				2010	-1.00	-			0.50	0		
			Hardness (mg/l)	2006	-0.82	-	-		0.50	0	0	
				2007	-0.40	0			0.95	-		
				2008	-0.72	0			-0.38	0		
				2009	-1.00	-			1.00	-		
				2010	-1.00	-			0.50	0		
			Chloride (mg/l)	2006	0.72	0	+		0.24	0	0	
				2007	0.00	0			-0.74	0		
				2008	0.93	+			0.19	0		
				2009	1.00	+			-1.00	+		
				2010	1.00	+			-0.50	0		
Temperature												
	Increased Mean Temperature							+				0
		Mean of previous quarter point measures										
			Water Temperature (deg F)	2006	0.82	+	+		-0.50	0	0	
				2007	0.40	0			-0.95	-		
				2008	0.93	+			0.19	0		
				2009	1.00	+			-1.00	-		
				2010	1.00	+			-0.50	0		
	Decreased Range							+				0
		Range of previous quarter point measures										
			Water Temperature (deg F)	2006	-0.82	+	+		0.50	0	0	
				2007	-0.40	0			0.95	-		
				2008	-0.57	0			0.19	0		
				2009	-1.00	+			1.00	-		
				2010	-1.00	+			0.50	0		

Table 14. Detailed scoring table of the reference condition comparison line of evidence for the increased conductivity and temperature candidate causes using the frequency approach to synthesizing multiple years of data.

Candidate Cause	Proximate Stressor	Measure	Component	Year	RD Value	Score	Most Frequent Score	Proximate Stressor Score
Increased Conductivity								
	Elevated Conductivity							+
		Mean of previous quarter point measures						
			Conductivity (µmhos/cm @25C)	2006	1207.3	+	+	
				2007	1236.7	+		
				2008	1210.0	+		
				2009	1230.0	+		
				2010	1240.0	+		
	Elevated TDS							NE
		Mean of previous quarter point measures						
			TDS (mg/l)	2006	788.0	NE	NE	
				2007	761.0	NE		
				2008	773.3	NE		
				2009	787.3	NE		
				2010	789.3	NE		
			Hardness (mg/l)	2006	350.0	NE		
				2007	336.0	NE		
				2008	342.3	NE		
				2009	317.7	NE		
				2010	344.2	NE		
			Chloride (mg/l)	2006	128.5	NE		
				2007	146.0	NE		
				2008	135.8	NE		
				2009	127.7	NE		
				2010	120.3	NE		
Temperature								
	Increased Mean Temperature							NE
		Mean of previous quarter point measures						
			Water Temperature (deg F)	2006	79.5	NE	NE	
				2007	78.2	NE		
				2008	75.2	NE		
				2009	73.4	NE		
				2010	72.6	NE		
	Decreased Range							NE
		Range of previous quarter point measures						
			Water Temperature (deg F)	2006	6.9	NE	NE	
				2007	4.1	NE		
				2008	15.1	NE		
				2009	12.3	NE		
				2010	9	NE		

Table 15. Detailed scoring table for outside of the case stressor-response for increased conductivity and temperature candidate causes and the four biological endpoints using the frequency approach to synthesizing multiple years of data.

Candidate Cause	Proximate Stressor	Measure	Component	Year	RD Stressor Value	% Collector-Gatherer Abundance Biotic Value	Score	Most Frequent	Proximate Stressor Score	% Non-Insect Taxa Biotic Value	Score	Most Frequent	Proximate Stressor Score
Increased Conductivity													
	Elevated Conductivity								--				+
		Mean of previous quarter point measures											
			Conductivity (umhos/cm @25C)	2006	1207.3	66.4	--	--		35.2	+	+	
				2006	1207.3	82.2	+			23.7	--		
				2007	1236.7	86.0	+			5.5	--		
				2008	1210.0	70.9	--			38.5	+		
				2008	1210.0	53.7	--			33.3	+		
				2009	1230.0	66.8	--			38.9	+		
				2010	1240.0	90.8	+			30.8	+		
	Elevated TDS								NE				NE
		Mean of previous quarter point measures											
			TDS (mg/l)	2006	788.0		NE	NE			NE	NE	
				2007	761.0		NE				NE		
				2008	773.3		NE				NE		
				2009	787.3		NE				NE		
				2010	789.3		NE				NE		
			Hardness (mg/l)	2006	350.0		NE				NE		
				2007	336.0		NE				NE		
				2008	342.3		NE				NE		
				2009	317.7		NE				NE		
				2010	344.2		NE				NE		
			Chloride (mg/l)	2006	128.5		NE				NE		
				2007	146.0		NE				NE		
				2008	135.8		NE				NE		
				2009	127.7		NE				NE		
				2010	120.3		NE				NE		

Candidate Cause	Proximate Stressor	Measure	Component	Year	RD Stressor Value	% Collector-Gatherer Abundance Biotic Value	% Collector-Gatherer Abundance Score	% Collector-Gatherer Abundance Most Frequent	% Collector-Gatherer Abundance Proximate Stressor Score	% Non-Insect Taxa Biotic Value	% Non-Insect Taxa Score	% Non-Insect Taxa Most Frequent	% Non-Insect Taxa Proximate Stressor Score
Temperature													
	Increased Mean Temperature								NE				NE
		Mean of previous quarter point measures											
			Water Temperature (deg F)	2006	79.5		NE	NE			NE	NE	
				2007	78.2		NE				NE		
				2008	75.2		NE				NE		
				2009	73.4		NE				NE		
				2010	72.6		NE				NE		
	Decreased Range								NE				NE
		Range of previous quarter point measures											
			Water Temperature (deg F)	2006	6.9		NE	NE			NE	NE	
				2007	4.1		NE				NE		
				2008	15.1		NE				NE		
				2009	12.3		NE				NE		
				2010	9		NE				NE		

Candidate Cause	Proximate Stressor	Measure	Component	Year	RD Stressor Value	% Tolerant Taxa Biotic Value	% Tolerant Taxa Score	% Tolerant Taxa Most Frequent	% Tolerant Taxa Proximate Stressor Score	# Predator Taxa Biotic Value	# Predator Taxa Score	# Predator Taxa Most Frequent	# Predator Taxa Proximate Stressor Score
Increased Conductivity													
	Elevated Conductivity								+				+
		Mean of previous quarter point measures										+	
			Conductivity (umhos/cm @25C)	2006	1207.3	29.0	+	+		8	--		
				2006	1207.3	16.5	--			5	+		
				2007	1236.7	14.3	--			3	+		
				2008	1210.0	38.5	+			4	+		
				2008	1210.0	27.8	+			8	--		
				2009	1230.0	29.4	+			7	--		
				2010	1240.0	16.7	--			3	+		
	Elevated TDS								NE				NE
		Mean of previous quarter point measures											
			TDS (mg/l)	2006	788.0		NE	NE			NE	NE	
				2007	761.0		NE				NE		
				2008	773.3		NE				NE		
				2009	787.3		NE				NE		
				2010	789.3		NE				NE		
			Hardness (mg/l)	2006	350.0		NE				NE		
				2007	336.0		NE				NE		
				2008	342.3		NE				NE		
				2009	317.7		NE				NE		
				2010	344.2		NE				NE		
			Chloride (mg/l)	2006	128.5		NE				NE		
				2007	146.0		NE				NE		
				2008	135.8		NE				NE		
				2009	127.7		NE				NE		
				2010	120.3		NE				NE		

Candidate Cause	Proximate Stressor	Measure	Component	Year	RD	% Tolerant Taxa				# Predator Taxa			
					Stressor Value	Biotic Value	Score	Most Frequent	Proximate Stressor Score	Biotic Value	Score	Most Frequent	Proximate Stressor Score
Temperature													
	Increased Mean Temperature								NE				NE
		Mean of previous quarter point measures											
			Water Temperature (deg F)	2006	79.5		NE	NE			NE	NE	
				2007	78.2		NE				NE		
				2008	75.2		NE				NE		
				2009	73.4		NE				NE		
				2010	72.6		NE				NE		
	Decreased Range								NE				NE
		Range of previous quarter point measures											
			Water Temperature (deg F)	2006	6.9		NE	NE			NE	NE	
				2007	4.1		NE				NE		
				2008	15.1		NE				NE		
				2009	12.3		NE				NE		
				2010	9		NE				NE		

The temperature candidate cause was scored "---" for spatial co-occurrence for RD vs. RB and "+" for RD vs. RC and RD vs. RE. The temperature candidate cause was comprised of two proximate stressors: elevated mean temperature across the 3 months prior to bioassessment and decreased range across the 3 months prior to bioassessment. Both temperature proximate stressors were most frequently scored "---" comparing RD to RB and both were most frequently scored "+" comparing RD to RC and RE (Table B).

The within the case stressor response line of evidence for temperature was scored "-" for % collector-gatherer abundance; most frequently scored "-" for elevated mean temperature and "0" for decreased temperature range. The % non-insect taxa was scored "+", with both increased mean temperature and decreased temperature range most frequently scored "+". Both % tolerant taxa and number of predator taxa were scored "0", as were both of the respective proximate stressors (Table 13).

No data were available for evaluation of either of the temperature proximate stressors using reference site comparison or stressor response from outside the case lines of evidence. Consequently, they were scored "NE" for all of the biological endpoints.

Table 16 details the scoring for each of the median, mean, percentiles, and frequency multi-year methods for within the case stressor-response for each of the biological endpoints. The different approaches to synthesizing the multi-year data produced relatively comparable patterns in the proximate stressor scores (and their constituent components), as well as the candidate causes. Temperature and elevated conductivity remained likely candidate causes.

The outcome of the causal assessment evaluating the temperature and elevated conductivity candidate causes was essentially the same whether the assessment was based only on the 2006 single-year data or all of the multi-year data from 2006-2010 (Table 11). In both approaches, the elevated conductivity assessment was driven by the pattern in the data from elsewhere and temperature was driven by the spatial co-occurrence and stressor-response patterns for within the case data.

The similarities in conclusions for conductivity and temperature candidate causes between the single-year and multi-year approaches to Casual Assessment, and the similarities in outcome regardless of the different approaches to scoring, synthesizing and assessing the multi-year data, provides increased confidence in the final conclusions. This type of multi-year evidence helps dissuade issues related to year-to-year variability.

Table 16. Summary score sheet for the within case stressor-response line of evidence comparing scoring results the frequency, percentile, median, and means approaches to synthesizing multiple years of data. Proximate stressor (PS Score) and candidate cause (CC Score) scores are presented for the increased conductivity and temperature candidate causes and their component proximate stressors.

Frequency									
Candidate Cause	Proximate Stressor	% Collector Abundance		% Tolerant Taxa		% Non-Insect Taxa		# of Predator Taxa	
		PS Score	CC Score	PS Score	CC Score	PS Score	CC Score	PS Score	CC Score
Increased Conductivity			+		0		-		0
	Elevated Conductivity	+		0		-		0	
	Elevated TDS	0		0		0		0	
Temperature			-		0		+		0
	Increased Mean Temperature	-		0		+		0	
	Decreased Range	0		0		+		0	

Percentiles									
Candidate Cause	Proximate Stressor	% Collector Abundance		% Tolerant Taxa		% Non-Insect Taxa		# of Predator Taxa	
		PS Score	CC Score	PS Score	CC Score	PS Score	CC Score	PS Score	CC Score
Increased Conductivity			+		0		-		-
	Elevated Conductivity	+		0		-		-	
	Elevated TDS	+		+		0		-	
Temperature			-		0		+		0
	Increased Mean Temperature	-		0		+		0	
	Decreased Range	-		0		+		-	

Medians									
Candidate Cause	Proximate Stressor	% Collector Abundance		% Tolerant Taxa		% Non-Insect Taxa		# of Predator Taxa	
		PS Score	CC Score	PS Score	CC Score	PS Score	CC Score	PS Score	CC Score
Increased Conductivity			0		0		0		-
	Elevated Conductivity	0		0		0		--	
	Elevated TDS	0		0		0		-	
Temperature			0		0		+		0
	Increased Mean Temperature	0		0		++		0	
	Decreased Range	0		0		+		-	

Means									
Candidate Cause	Proximate Stressor	% Collector Abundance		% Tolerant Taxa		% Non-Insect Taxa		# of Predator Taxa	
		PS Score	CC Score	PS Score	CC Score	PS Score	CC Score	PS Score	CC Score
Increased Conductivity			0		0		0		0
	Elevated Conductivity	0		0		0		0	
	Elevated TDS	0		0		0		0	
Temperature			-		+		0		0
	Increased Mean Temperature	-		+		+		+	
	Decreased Range	-		+		-		-	

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