Analyzing Multiple Stressors in a Small Urbanizing Watershed and Lessons Learned for Stressor Identification

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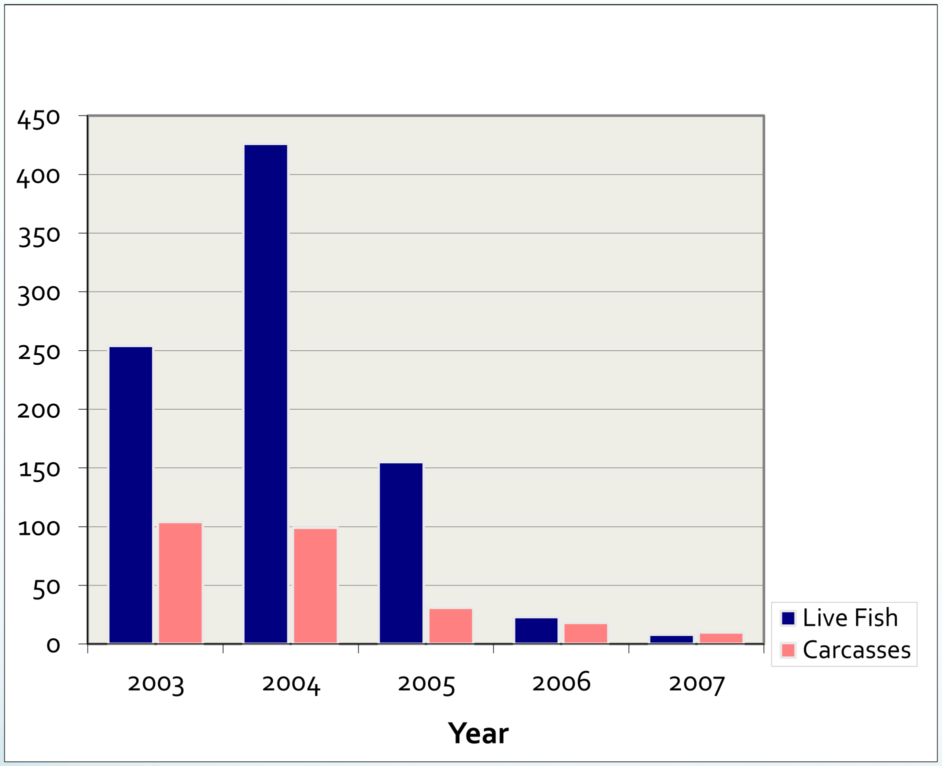
Outline

- Background and purpose
- Analysis of Stressors in the Dry Creek Watershed
- Results of Analysis
- Lessons Learned

Background & Purpose



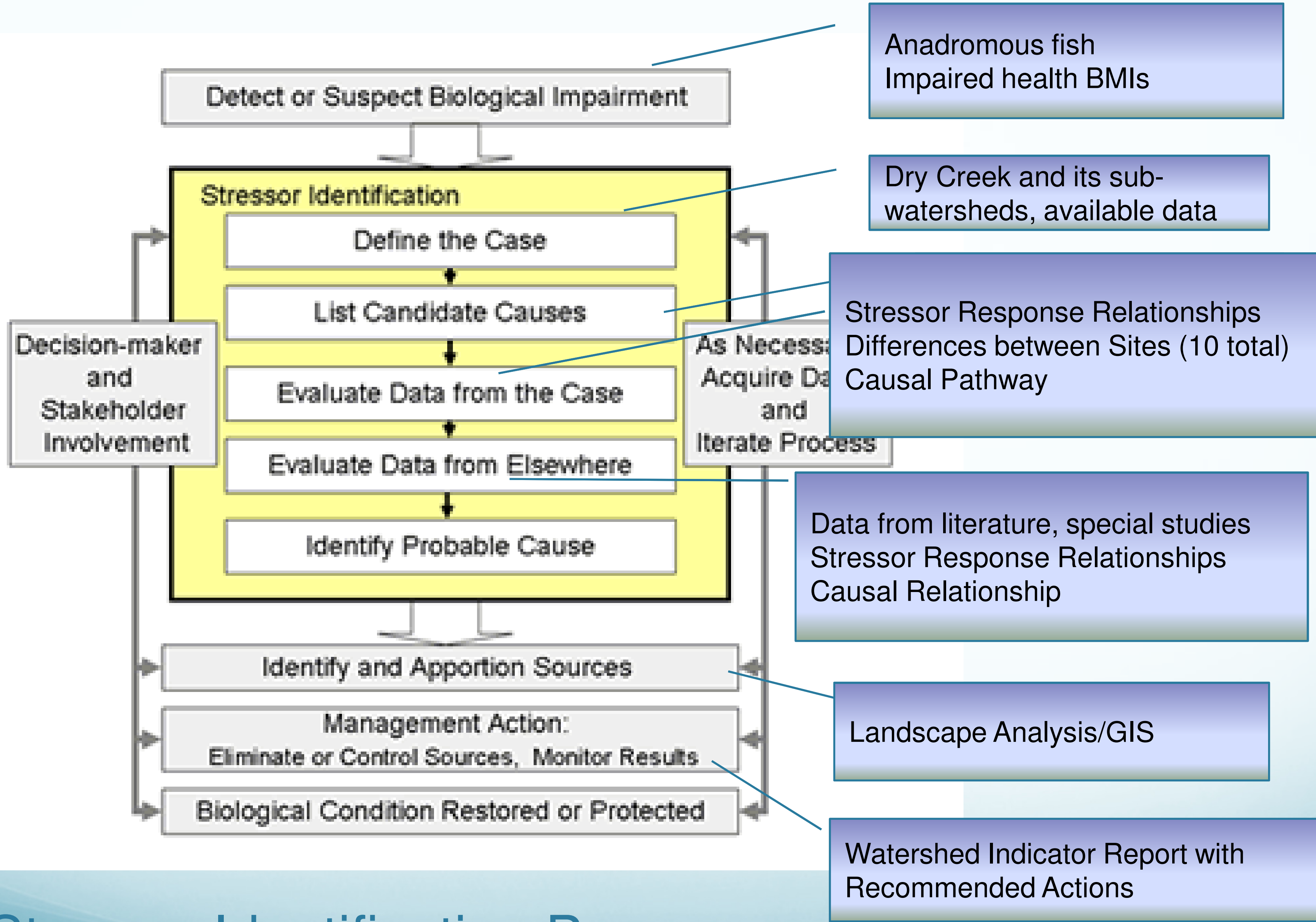
- Approached by Dry Creek Conservancy to help make sense of large, multi-year dataset
- Concerned about impairment of valuable aquatic habitat in the urbanizing Dry Creek watershed (Sacramento region)
  - History of declining chinook salmon population

Large dataset with many gaps

- Chemical
  - Conventional WQ
  - Pesticides, PAHs, large number of contaminants
- Physical
  - PHAB
- Landscape
  - Impervious cover at various spatial scales
  - Land uses (residential, open space, GLU, etc.)
- Many special studies
  - 2 + years logger data (DO, temp, TSS, etc.)
  - Pebble counts, cross sections
  - Pyrethroids
  - etc.

Method of Analysis

- Few methods available to assess chemical, physical, and biological stressors in the same analysis
- Needed a method that was:
  - Relatively simple
  - Systematic and scientifically sound
- Modified Stressor Identification method, developed by US EPA, met these criteria



Stressor Identification Process

Statistics

- Data characteristics:
  - Ten sites
  - Inconsistent data collections from all sites
  - Locations of some sites changed
- Non-parametric stats with Bonferonni's correction for multiple comparisons
- Quantile regression to compare stressor response relationships at different sampling sites
- Kruskal-Wallis test for differences between sites

Criteria for Ranking Stressors

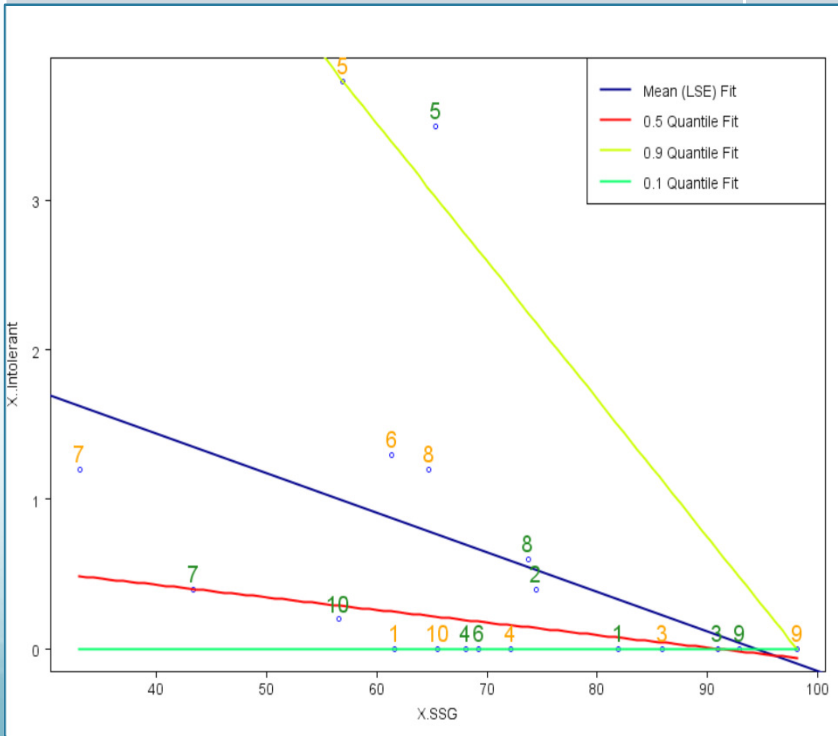
- Stressor score of 1 – 5 was assigned based on results of analysis, reporting on:
  - Spatial co-occurrence (data from the case)
  - Stressor response relationship (case & elsewhere)
  - Complete causal pathway (case & elsewhere)
- Confidence score of 1 -3 assigned based on quality and quantity of data analyzed (case only)

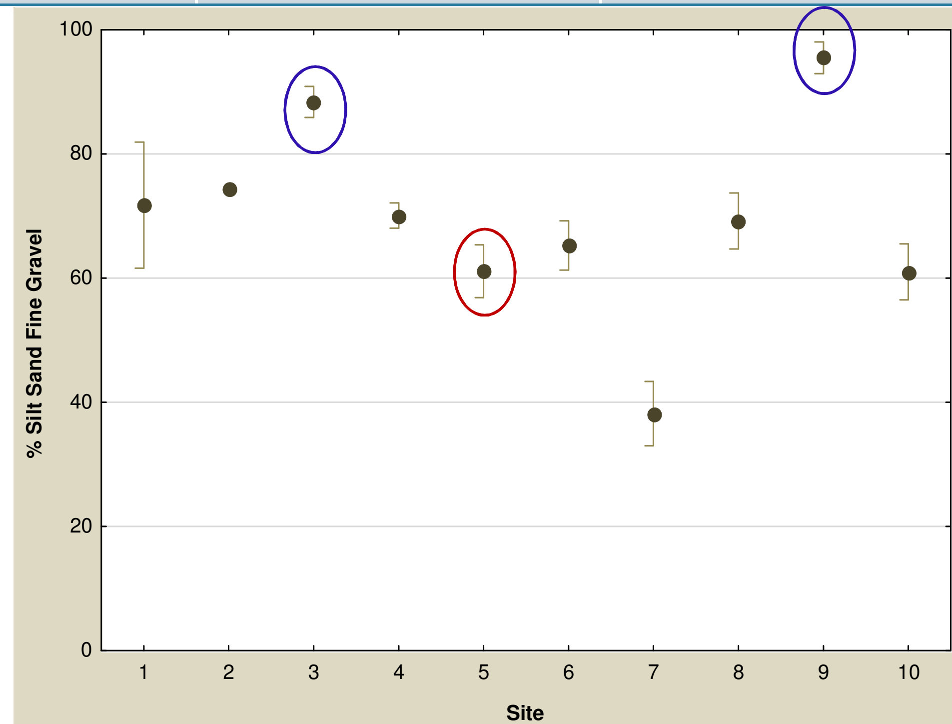
How we focused the analysis

- Used non-parametric statistics to link biological metrics with WQ, physical habitat, and landscape conditions.
- Began 2 step Stressor ID process
  - Analysis of data from the 'case' (watershed). Eliminated many stressors based on scoring.
  - Analysis of data from special studies (1 time or limited scope) and the literature.

Assessing a Stressor: % Silt, Sand, & Fine Gravel

% Silt, Sand, Fine Gravel			
Strength of Evidence Criteria from the Case	***Data Score***	***Confidence in Score***	***FINAL SCORE (score*confidence)***
1. Differences between sites	4	3	12





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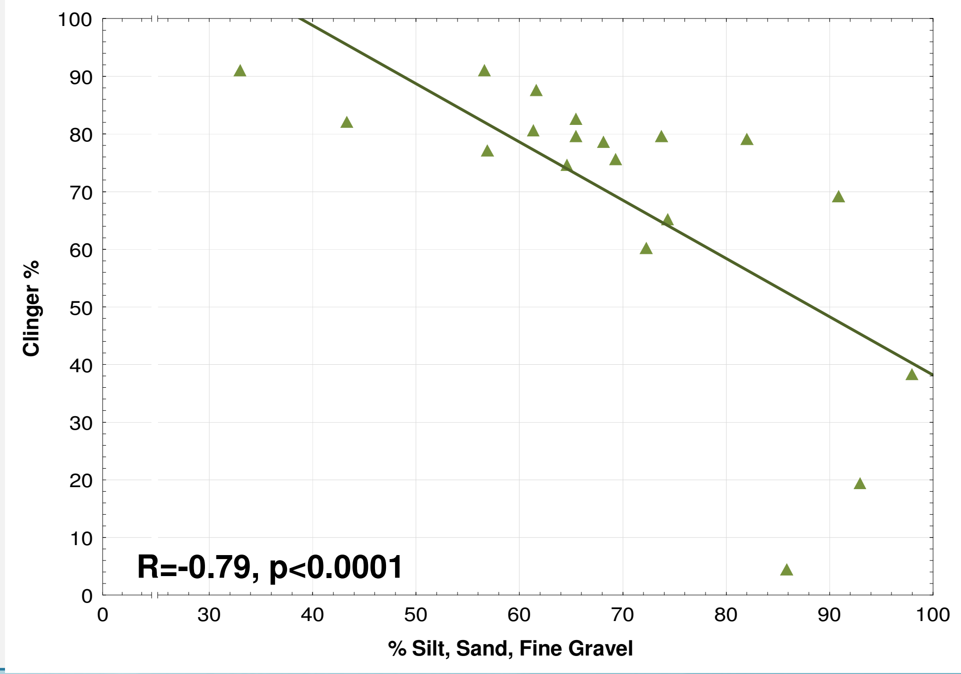
1. Differences between sites	4	3	12
2. Stressor-Response Relationship	5	3	15



Assessing a Stressor: % Silt, Sand, & Fine Gravel

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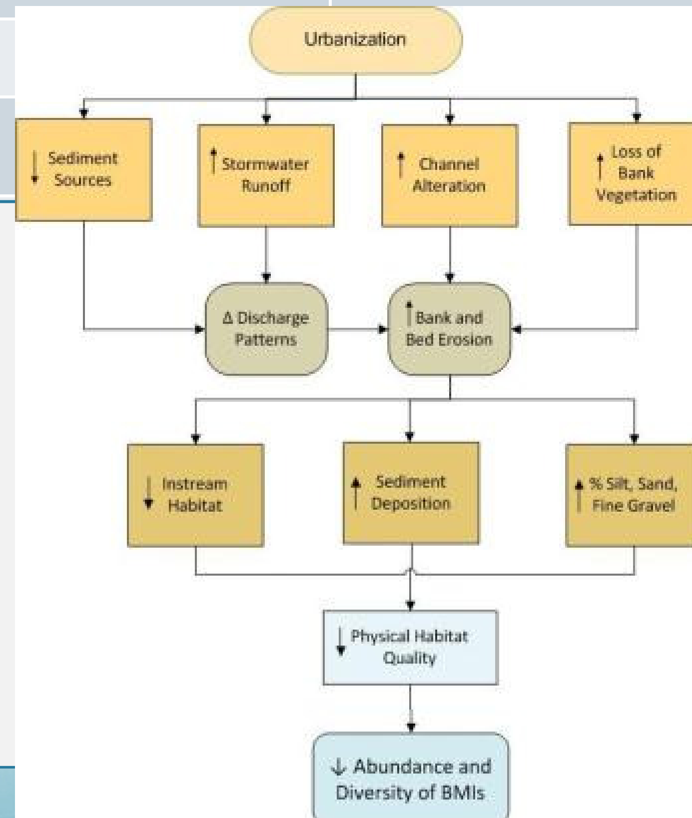
Strength of Evidence Criteria from the Case	*Data Score*	*Confidence in Score*	*FINAL SCORE (score*confidence)*
1. Differences between sites	4	3	12
2. Stressor-Response Relationship	5		
3. Complete Causal Pathway	5		



Assessing a Stressor: % Silt, Sand, & Fine Gravel

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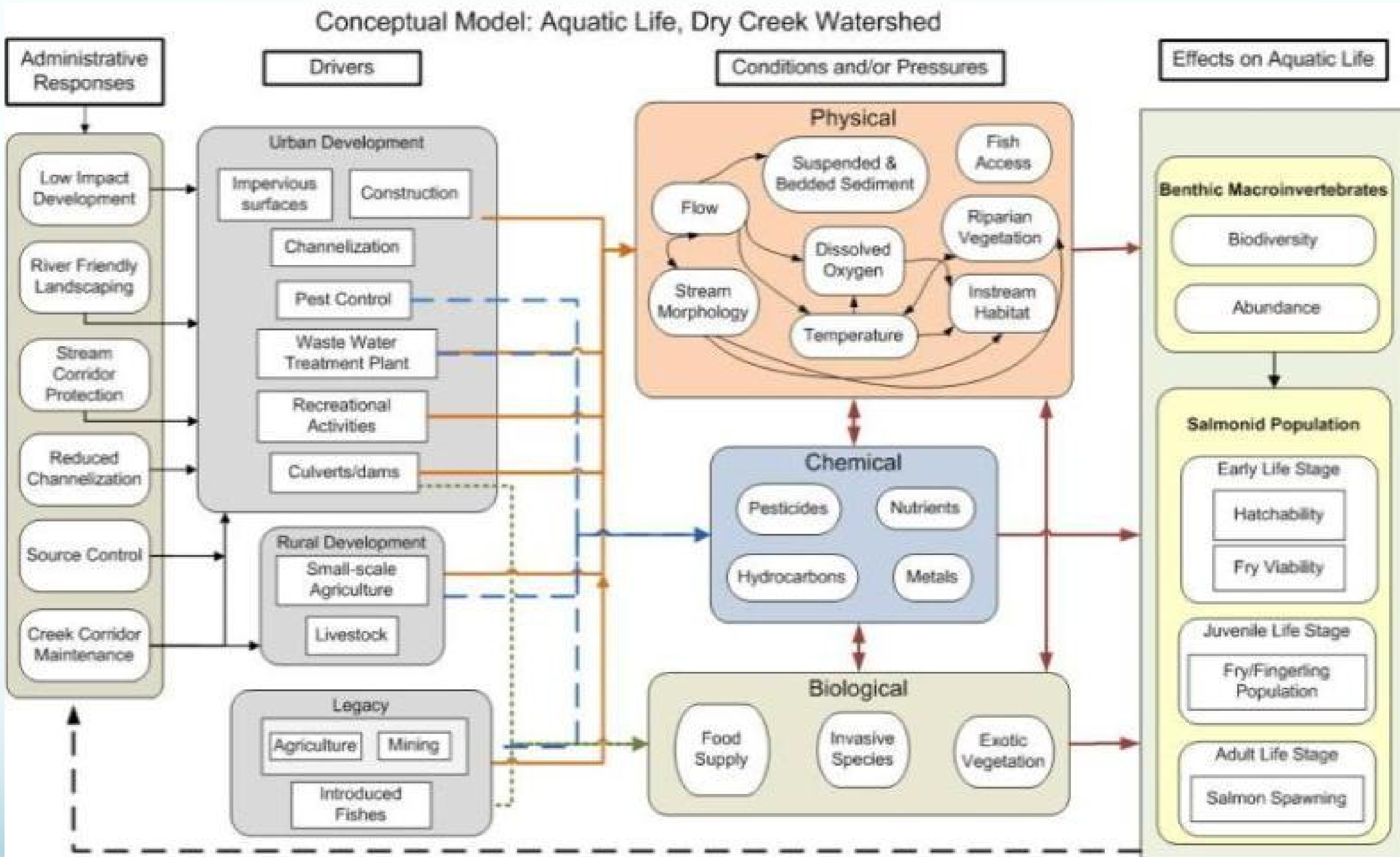
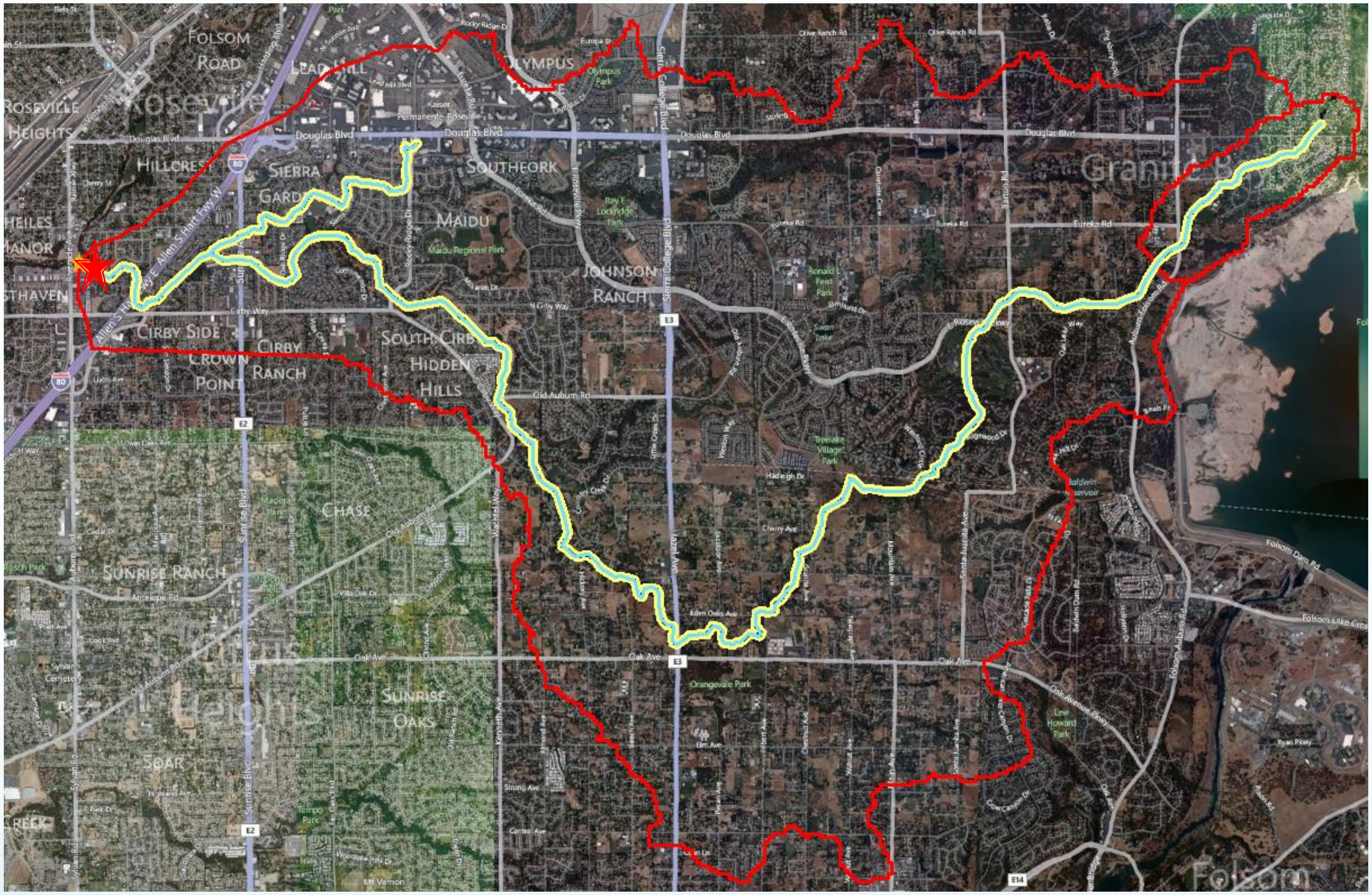
Strength of Evidence Criteria from the Case	***Data Score***	***Confidence in Score***	***FINAL SCORE (score*confidence)***
1. Differences between sites	4	3	12
2. Stressor-Response Relationship	5	3	15
3. Complete Causal Pathway	5	3	15
		Sub-total	**42**
Strength of Evidence from other situations			
1. Stressor-Response Relationship	5		5


Conceptual Model: Aquatic Life, Dry Creek Watershed
Administrative Responses
Drivers
Conditions and/or Pressures
Effects on Aquatic Life
Low Impact Development
River Friendly Landscaping
Stream Corridor Protection
Reduced Channelization
Source Control
Creek Corridor Maintenance
Urban Development
Impervious surfaces
Construction
Channelization
Pest Control
Waste Water Treatment Plant
Recreational Activities
Culverts/dams
Rural Development
Small-scale Agriculture
Livestock
Legacy
Agriculture
Mining
Introduced Fishes
Physical
Flow
Suspended & Bedded Sediment
Fish Access
Riparian Vegetation
Dissolved Oxygen
Stream Morphology
Temperature
Instream Habitat
Chemical
Pesticides
Nutrients
Hydrocarbons
Metals
Biological
Food Supply
Invasive Species
Exotic Vegetation
Benthic Macroinvertebrates
Biodiversity
Abundance
Salmonid Population
Early Life Stage
Hatchability
Fry Viability
Juvenile Life Stage
Fry/Fingerling Population
Adult Life Stage
Salmon Spawning

Analysis of Sources - Landscape

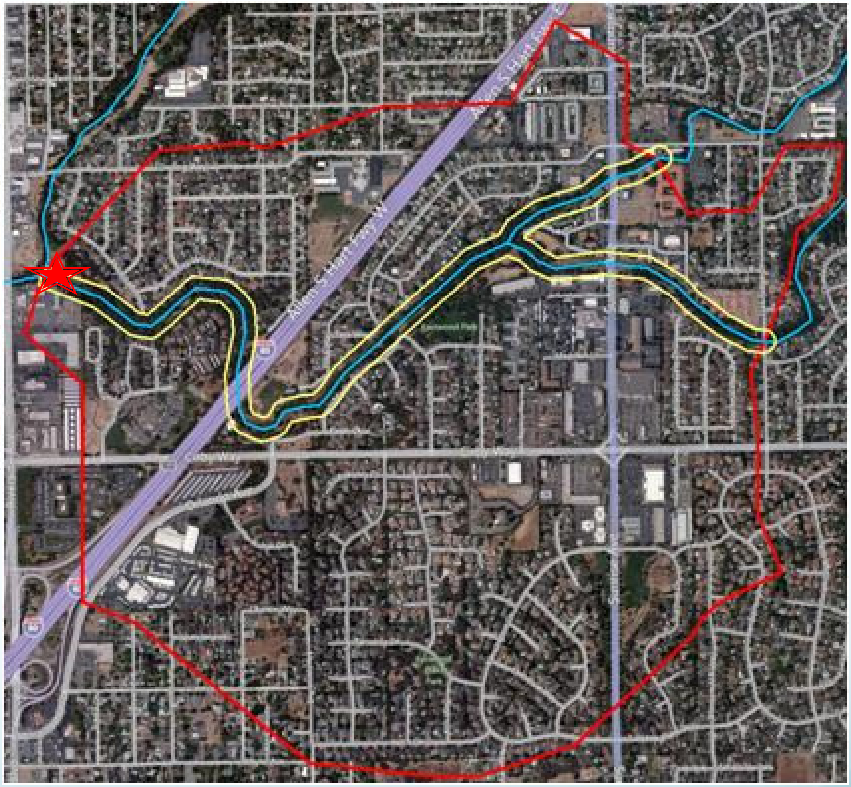
- GIS analysis included:
  - Impervious Cover
  - Land uses, included land designated as open space
  - Special analysis: Geomorphic Landscape Units (GLU)
- To identify sources and their relative importance, used same methodology as for stressor identification.



Impervious Cover – sub-watershed scale

DCC5 – near Rocklin Rd.

DCC 9 – near Sunrise Blvd



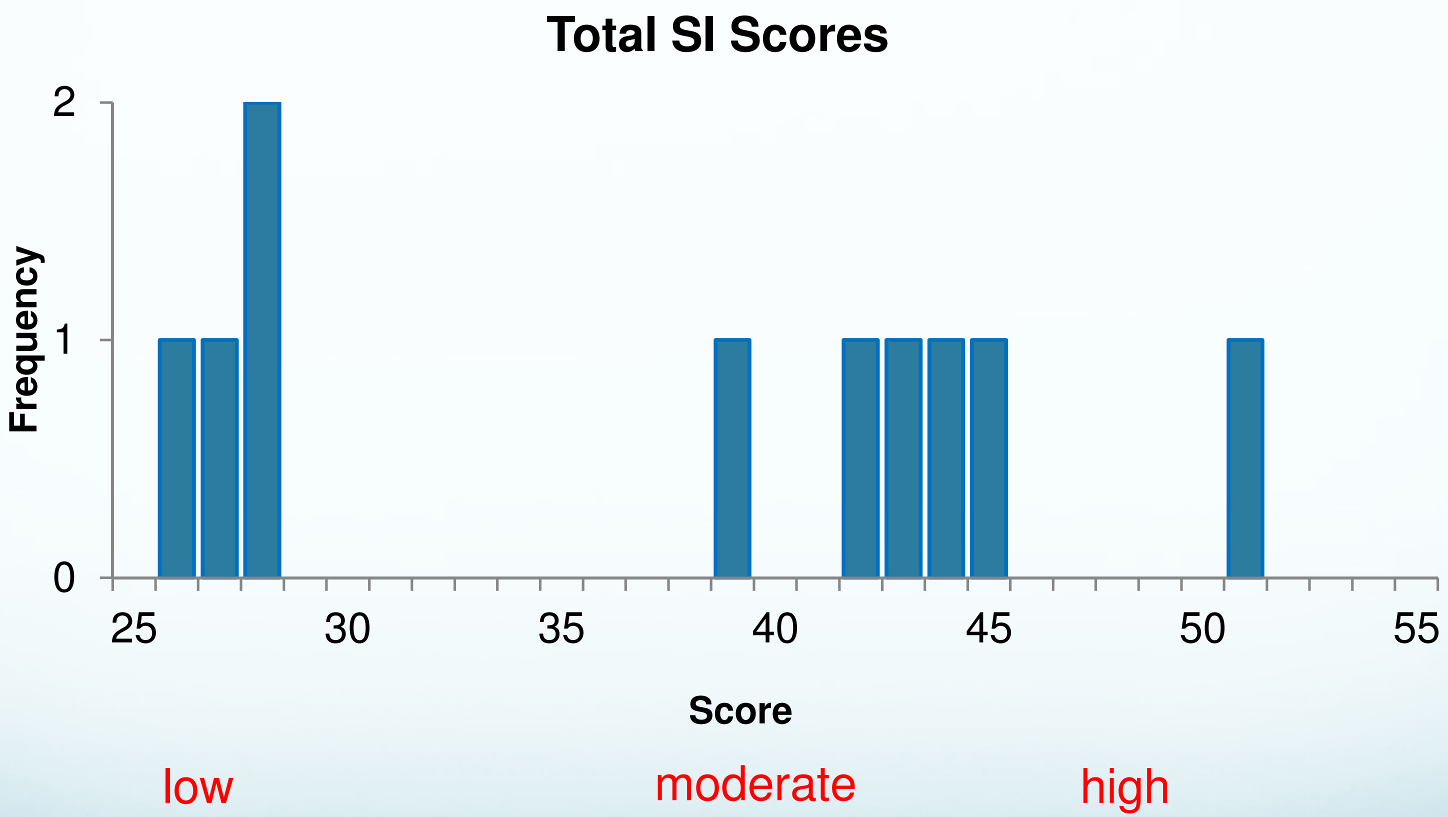
Within the reach - boundaries defined by point 1.5 km upstream from sampling site

Impervious Cover – reach scale

Summary of Results

- Proximate stressors
  - High risk: Fines in streambed
  - Lower risk: Low DO, poor instream cover, high TSS
  - Needs more study: Nutrients, pyrethroids (site specific)
- Landscape sources
  - Most significant: % impervious cover in 100 ft. buffer within stream network and reach (inversely, open space land use)
  - Less significant: % IC in sub-watershed, % residential land use

Assigned scores to risk category



Lessons Learned

- Stressor ID method is currently being considered for identifying causes of biological impairment
- We hope our experience might contribute to this process
- A couple of suggestions

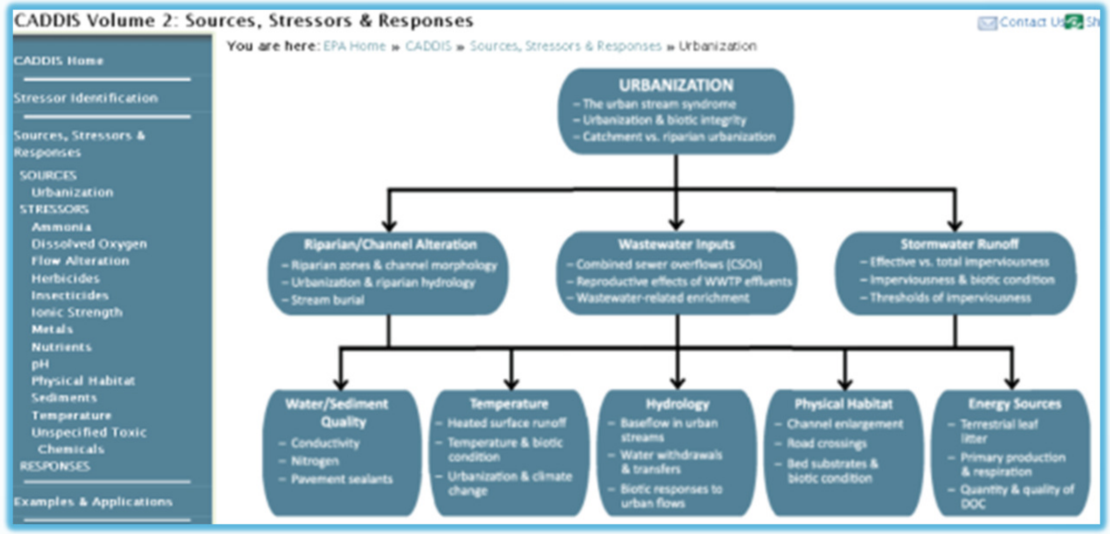
Lessons We've Learned

- Data from other sources (specifically from the literature)
  - Might artificially alter score, depending on the amount and type of research on any one stressor
  - Ex: More lit on chemical stressors, much fewer on physical stressors
  - For our team, extremely time consuming process
  - Knowledge already needed to assess data from the case (watershed)
  - Consider eliminating

Lessons Learned

- Our evaluation was unique because we had an unusually large data set
- We probably could have reached similar conclusions regarding stressors and sources if we had performed a screening level analysis with fewer inputs
- Urban stressors and sources are well documented condition with a characteristic 'fingerprint' aka Urban Stream Syndrome (USS)
- Monitoring data collected from various programs
  - NPDES: Bioassessment, PHAB, WQ
  - DPR/WB: Pyrethroid program

SI Screening Approach



- Part 1: Utilize knowledge of USS
  - Typical stressors, effects, and sources
  - Assume these to be present in urban/urbanizing areas
  - Common set of responses that in most cases address common problems:
    - LID and hydromodification management (new development)
    - Source control
    - Stream corridor protection
    - Creek open space maintenance practices

SI Screening Approach

- Part 2: Incorporate data from existing programs, collect targeted additional data as needed
- Part 3: GIS landscape analysis to identify special landscape conditions that might influence impairment and potential solutions, such as
  - IC in buffer and watershed
  - Point sources of pollution
  - Unique landscape conditions (GLU, VLDR land use to identify large areas of turf)
  - Barriers
  - WWTP
  - Size of riparian corridor

How GLU analysis suggested opportunity for a unique solution to address impairment of aquatic life

Conclusions

- SI method provided an excellent framework for analysis for our project
- Complete SI process is time intensive and costly
- For wider use, a screening method might be preferable

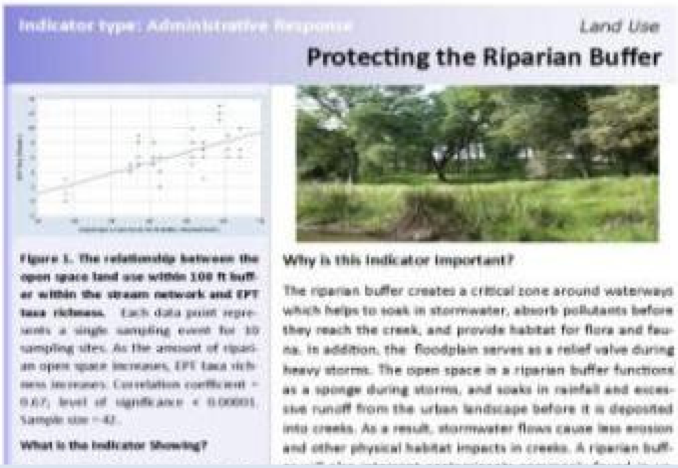
Findings ⟹ Watershed Indicator Report

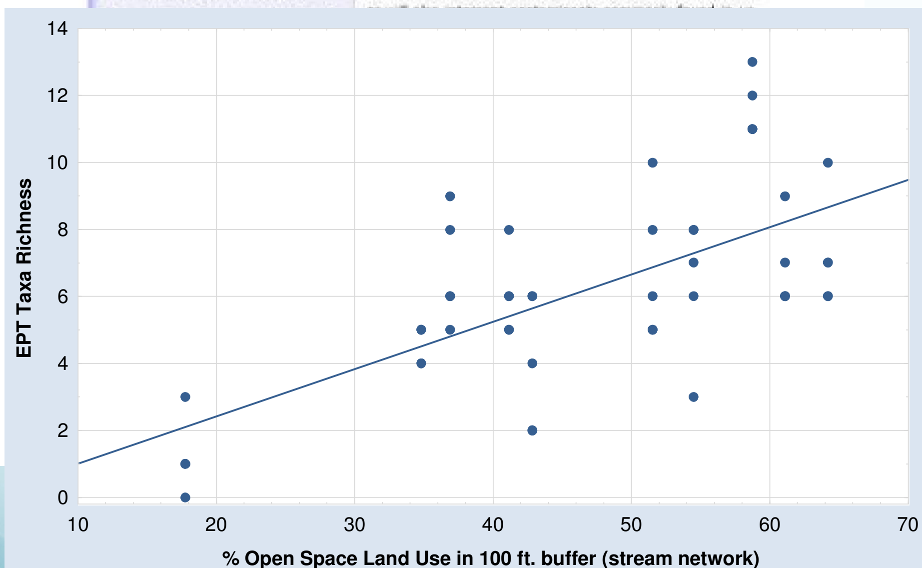
- Purpose
  - Educational for watershed stakeholders
  - Guide to management at the municipal level
- Stressors and sources developed into indicators
- Each indicator organized into 2 sections
  - Section 1: Broad audience
  - Section 2: Technical information
- Indicator framework – a blending of PSER model, SAB Report on Ecological Conditions & modification recommended by Health Watersheds Initiatives

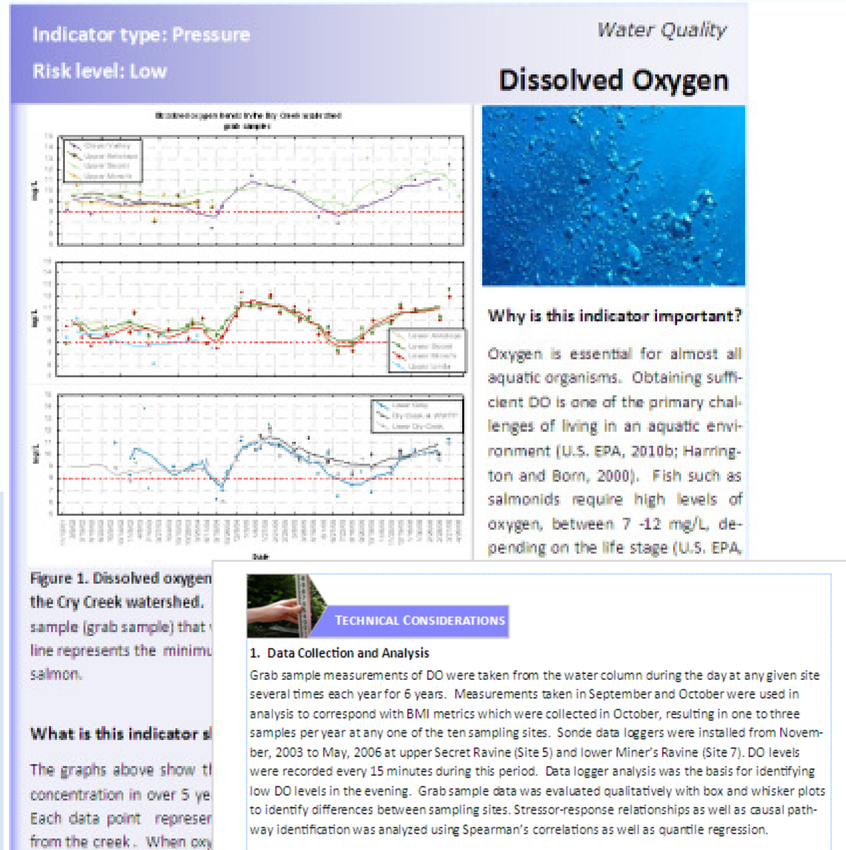
Watershed Indicator Report

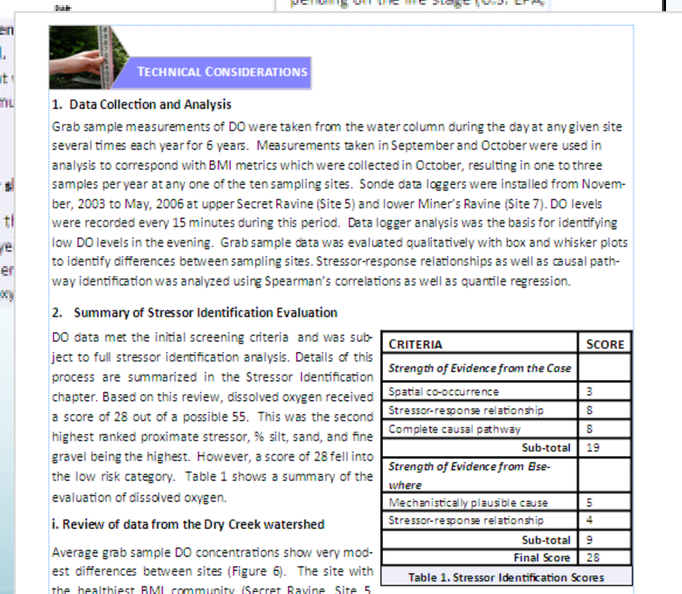
Indicator Category	Sample Indicators
Landscape Conditions	% IC at various spatial scales % open space in 100 ft. riparian buffer
Habitat Conditions	Instream Cover Velocity Depth Regime
Hydrologic Conditions	Flashiness
Geomorphic Conditions	% silt, sand, fine gravel
Water Quality	Dissolved Oxygen Pyrethroids Nutrients
Biological Conditions	BMI metrics
Administrative Responses	River-friendly Landscaping Creek Corridor Maintenance Practices Protection of Riparian Buffers

Sample Indicators









% OS 100ft CUM:EPT Taxa: r = 0.6697, p = 0.00000; r^2 = 0.4484

Useful Info

- Report from "Healthy Watersheds Integrated Assessments Workshop", March 2011
- CADDIS website www.epa.gov/caddis

- Contact:

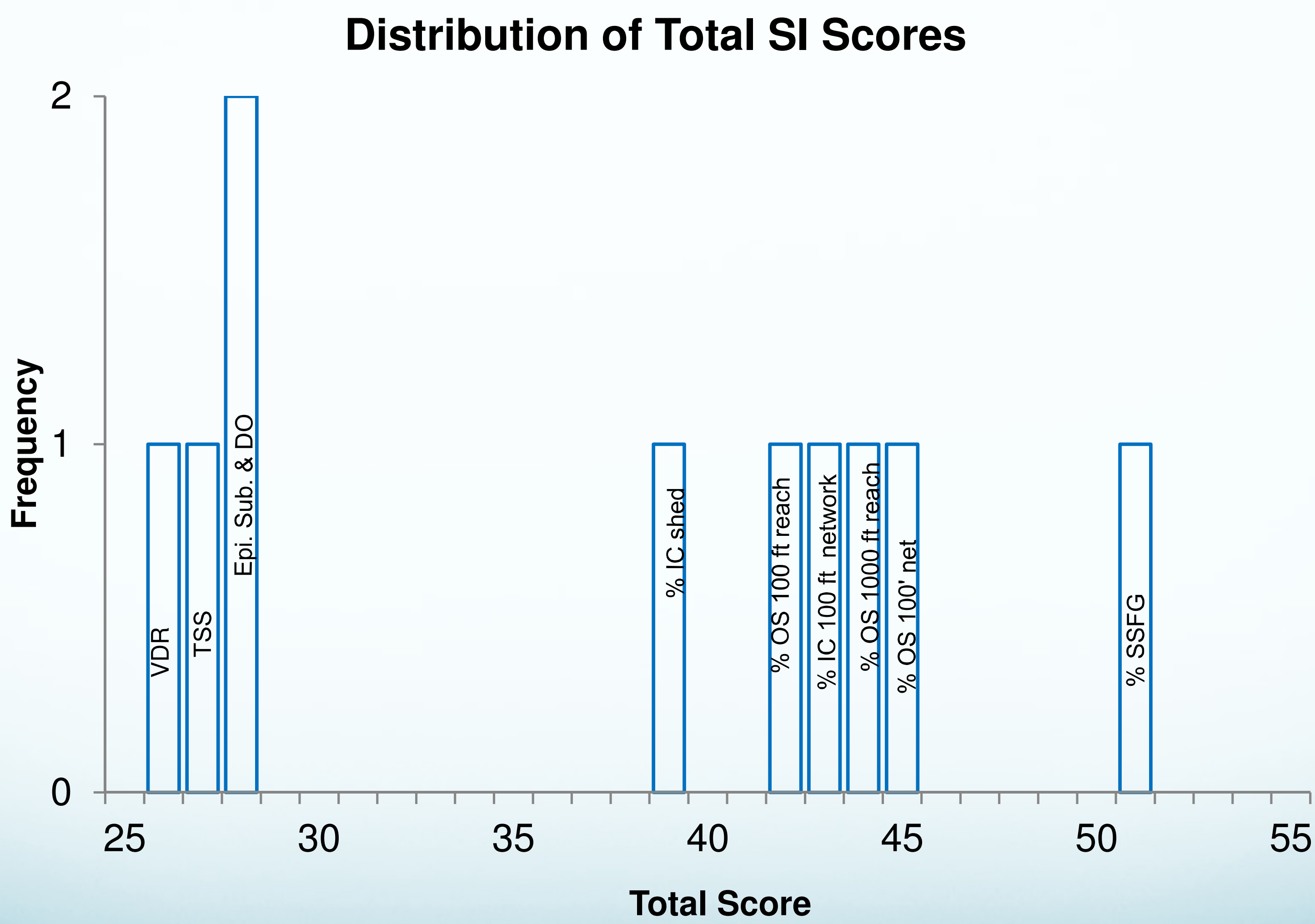
Barbara Washburn, barbara.washburn@oehha.ca.gov

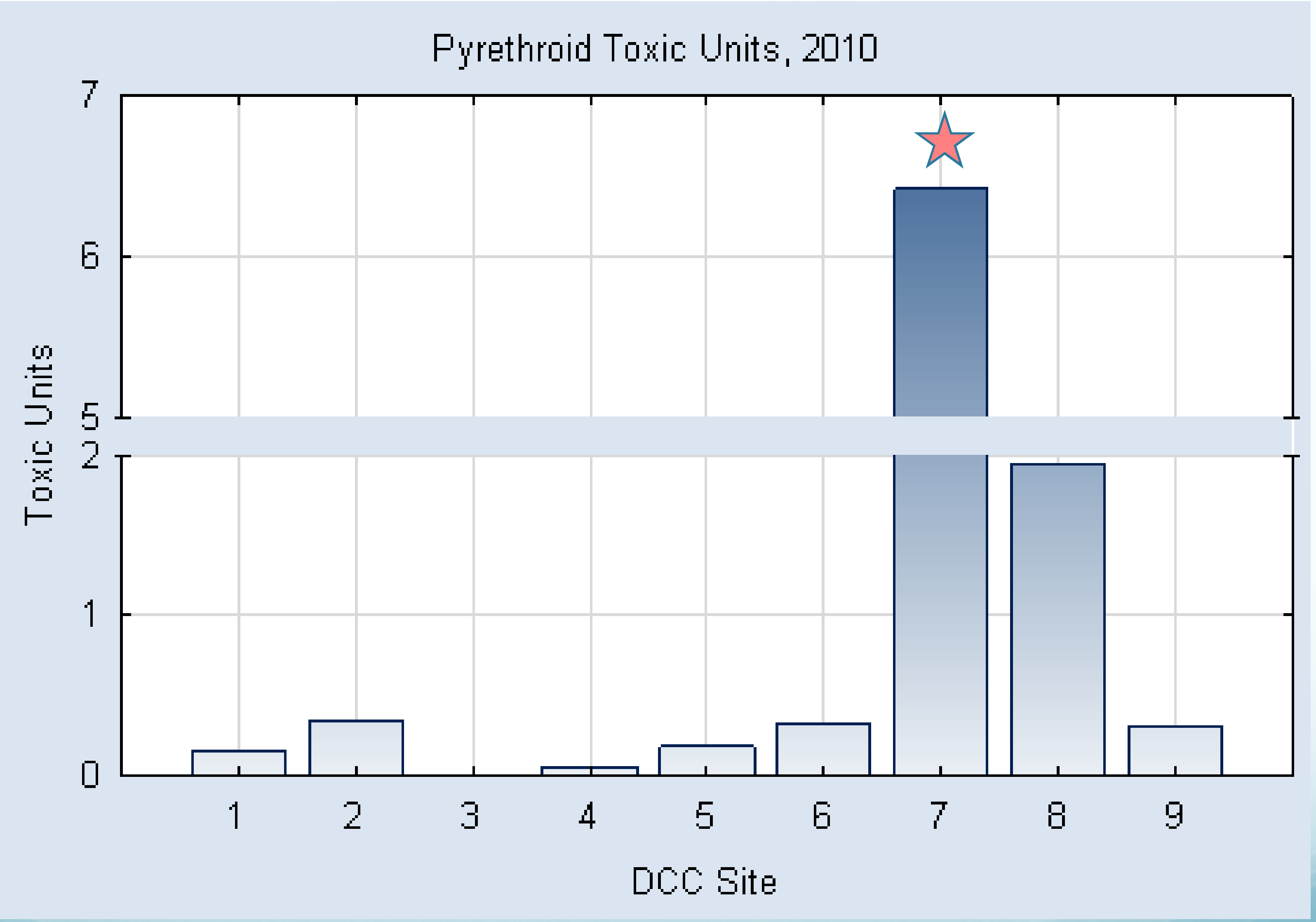
THANK YOU

Effect of including scores from outside the case on stressor ranking

Altered the relationship between stressors; both increasing and decreasing the importance of a stressor.

Scores used to inform assessment, not determine it.


Distribution of Total SI Scores
Frequency
Total Score
0
1
2
25
30
35
40
45
50
55
VDR
TSS
Epi. Sub. & DO
% IC shed
% OS 100 ft reach
% IC 100 ft network
% OS 1000 ft reach
% OS 100' net
% SSFG


Pyrethroid Toxic Units, 2010
Toxic Units
7
6
5
2
1
0
1
2
3
4
5
6
7
8
9
DCC Site

Criteria for Ranking of Stressors
November 17, 2011

Criteria	Low Score = 1	Medium Low Score = 2	Medium Score = 3	Medium High = 4	High = 5
Comparison between sites	Differences between DCC5 and 3/9 non-existent. Other sites the same. This condition refutes candidate cause.	Differences between 5 and 3 &/or 9 are very slight. Gradient in expected direction. Other sites might not fall in between. This condition weakens the case.	Differences between 5 and 3 and/or 9 are clear, but not large. Gradient in expected direction. Other sites might not fall in between. This condition neither strengthens nor weakens the possible cause.	Differences between 5 and 3 and 9 AND gradient in expected direction. Other sites fall in between. This condition strengthens the candidate cause.	Large differences between 5 and 3 and 9. Direct of differences as expected. Other sites fall in between. This condition greatly strengthens the case.
Confidence (consider data quality & method of stat analysis)	Grab samples for WQ data, n < 3	Grab samples for WQ, n=3	Have logger data for most sites for at least 1 year.		
Stressor Response Relationship	No S-R relationship No significant R values although a handful of sign p values. Mixed direction of gradient. Refutes the case.	Inconsistent relationship. Ex: No sig R values, 10-20% sig p values. Some correlation in approp. Direction. Weakens the case.	A weak relationship. For ex: 10% R values > 0.55, 30% with sig p values. Corr in appropriate direction. Neither strengthens nor weakens the case.	Evident relationship but not very strong. For ex: Greater than 20% have R values above 0.55, 20% (5) sig p values, but relationships are super tight. Corr in appropriate direction. Strengthens the case.	Strong relationship For ex: Greater than 30% above 0.55, 30% or more sig p values. DCC 5 frequently in 90th quantile. All correlation in appropriate direction. Greatly strengthens the case.
Confidence (consider data quality & method of stat) analysis)	Poor data quality, no stats	Reasonably good data quality, some stats	Good data quality, good statistical analysis performed		
Complete Causal Pathway (includes sources, stressor & effect)	Data shows with great certainty that there are 1 or more missing steps in the pathway . Greatly weakens the case.	Data shows at least 1 missing step in pathway. Somewhat weakens the case.	Data shows the presence off all steps in the pathway are uncertain. Neither strengthens nor supports the case.	Data show that some steps in at least 1 causal pathway are present. Strengthens the cau=se	Data shows that most all steps in at least one causal pathway are present. Strongly strengthens the case.