Sediment Quality Assessment: Aquatic Life SQO Assessment Example Calculation

This document describes the calculations needed to evaluate sediment with respect to the statewide sediment quality assessment framework for marine embayments in southern California. The implementation of the Aquatic Life SQO (ALSQO) requires a series of specific analyses and a data interpretation framework based on the integration of three Lines of Evidence (LOEs): 1) sediment chemistry, 2) sediment toxicity, and 3) benthic community (Figure 1.1). The data from each LOE are summarized, interpreted using multiple indices, and integrated to determine a LOE condition category. The final step of the evaluation process is to combine the three LOE category classifications to determine the station assessment category.

The different portions of this example were taken from Chapters 3-6 in the Technical Report #777. The figure and table numbers reflect the numbers used in the main technical report. The data analyses described in this example have been broken down into several intermediate steps to allow the reader who is unfamiliar with these analyses to follow the calculations. In practice, many of these steps are accomplished with a single calculation and the calculations are easily automated using readily available computer software.

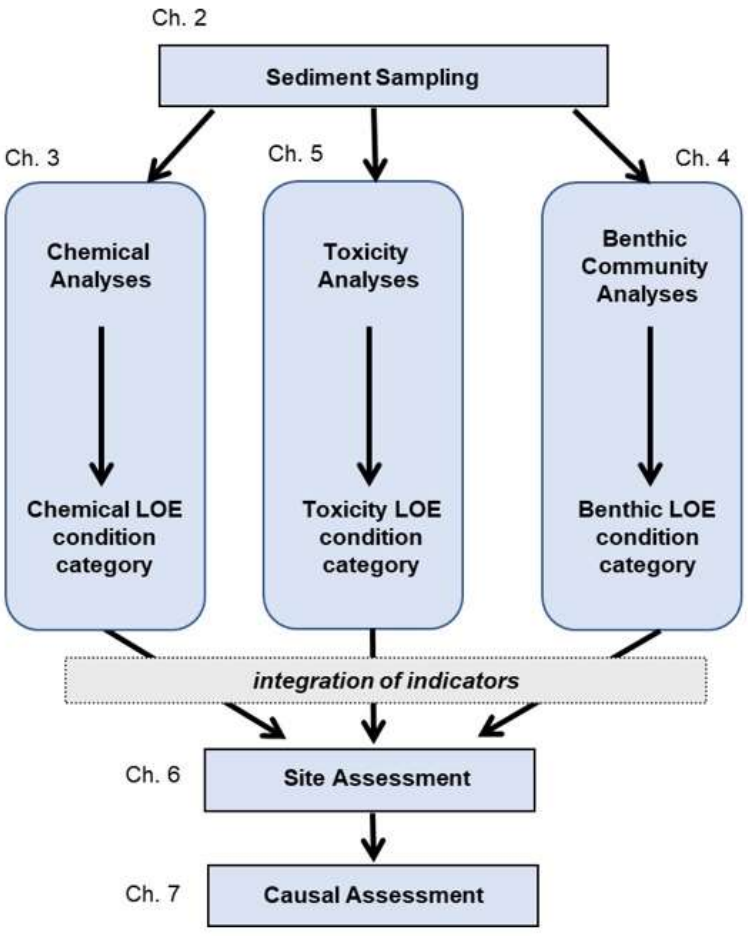

Figure 1.1. Overview of the Aquatic Life SQO station assessment process.

Example of Chemistry LOE Calculation

This section demonstrates the process for data preparation and calculation to generate the Chemistry LOE for the CASQO assessment framework. The data used in this demonstration are shown in Table 3.4. They represent all the sediment chemistry constituents that are recommended for inclusion within the CASQO framework. The sample data provided are within ranges that are typical for each constituent for the sediment of California marine and estuarine habitats.

All the necessary calculations can be carried out using a standard desk calculator or a spreadsheet program, such as Microsoft Excel. For convenience, the Southern California Coastal Water Research Project (SCCWRP) website provides a spreadsheet tool for these calculations. Note that this spreadsheet tool is periodically updated to incorporate input from users; the current version can be found in the *Sediment Quality Assessment Tools* section of the *Sediment Quality* research area page at www.sccwrp.org.

Table 3.4. CASQO sediment chemistry target constituents, the Chemistry LOE indices for which they are used, and example values used for the demonstration calculations in this chapter.

Sediment Constituent	Applicable Index		Example Concentration
	CSI	CA LRM	
Cadmium (mg/kg)		X	0.15
Copper (mg/kg)	X	X	43.6
Lead (mg/kg)	X	X	33.5
Mercury (mg/kg)	X	X	1.37
Zinc (mg/kg)	X	X	45.4
HPAH (µg/kg)	X	X	1672
LPAH (µg/kg)	X	X	261
Alpha Chlordane (µg/kg)	X	X	3.1
Gamma Chlordane (µg/kg)	X		2.4
Dieldrin (µg/kg)		X	1.7
Trans Nonachlor (µg/kg)		X	2.5
DDDs, total (µg/kg)	X		6.7
DDEs, total (µg/kg)	X		2.7
DDTs, total (µg/kg)	X		10.6
4,4'-DDT (µg/kg)		X	2.5
PCBs, total (µg/kg)	X	X	22.7

Data Preparation

The first step in the Chemistry LOE calculations is to confirm that the data are in the proper format. All constituents must be expressed on a sediment dry-weight basis. Specifically, all metals should be in mg/dry kg and all organic constituents should be in µg/dry kg. Note that if calculations using non-detected (ND) analytes are necessary, an estimated value must be used. One estimation approach is to use 50% of the MDL for any samples with ND results for that analyte; however, the previous section should be consulted for addressing ND values within summed groups of constituents.

Calculation of Component Indices

To generate the Chemistry LOE score, the values of the CA LRM and the CSI must first be calculated. Those values are then integrated into a single Chemistry LOE category value for each sampling location. It should be noted that the CA LRM and the CSI indices do not utilize all the same sediment chemistry constituents. While cadmium, dieldrin, trans nonachlor and 4,4'-DDT are solely utilized in the CA LRM calculation, gamma chlordane, total DDDs, total DDEs and total DDTs are solely utilized in the CSI calculation. All other target constituents are used in both indices. The first two columns of Table 3.4 indicate which of the indices utilizes each of the constituents.

California Logistic Regression Model

The CA LRM uses a logistic regression model to predict the probability of sediment toxicity based on sediment chemical constituent concentrations. The relationships between concentration and probability of toxicity have been established for all of the constituents used in the CA LRM (Bay *et al.* 2012). An example, for cadmium, is shown in Figure 3.1.

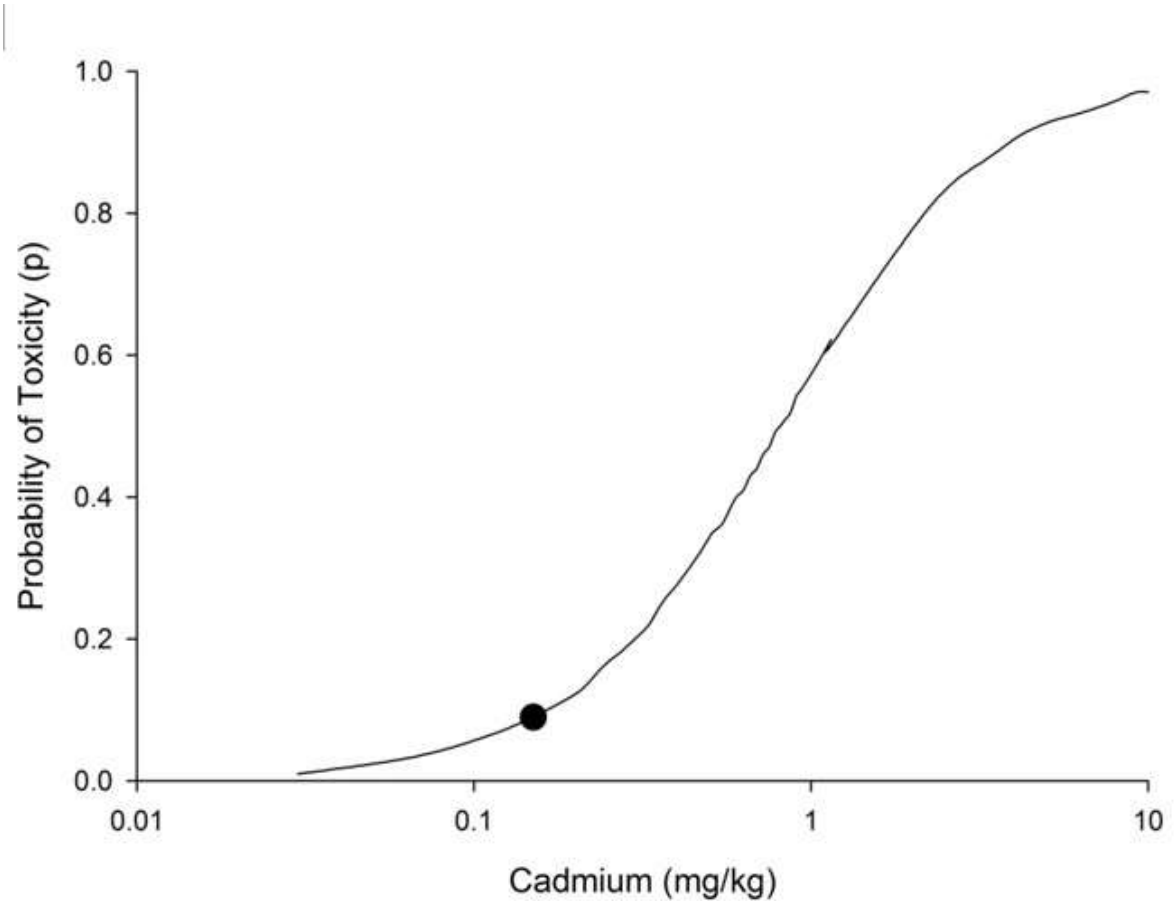

Figure 3.1. Logistic regression curve relating sediment cadmium concentration to probability of toxicity. **The solid circle indicates the calculated probability of toxicity (> 0.1) based on a cadmium concentration of 0.15 mg/kg.**

To determine the probability of toxicity for all the target constituents, the concentration data for each is entered in the following logistic regression equation:

$$p = e^{B0+B1(x)} / (1 + e^{B0+B1(x)})$$

Where: p = the probability of observing a toxic effect;

B0 = the intercept parameter (a *constant*, provided in Table 3.5);

B1 = the slope parameter (a *constant*, provided in Table 3.5); and,

x = the log of the concentration of the analyte of interest (a *variable*, user-entered).

The result of each calculation is rounded to two decimal places.

Table 3.5 provides the values of B0 and B1 that should be used for the various sediment chemistry constituents to determine the CA LRM. It also shows the p values calculated for each target analyte given the data in Table 3.4.

Table 3.5. CA LRM parameters (constants B0 and B1) and p results (calculated) based on the data in Table 3.4.

Chemical	B0	B1	p value
Cadmium	0.2894	3.1764	0.09
Copper	-5.5931	2.5885	0.21
Lead	-4.7228	2.8404	0.40
Mercury	-0.0618	2.6837	0.58
Zinc	-5.1337	2.4205	0.25
HPAH	-8.1922	1.9995	0.15
LPAH	-6.8071	1.8827	0.09
Alpha Chlordane	-3.4080	4.4570	0.23
Dieldrin	-1.8344	2.5890	0.22
Trans Nonachlor	-4.2590	5.3135	0.10
PCBs, total	-4.4144	1.4837	0.08
4,4'-DDT	-3.5531	3.2621	0.09

Using the same logistic regression equation, the probability (p) of cadmium toxicity, based on data from Table 2.4 and parameters from Table 3.5, would be determined as follows:

$$p = e^{0.2894 + 3.1764 * \log(0.15)} / (1 + e^{0.2894 + 3.1764 * \log(0.15)})$$

$$p = e^{-2.328}/(1 + e^{-2.328})$$

$$p = 0.09749/1.09749$$

p = 0.09 (indicated by the dot in Figure 3.1)

The maximum p value among the target analytes from a given sediment sample is referred to as the "Pmax" value for that sample. The Pmax for the results in Table 3.5 corresponds to mercury. This Pmax value of **0.58** is compared to a set of response ranges to determine the CA LRM category for the sample. Table 3.6 provides these categories. A Pmax value of 0.58 places the sample in the Moderate Exposure category (> 0.49 to 0.66 ≤), which yields a category score of **3**. Thus 3 is the CA LRM result for the site in the example.

Table 3.6. Response ranges of Pmax for determination of the CA LRM category score.

Category	Range	Category Score
Minimal Exposure	< 0.33	1
Low Exposure	≥ 0.33 - 0.49 ≤	2
Moderate Exposure	> 0.49 - 0.66 ≤	3
High Exposure	> 0.66	4

Chemical Score Index

The CSI is calculated independently of the CA LRM and requires a four-step process. The first step involves comparing the concentration of each chemical constituent (e.g., the data in Table 3.4) to a series of concentration ranges that correspond to predicted benthic disturbance level (Ritter *et al.* 2012). Where the chemical constituent falls within these ranges determines the chemical exposure score (Table 3.7).

Table 3.7. Chemical concentration ranges for the chemical exposure categories used in the CSI calculation.

	Chemical Exposure Score			
Chemical Constituent	**1**	**2**	**3**	**4**
Copper (mg/kg dry wt.)	≤ 52.8	> 52.8 to ≤ 96.5	> 96.5 to ≤ 406	> 406
Lead (mg/kg dry wt.)	≤ 26.4	> 26.4 to ≤ 60.8	> 60.8 to ≤ 154	> 154
Mercury (mg/kg dry wt.)	≤ 0.09	> 0.09 to ≤ 0.45	> 0.45 to ≤ 2.18	> 2.18
Zinc (mg/kg dry wt.)	≤ 113	> 113 to ≤ 201	> 201 to ≤ 629	> 629
HPAH (µg/kg dry wt.)	≤ 313	> 313 to ≤ 1325	> 1325 to ≤ 9320	> 9320
LPAH (µg/kg dry wt.)	≤ 85.4	> 85.4 to ≤ 312	> 312 to ≤ 2471	> 2471
Alpha Chlordane (µg/kg dry wt.)	≤ 0.50	> 0.50 to ≤ 1.23	> 1.23 to ≤ 11.1	> 11.1
Gamma Chlordane (µg/kg dry wt.)	≤ 0.54	> 0.54 to ≤ 1.45	> 1.45 to ≤ 14.5	> 14.5
DDDs, total (µg/kg dry wt.)	≤ 0.77	> 0.77 to ≤ 3.56	> 3.56 to ≤ 26.37	> 26.37
DDEs, total (µg/kg dry wt.)	≤ 1.19	> 1.19 to ≤ 6.01	> 6.01 to ≤ 45.84	> 45.84
DDTs, total (µg/kg dry wt.)	≤ 0.61	> 0.61 to ≤ 2.79	> 2.79 to ≤ 34.27	> 34.27
PCBs, total (µg/kg dry wt.)	≤ 11.9	> 11.9 to ≤ 24.7	> 24.7 to ≤ 288	> 288

In the second step, the weighted score for each constituent is calculated by multiplying its score by its respective weighting factor, provided in Table 3.8.

$$CSI = \Sigma(w_i * S_i)/\Sigma w$$

Where: S_i = score for chemical i (from Table 3.7);

w_i = weight factor for chemical i (from 3rd column in Table 3.8); and

Σw = sum of all weights.

Table 3.8. Results of CSI calculations based on example dataset in Table 3.4.

Chemical	Score (*determined* from Table 3.7)	Weight (a *constant*)	Weighted Score (*calculated*)
Copper	1	100	100
Lead	2	88	176
Mercury	3	30	90
Zinc	1	98	98
HPAH	3	16	48
LPAH	2	5	10
Alpha Chlordane	3	55	165
Gamma Chlordane	3	58	174
DDDs, total	3	45	135
DDEs, total	2	33	66
DDTs, total	3	20	60
PCBs, total	2	55	110
Sum		603	1232

Weighted Mean (Weighted Score Sum/Weight Sum) = **2.04**

The third step is to calculate the weighted mean score (CSI) by summing the weighted scores for all target analytes and dividing by the sum of all the weights (shown on the bottom of Table 3.8). If data are missing for any constituent, both the score and weight for that constituent become zero, thus adjusting both the sum of the weighted scores and sum of all weights accordingly.

The final part of the process is to compare the CSI value to a series of ranges to determine the CSI category. These ranges are provided in Table 3.9. The CSI value for the example data in Table 3.8 is **2.04**, which places it in the Low Exposure category from Table 3.9, yielding a category score of **2**. Thus 2 is the CSI result for the site in the example.

Table 3.9. CSI threshold ranges.

Category	Range	Category Score
Minimal Exposure	< 1.69	1
Low Exposure	≥ 1.69 - 2.33 ≤	2
Moderate Exposure	> 2.33 - 2.99 ≤	3
High Exposure	> 2.99	4

Integration of the Sediment Chemistry Indices

The final step in calculating the Chemistry LOE is to integrate the results for the two sediment chemistry indices: CA LRM and CSI. This is achieved by calculating the average of their two category scores. If the average falls between two response ranges, the value is rounded up to the next integer. The rounding methodology was specified by the SWRCB to provide a conservative estimate of the Chemistry LOE when the index results disagree. The numeric average can be also expressed as a descriptive category corresponding to the score. For the example data, the category score for the CA LRM was 3 and the category score for the CSI was 2. The average is 2.5, which rounds up to 3, yielding a Chemistry LOE category of Moderate Exposure.

Example of Benthic Community Line of Evidence Calculation for Southern California Marine Bays

For the Benthic LOE, the steps involved are gathering the data, calculating benthic community indices, comparing the index values to response ranges, and integrating the individual index results into a single Benthic LOE. While the general process of calculating the indices is similar between habitat types, the details may differ. The following example calculations are for the Southern California Marine Bays habitat. Most of the benthic index calculations can be made with a hand calculator, but it is simpler to use a spreadsheet program, such as Excel.

Data Preparation

A sample data set is shown in Table 4.17. This table presents species abundances for all the benthic organisms found at the station. Each species is designated as sensitive or not, based on a list of sensitive species for the habitat, and identified as to whether it is a mollusc, crustacean, or neither.

Table 4.17. Example benthic community data set.

Species Name	Abundance	Sensitive	Mollusc	Crustacean
Acteocina inculta	296	Yes	Yes	No
Ampithoe valida	9	Yes	No	Yes
Capitella capitata Cmplx	764	No	No	No
Chironomidae	17	No	No	No
Dipolydora sp	73	No	No	No
Exogone lourei	5	Yes	No	No
Geukensia demissa	1	No	Yes	No
Grandidierella japonica	1116	No	No	Yes
Harpacticoida	1	No	No	Yes
Hemigrapsus oregonensis	1	No	No	Yes
Lineidae	1	No	No	No
Marphysa angelensis	9	No	No	No
Marphysa stylobranchiata	2	No	No	No
Mayerella acanthopoda	1	No	No	Yes
Mediomastus sp	2	No	No	No
Monocorophium insidiosum	3	Yes	No	Yes
Musculista senhousia	27	No	Yes	No
Oligochaeta	1584	No	No	No
Podocopida	1	No	No	Yes
Polydora nuchalis	73	No	No	No
Protothaca sp	1	No	Yes	No
Pseudopolydora paucibranchiata	60	No	No	No
Streblospio benedicti	1459	No	No	No
Tagelus subteres	4	Yes	Yes	No
Tryonia sp	2	No	Yes	No
Tubulanus sp	1	No	No	No
Turbellaria	1	No	No	No

Index of Biotic Integrity (IBI)

The specific data needed to calculate the IBI are the total number of taxa, number of mollusc taxa, abundance of *Notomastus* sp., and number of sensitive taxa. The sensitive species list should be from the list specific to the station's habitat.

The IBI metric values for the sample data set are presented in Table 4.18. There were 27 different taxa represented in the sample, 6 of which were molluscs. There were no occurrences of the polychaete, *Notomastus* sp. Finally, there were 5 sensitive species in the sample, which represents 18.5% of the taxa, based on the following:

% sensitive taxa= (number of sensitive taxa/total number of taxa) * 100

Table 4.18. IBI metrics for sample data set.

Metric	Value
Total Number of Taxa	27
Number of Mollusc Taxa	6
Abundance of *Notomastus* sp.	0
Percentage of Sensitive Taxa	18.5

Once the IBI metrics have been calculated, the next step is to compare the values for each of the metrics to a reference range for that specific metric (Table 4.19). The IBI score is set to zero before comparison to the reference ranges. For each metric that is out of the reference range (above or below), the IBI score goes up by one.

For the sample data set, the total number of taxa, number of mollusc taxa and abundance of *Notomastus* sp. all fell within their reference ranges and therefore did not cause the IBI score to rise. However, the percentage of sensitive taxa was below the reference range and therefore caused the IBI score to rise by one. The final IBI score for this data set is thus 1.

Table 4.19. Reference ranges for IBI metrics.

Metric	Reference Range
Total Number of Taxa	13 - 99
Number of Mollusc Taxa	2 - 25
Abundance of *Notomastus* sp.	0 - 59
Percentage of Sensitive Taxa	19 - 47.1

The final step is to compare the IBI score to the category response ranges (Table 4.20) in order to determine the IBI category and score. For the example, the IBI score of 1 corresponds to the Low Disturbance category with a category score of 2.

Table 4.20. IBI category response ranges.

IBI Score	Category	Category Score
0	Reference	1
1	Low Disturbance	2
2	Moderate Disturbance	3
3 or 4	High Disturbance	4

Relative Benthic Index (RBI)

The RBI is the weighted sum of: 1) several community metrics, 2) the abundances of three positive indicator species, and 3) the presence of two negative indicator species.

The first step is to normalize the values for the benthic community metrics relative to the test sample habitat type. In the case of this example the data come from the Southern California Marine Bays habitat. These values are referred to as the scaled values. The calculations use the following four equations:

Total number of taxa/99

Number of mollusc taxa/28

Number of crustacean taxa/29

Abundance of Crustacea/1693

The results of these calculations using the sample data set are shown in Table 4.21.

Table 4.21. Scaled RBI Metric Values.

RBI Metric	Raw	Scaled
Total number of taxa	27	0.272727
Number of Mollusc taxa	6	0.214286
Number of Crustacean taxa	7	0.241379
Abundance of Crustacea	1132	0.668636

The next step is to calculate the TWV. This is calculated using the following:

TWV = Scaled total number of taxa + Scaled number of mollusc taxa + Scaled number of crustacean taxa + (0.25 * Scaled abundance of Crustacea)

For the sample data set the TWV= 0.89555.

Next, the value for the two NIT is calculated. The two negative indicator taxa are *Capitella capitata* complex and Oligochaeta. For each of these taxa that are present, in any abundance whatsoever, the NIT is decreased by 0.1. Therefore, if neither were found the NIT = 0, if both are found the NIT = -0.2. For our example data, both taxa were present, so the NIT = -0.2.

The next step is to calculate the value for the three PIT. The positive indicator taxa are *Monocorophium insidiosum*, *Asthenothaerus diegensis*, and *Goniada littorea.* First, the PIT value is calculated for each species using the following equations:

$$\frac{\sqrt[4]{Monocorophium\ insidiosum\ \text{abundance}}}{\sqrt[4]{473}}$$

$$\frac{\sqrt[4]{Asthenothaerus\ diegensis\ \text{abundance}}}{\sqrt[4]{27}}$$

$$\frac{\sqrt[4]{Goniada\ littorea\ \text{abundance}}}{\sqrt[4]{15}}$$

The three species PIT values are then summed to calculate the PIT value for the sample. If none of the three species is present, then the sample PIT = 0. For the example data, only *M. insidiosum* was present and the result of its calculation was 0.282205, which in the absence of the other species is also the PIT value.

The next step is to calculate the Raw RBI:

Raw RBI = TWV + NIT + (2 * PIT)

For the sample data set:

Raw RBI = 0.89555 + (-0.2) + (2 * 0.282205) = 1.25996

The final calculation is for the RBI Score:

RBI Score = (Raw RBI - 0.03)/4.69

For the sample data set:

RBI Score = (1.25996 - 0.03)/4.69 = 0.26

The last step in the RBI process is to compare the RBI Score to a set of response ranges to determine the RBI category (Table 4.22). For the example, the RBI score falls into the Low Disturbance category, with a category score of 2.

Table 4.22. RBI category response ranges.

RBI Score	Category	Category Score
> 0.27	Reference	1
0.17 to 0.27	Low Disturbance	2
0.09 to 0.16	Moderate Disturbance	3
< 0.09	High Disturbance	4

Benthic Response Index (BRI)

The BRI is the abundance weighted pollution tolerance score of the organisms present in a given benthic community sample. The higher the BRI score, the more degraded the benthic community present in the sample.

The first step in the BRI calculation is to compute the 4^{th} root of the abundance of each taxon in the sample for which pollution tolerance (P) values are available. For the sample data set, the calculated values are found in Table 4.23. The next step is to multiply the 4^{th} root abundance value by the P value, for each taxon (Table 4.23).

Next, separately sum all of the 4^{th} roots of the abundances and all of the products of the 4^{th} roots of abundance and P values (Table 4.23). Any taxa that lack P values are not included in either sum.

The next step is to calculate the BRI score as:

$$\frac{\sum\left(\sqrt[4]{Abundance}\right)\times P}{\sum \sqrt[4]{Abundance}}$$

For the sample data set, the BRI score is 82.56.

The last step is to compare the BRI score to BRI response range values in Table 4.24 to determine the BRI category and category score. For the example, the BRI corresponds to the High Disturbance category, with a category score of 4.

Table 4.23. BRI component calculations for the sample data set. na = pollution tolerance (P) value not available for that taxon**.**

Taxon Name	Abundance	P	Abundance 4th root	Abundance 4th root * P
Acteocina inculta	296	110.15	4.1478	456.88
Ampithoe valida	9	90.96	1.7321	157.56
Capitella capitata Cmplx	764	130.84	5.2574	687.90
Chironomidae	17	138.87	2.0305	281.99
Dipolydora sp	73	56.56	2.9230	165.33
Exogone lourei	5	41.86	1.4953	62.59
Geukensia demissa	1	na	na	na
Grandidierella japonica	1116	105.98	5.7798	612.57
Harpacticoida	1	32.91	1	32.91
Hemigrapsus oregonensis	1	60.70	1	60.70
Lineidae	1	3.96	1	3.96
Marphysa angelensis	9	97.82	1.7321	169.43
Marphysa stylobranchiata	2	94.27	1.1892	112.10
Mayerella acanthopoda	1	22.26	1	22.26
Mediomastus sp	2	57.84	1.1892	68.78
Monocorophium insidiosum	3	103.42	1.3161	136.11
Musculista senhousia	27	68.05	2.2795	155.12
Oligochaeta	1584	69.96	6.3087	441.35
Podocopida	1	na	na	na
Polydora nuchalis	73	108.42	2.9230	316.91
Protothaca sp	1	55.94	1	55.94
Pseudopolydora paucibranchiata	60	81.68	2.7832	227.34
Streblospio benedicti	1459	61.83	6.1804	382.11
Tagelus subteres	4	37.28	1.4142	52.73
Tryonia sp	2	127.95	1.1892	152.16
Tubulanus sp	1	0.61	1	0.61
Turbellaria	1	44.95	1	44.95
Sum			58.8708	4860.23

Table 4.24. BRI category response ranges and category scores.

BRI Score	Category	Category Score
<39.96	Reference	1
39.96 to 49.14	Low Disturbance	2
49.15 to 73.26	Moderate Disturbance	3
> 73.26	High Disturbance	4

River Invertebrate Prediction and Classification System (RIVPACS)

The RIVPACS index calculates the number of reference taxa present in the test sample (observed or "O") and compares it to the number expected to be present ("E") in a reference sample from the same habitat. The data needed for the calculation are the latitude, longitude, and depth of the station, along with the taxa names and abundance data (the first two columns from 4.23). For the example data, the station information parameters are: Latitude = 33.64565, Longitude = - 117.88676, with a depth of 5 m and is in the Southern California Marine Bays habitat (habitat C). For SCCWRP online calculator, all of this data is submitting using an Excel template which is provided on the web site.

The computer program calculates the number of expected reference site species (E), which is 4.1794 for the example data set. The number of observed species (O) is also determined, which is equal to five in this case. The RIVPACS score is therefore 1.1964 (5/4.1794).

The score is then compared to the response ranges in Table 4.25 to determine the RIVPACS category and category score. For the example, the RIVPACS score corresponds to the Low Disturbance category, with a category score of 2.

Table 4.25. RIVPACS category response ranges and category scores.

RIVPACS Score	Category	Category Score
> 0.90 to < 1.10	Reference	1
0.75 to 0.90 or 1.10 to 1.25	Low Disturbance	2
0.33 to 0.74 or > 1.25	Moderate Disturbance	3
< 0.33	High Disturbance	4

Integration of Benthic Community Indices

The Benthic LOE category is based on the integration of the four benthic index category scores. The integration is accomplished by calculating the median of the four individual index category scores. If the median falls between two adjacent categories, the value is rounded up. For the sample data set, the index category scores were 2, 2, 2, and 4 for the IBI, RBI, RIVPACS, and BRI, respectively. The median for those values is 2. Therefore, the Benthic LOE for the example is Low Disturbance.

Example of Toxicity Line of Evidence Calculation

Data Preparation

The raw data from at least two toxicity test methods are compiled and the mean response (e.g., % survival) for each sample is calculated. The response data must be control normalized ((data from assessment station/control data) * 100). T-tests must be performed on the raw data from the assessment station versus control response. A sample data set containing results from two tests, the amphipod *E. estuarius* survival test and sediment-water interface test using the mussel *M. galloprovincialis* embryo development, is shown in Table 5.6.

Table 5.6. Toxicity data used in the example.

Test Method	*E. estuarius* survival	*M. galloprovincialis* Percent Normal Alive
Raw Station Response	90%	57%
Raw Control Response	92%	92%
Control Normalized Response	98%	62%
Statistical Difference from Control	No	Yes

Individual Toxicity Test Result Classification

The data from each toxicity test are compared to a series of response ranges that are unique to each test method (Table 5.2). Note that in the case of *Eohaustorius* and *Mytilus*, for the Nontoxic category, the *non-normalized* mean response for the assessment station is compared to the range, whereas for the Moderate and High toxicity categories, the *control-normalized* response is compared to the ranges. Figures 5.8 and 5.9 show the data classification results for each test organism. The toxicity category is based on both the response level and whether a statistically significant difference is present. The raw *Eohaustorius* survival value of 90% classifies it in the Nontoxic category (Figure 5.8) and the *Mytilus* percent normal-alive value of 62% (control normalized) classifies is in the Moderate Toxicity category (Figure 5.9).

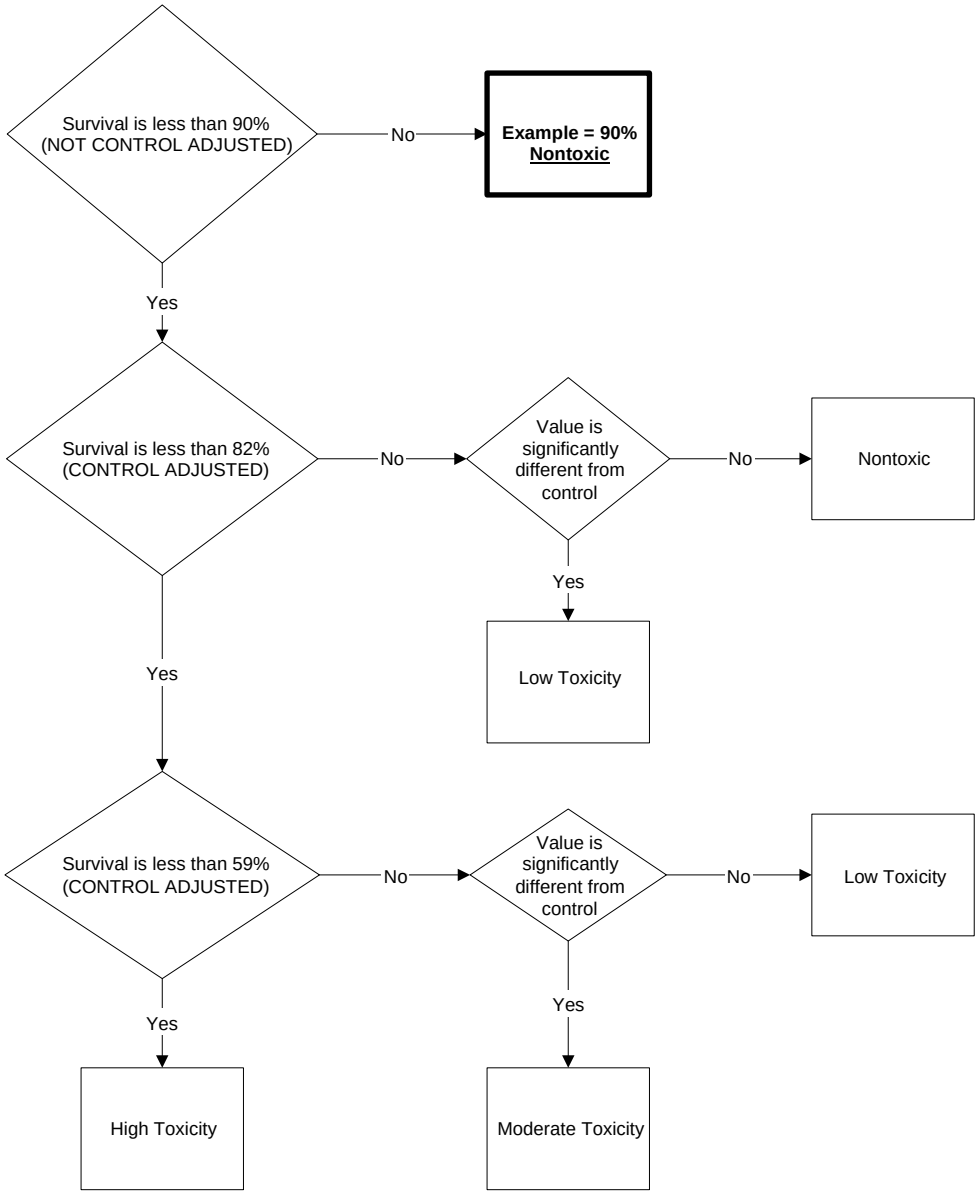

Figure 5.8. Flow chart for assignment of toxicity response category for *E. estuarius* example data.

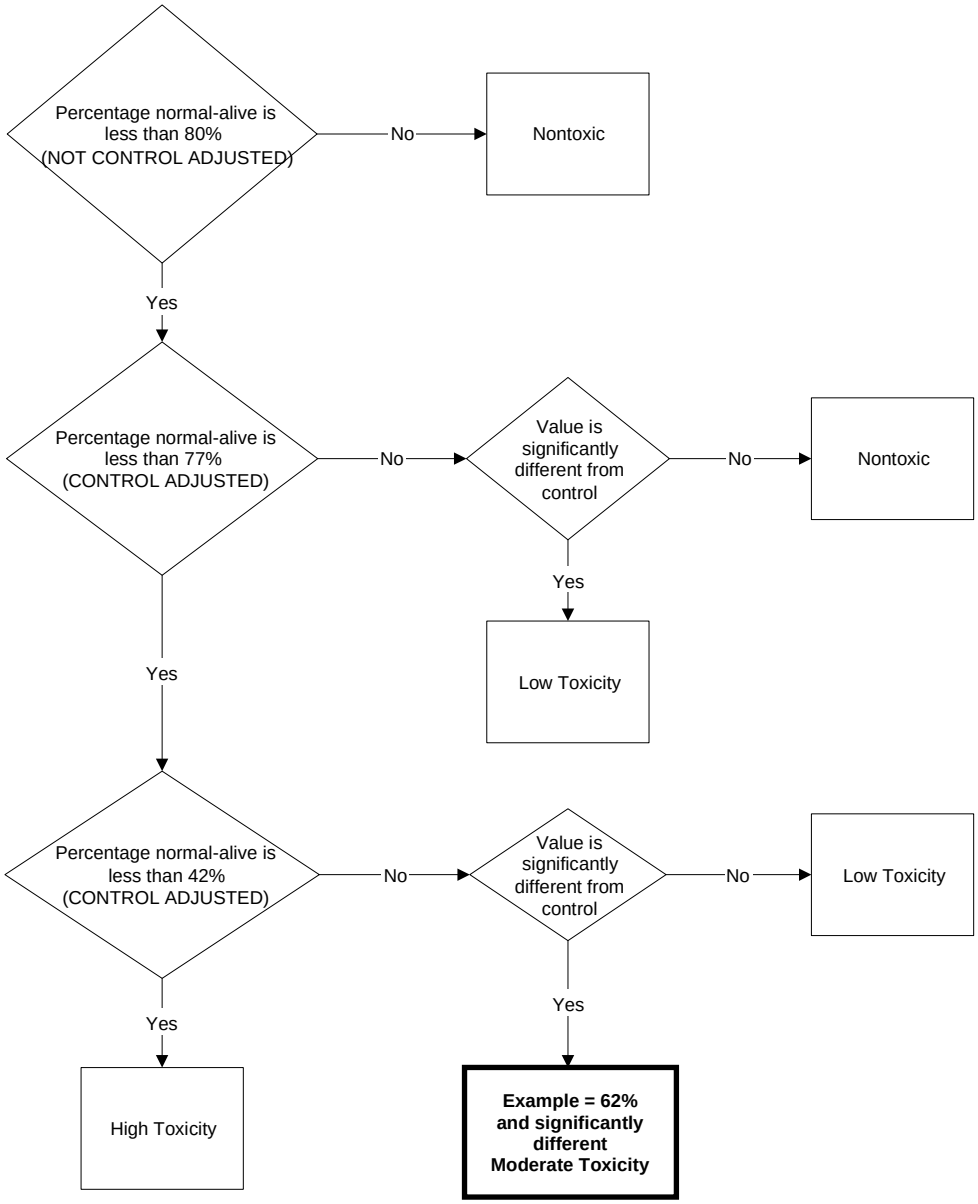

Figure 5.9. Flow chart for assignment of toxicity response category for *M. galloprovincialis* example data.

Integration of Toxicity Test Results

The final step in determining the Toxicity LOE is to integrate the toxicity test results. This is accomplished by assigning numeric category scores for each test result (Nontoxic = 1, Low Toxicity = 2, Moderate Toxicity = 3, High Toxicity = 4). The arithmetic mean of all tests corresponds to the Toxicity LOE category. Means with decimal values of 0.5 and higher are rounded up to the nearest category. Means with decimal values of less than 0.5 are rounded down.

For the example data, the *Eohaustorius* result is classified as Nontoxic (score = 1) and the *Mytilus* result is classified as Moderate Toxicity (score = 3). The mean category score for the two toxicity tests for this station is 2, which corresponds to the Low Toxicity category for the Toxicity LOE.

Example Station Assessment for Southern California Marine and Polyhaline San Francisco Bay Habitats

The examples that were presented in Chapters 3, 4, and 5 had the following outcomes for the three LOEs:

- Chemistry LOE = ***Moderate***
- Benthic LOE = ***Low***
- Toxicity LOE = ***Low***

Applying this information to the matrix, we see that this combination corresponds to Line of Evidence Category Combination in row 38, which yields a Station Assessment (Site Condition) category of ***Possibly Impacted.*** The text in this row of the table is bold and italicized in Table 6.2, which is a subset of Table 6.1 shown for illustrative purposes.

Table 6.2. Subset of rows from Table 6.1 showing the results from the sample dataset.

Line of Evidence Category Combination	Chemistry LOE: Sediment Chemistry Exposure	Benthic LOE: Benthic Community Condition	Toxicity LOE: Sediment Toxicity	Station Assessment (Site Condition)
37	Moderate	Low	Nontoxic	Unimpacted
38	***Moderate***	***Low***	***Low***	***Possibly impacted***
39	Moderate	Low	Moderate	Possibly impacted
40	Moderate	Low	High	Possibly impacted