Habitat and Macroinvertebrate Assessment in San Pablo Creek

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Abstract San Pablo Creek is an urban creek that flows through El Sobrante, San Pablo and Richmond, California. San Pablo Creek has three primary land uses in its watershed: an uninhabited park area, a residential area, and an industrial sector. In this study, the overall health of each zone was evaluated using habitat quality and macroinvertebrate abundance. Four sites were selected within each of the three land use zones. At each site a habitat assessment was performed using EPA guidelines for habitat characteristics such as riparian abundance and creek-bed substrate. Macroinvertebrates were collected using a D-net, then counted and identified to the family level. An index of water quality was constructed using the EPA's Macroinvertebrate Survey and Water Quality Rating, where the water quality is rated by comparing the results of the macroinvertebrate collection to a given range of overall scores. The park area had higher scores than the residential and industrial areas, in both habitat assessment and macroinvertebrate index. However, one-way ANOVA testing showed no significant differences in the mean scores between the three regions.

Introduction

San Pablo Creek is part of the San Pablo Watershed system. It originates near Orinda, where the upper section drains into San Pablo Reservoir. The section below the dam travels through a park, a residential region, and an industrial area, until it flows into San Pablo Bay (The San Pablo Bay Watershed Restoration Program 2002). This is an urban creek and so is likely to be quite contaminated, as runoff from urban surfaces contains a wide range of pollutants (Bhaduri *et al.* 2000). Water quality is important to the creek for many reasons. Much of the residential portion of the creek passes through people's backyards, so human contact with the creek is inevitable. This human contact makes the creek an important part of the community. Stream flow provides input to groundwater (Rose and Peters 2001), and there is some evidence that pollutants can leach through soils into local aquifers (Ibe *et al.* 2001). The creek drains into San Pablo Bay, where it passes through a salt marsh that is the home of several endangered species (SPAWNERS, 2003). Additionally, fish and other aquatic organisms live in the creek and need a healthy environment to survive.

Rapid bioassessment methods are commonly used to measure stream health (Resh *et al.* 1995). It is a relatively inexpensive way to assess human impact on streams and rivers. Many different metrics have been developed by the Environmental Protection Agency (EPA) for water quality monitoring in the US, and are currently used by 85% of state water quality programs (Resh *et al.* 1995). The EPA water quality monitoring program now includes aquatic macroinvertebrate assessment, as many species are very sensitive to poor conditions (USEPA, 1997). In-stream characteristics are also included in assessment procedures because aquatic invertebrates may show a response to changes in these, despite a lack of noticeable water quality problems (Resh *et al.* 1995).

The purpose of this study was to test the water quality in San Pablo Creek. The upper section of the creek, below the dam, flows through a park. The middle section passes through a residential area, and the downstream section is mostly industrial. The different land uses surrounding the creek might offer possible reasons for impairment. This study looked for differences in water quality between the different land use areas, evaluated using EPA guidelines for stream biosurveys, specifically, habitat score and macroinvertebrate assessment (USEPA 1997, Barbour *et al.* 1999). The hypothesis was that a lower score of overall health would be found in the downstream, industrial sector. Conversely, a higher score was expected in the upstream section of the creek, the park zone. Scores in the residential area were expected to lie somewhere in between those of the other two land use segments.

Methods

San Pablo Creek spans approximately 16 km, beginning above San Pablo Reservoir and ending at San Pablo Bay. About 3 km of the upper reach is park and grassland, and basically uninhabited. Approximately 10 km of the middle section is residential, while the remaining 3 km downstream is mostly industrial. This study compared overall health of the creek in the different land use segments. Overall health was defined through the habitat and macroinvertebrate assessments, with a score for each assigned to each site using EPA guidelines (USEPA 1997, Barbour *et al.* 1999). Table 1 lists the macroinvertebrate species designated as indicator species for macroinvertebrate assessment, and the Habitat Assessment scoring sheet is found in Appendix 1.

The individual sites were selected using stratified random sampling; that is, within the designated land use segments sites of similar characteristics were chosen for sampling (Horne 2003, pers. comm.). Each site sampled had a dominant mud or silt substrate, with some bank vegetation wherever possible. Riffled or cobbled substrate sites were not used because not enough sites were available. For purposes of replication four sites were chosen within each land use segment, i.e. industrial, residential, and park, for a total of twelve sites tested. Each site was a minimum of 100 m apart to ensure some degree of site independence. Within each segment sampling was done working downstream to upstream in order to minimize possible confounding factors caused by upstream disturbances.

A rapid biological assessment was done at each site to assess the condition of the aquatic community and a habitat assessment score was tabulated using the EPA's Field Assessment Data Sheet (Barbour *et al.* 1999) (Appendix 1). The habitat assessment rates stream characteristics such as embeddedness (amount of gravel, cobbles or silt in the stream bed), sediment deposition, velocity/depth, bank stability, channel flow and width of the riparian zone. The total score is represented as a percentage of a total possible score of 200.

Macroinvertebrate samples were taken from the stream using D-net muddy-bottom sampling methods as outlined in EPA stream monitoring guidelines (USEPA 1997). This involves using the net to "bonk" the bank vegetation and streambed and catch any macroinvertebrates found there. The net is then rinsed into a sampling tray to look for any organisms. Each species found in the sampling tray was counted. One of each species was then narcotized using seltzer water, which causes them to relax and makes identification easier (Horne 2003, pers. comm.). Each of these narcotized organisms were stored in ethanol and identified to the family level. The rest of the organisms were returned to the creek. The species counts, based on taxonomic family, were then recorded in the macroinvertebrate assessment shown in table 1.

MACROINVERTEBRATE COUNT

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1. Identify the macroinvertebrates in your sample and assign them letter codes based on their abundance: R (rare) = 1-9 organisms; C (common) = 10-99 organisms; and D (dominant) = 100 plus organisms.

Group I Sensitive	Group II Somewhat-Sensitive	Group III Tolerant
____ Water penny larvae	____ Beetle larvae	____ Aquatic worms
____ Hellgrammites	____ Clams	____ Blackfly larvae
____ Mayfly nymphs	____ Crane fly larvae	____ Leeches
____ Gilled snails	____ Crayfish	____ Midge larvae
____ Riffle beetle adult	____ Damselfly nymphs	____ Snails
____ Stonefly nymphs	____ Scuds	
____ Non net-spinning caddisfly larvae	____ Sowbugs	
	____ Fishfly larvae	
	____ Alderfly larvae	
	____ Net-spinning caddisfly larvae	

2. To calculate the index value, add the number of letters found in the three Groups above and multiply by the indicated weighting factor.

Group I	Group II	Group III
____ (# of R's) x 5.0 = ____	____ (# of R's) x 3.2 = ____	____ (# of R's) x 1.2 = ____
____ (# of C's) x 5.6 = ____	____ (# of C's) x 3.4 = ____	____ (# of C's) x 1.1 = ____
____ (# of D's) x 5.3 = ____	____ (# of D's) x 3.0 = ____	____ (# of D's) x 1.0 = ____
Sum of the index value for Group I = ____	Sum of the index value for Group II = ____	Sum of the index value for Group III = ____

To calculate the water quality score for the stream site, add together the index values for each group. The sum of these values equals the water quality score.

Water quality score = ____

Compare this score to the following number ranges to determine the quality of your stream site.

- Good >40
- Fair 20 - 40
- Poor <20

Table 1. EPA guidelines for calculating macroinvertebrate index score. When the counts are totaled an overall assessment is made to determine water quality. From USEPA 1997.

For the statistical analysis a one-way ANOVA was used to look for differences in habitat assessment score and macroinvertebrate score between the different land use segments. A regression was also done to look for correlation between habitat score and macroinvertebrate assessment at each sampling site.

Results

The raw data detailing individual habitat scores at each site are shown in Appendix 2. A one-way ANOVA comparing habitat assessment scores from the three land use regions showed no significant difference between any of the three groups. The calculated F-value was 2.79, which was less than the F-critical value of 4.26, and p=0.11. Figure 1 shows the histogram of the mean habitat scores in the different land use zones.

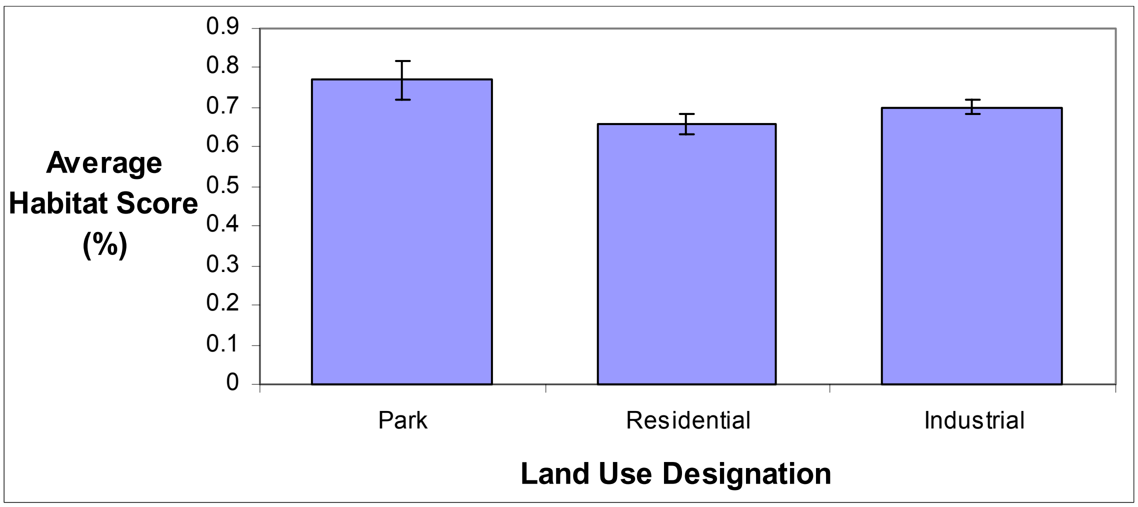

Figure 1. Histogram of the mean habitat assessment scores in the different land use zones. The park region had a higher mean value than the other zones, with residential having the lowest mean score. A one-way ANOVA indicated that there were no significant (p=0.11) differences between the three land use segments.

Raw data detailing the number and types of species collected are shown in Appendix 2. A one-way ANOVA comparing macroinvertebrate score between the three land use zones showed no significant difference between the three zones. The F-value was 1.25 and was below the F-critical value of 4.25, with p=0.33. Histogram results of the mean macroinvertebrate index scores are shown in figure 2.

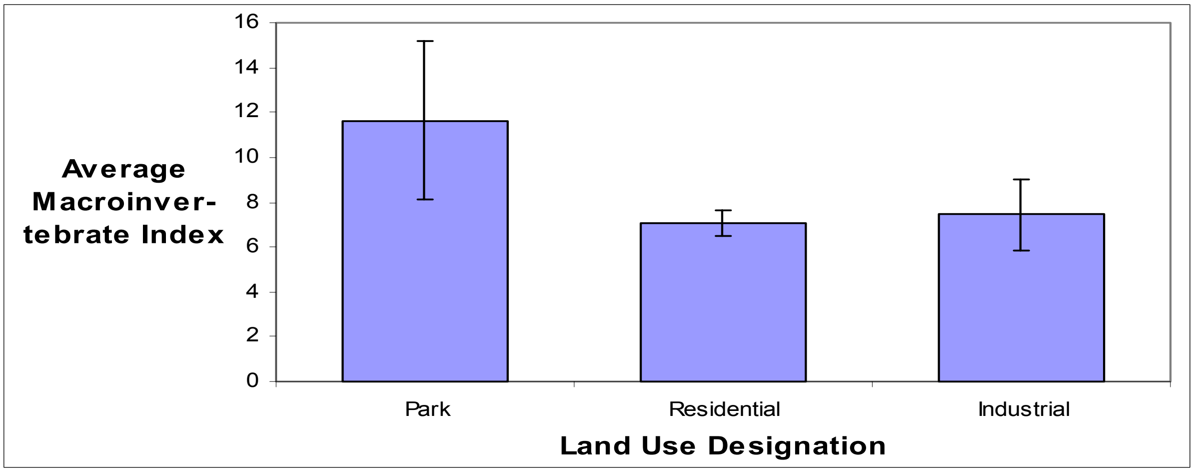

Figure 2. Histogram of the mean macroinvertebrate index score in each land use zone. Although the park region had a higher mean score, a one-way ANOVA showed no significant ($p=0.33$) difference between the three zones.

A plot of habitat assessment score and macroinvertebrate index is shown in figure 3. R^2 in this regression is 0.04 so no trendline has been shown.

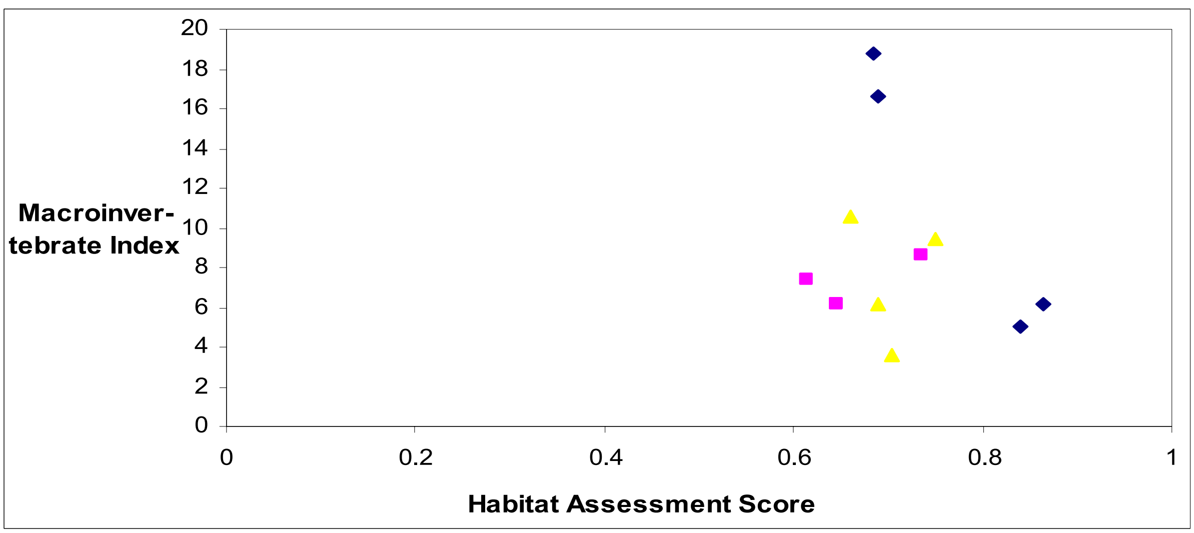

Figure 3. Plot of habitat assessment over macroinvertebrate index. No clear trend is seen between habitat score and macroinvertebrate index over the three land uses. Blue diamonds represent the park zone, pink squares are residential (2 are identical) and yellow triangles are the industrial zone. $R^2 = 0.04$.

Discussion

The EPA guidelines, as shown in Table 1, consider a macroinvertebrate score less than 20 to indicate "poor" water quality. San Pablo Creek had macroinvertebrate index scores below 20 in all three zones. No other macroinvertebrate surveys on local creeks could be found to use as a reference for comparison, so it is not known if this rating should apply to creeks in Northern California. However, this survey was designed to look for differences within the creek, and none were found. No statistical differences in habitat assessment or macroinvertebrate score were seen between the three land use zones of the creek. It can be seen in Figs. 1 and 2 that, although not statistically significant, the residential region had lower mean scores in both habitat assessment and macroinvertebrate index than either the park or industrial regions. This does not support the hypothesis that the industrial zone would show the highest level of impairment, as indicated by lower habitat assessment and macroinvertebrate index scores.

No relationship was seen between habitat assessment and macroinvertebrate score (Fig. 3). This indicates that habitat condition, as observed in the three land use zones, is not correlated to the macroinvertebrate index. This would indicate that the presence or absence of macroinvertebrate species in the creek are due to factors which may or may not include habitat characteristics.

Although the initial hypotheses were not supported by the results, it was interesting to see that the creek showed similar levels of impairment (or lack of impairment) over the different land use regions. The results do not offer any conclusive indication if the creek is healthy or not, as some pollution-sensitive macroinvertebrate species were found in all three zones, but not in any large quantity.

One issue to be recognized about this survey is that macroinvertebrate sampling, and rapid bioassessment methods in general, are often an important first step in a more thorough assessment program. Due to the nature of the sampling methods (small samples and lack of replicates), when impairment is detected, Resh (1995) recommends a more detailed study to determine where the problems are. Further water quality tests could be done in the creek to discover why certain organisms are present or not. For example, a lack of dissolved oxygen (DO) can be fatal for sensitive organisms such as stoneflies, but more detailed chemical testing might be able to ascertain why DO was low in that spot (Resh *et al.* 1995).

A possible reason no differences in impairment were determined is that the community is already taking steps to protect the creek. A local group, SPAWNERS, has organized several restoration projects, designed to keep the community involved in the creek's health. These projects have focused specifically on replacing invasive vegetation with native plants, as well as promoting community awareness of the damages of pollutants (SPAWNERS 2003). There is great potential for human impact on the creek, as with any urban creek, because so many people are in direct contact with it. A higher level of human contact may have influenced the habitat assessment and macroinvertebrate index scores found in the residential zone. While sampling in the residential area, a large amount of garbage was observed. The residential area has the highest level of human activity near the creek since the creek passes through many backyards. The park area has no nearby houses and a very wide riparian zone, and the industrial region has a fairly wide riparian zone, with a fence to keep people out of the creek in this area. The residential section does not have any protection of this type.

Another factor that may have influenced the results of this project was the weather. All of the sampling was done in spring, but the weather conditions varied. The park zone was sampled after about a week of dry, sunny weather. However, the residential and industrial areas were sampled after several weeks of consistent rain. This would probably have an effect on the types of organisms found. A more thorough study of the creek might need to incorporate testing either seasonally or at least during several different weather patterns to determine how rain, or lack of rain, influences the macroinvertebrates found in the creek.

In conclusion, the habitat assessment and macroinvertebrate survey done in San Pablo Creek did not show any differences in impairment between the three land-use sections. Further studies might incorporate chemical water quality testing to more accurately assess the condition of the creek in the different zones. Additionally, studies done during different weather conditions could be useful when assessing macroinvertebrate populations in the creek.

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Appendix 1. From Barbour *et al.* 1999.

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE__________	STREAM CLASS	
LAT ______________ LONG ______________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME ________ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Appendix 1, continued.

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ___________

Appendix 2. Raw data – organisms collected. I, II, or III represents the sensitivity group as assigned by the EPA, shown in table 1.

PARK

Site 1

Diptera (chironomid/midge larva) 1	III
Gastropoda (snail) 2	III
Plecoptera (stonefly) 1	I
Tricoptera (net spinning caddisfly) 1	II
Ephemeroptera (mayfly) 1	I
Amphipoda (scud) 2	II

Site 2

Ephemeroptera (mayfly) 2	I
Hemiptera (water strider) 1	
Gastropoda (snail) 1	III
Plecoptera (stonefly) 1	I
Diptera (chironomid/midge larva) 14	III

Site 3

Arachnid (Spider) 1	
Hemiptera (water strider) 7	
Ephemeroptera (mayfly) 1	I

Site 4

Ephemeroptera (mayfly) 2	I
Hemiptera (bugs) 14	
Diptera (chironomid/midge larva) 1	III

RESIDENTIAL

Site 1

Hemiptera (water strider) 10	
Ephemeroptera (mayfly) 7	I
Oligochaete (segmented worm) 4	III

Site 2

Hemiptera (water strider) 8	
Oligochaete (segmented worm) 3	III
Ephemeroptera (mayfly) 6	I
Turbellaria (flatworm) 1	III
Diptera (chironomid/midge larva) 3	III

Site 3

Hemiptera (water strider) 7	
Ephemeroptera (mayfly) 5	I
Oligochaete (segmented worm) 2	III

Site 4

Diptera (chironomid/midge larva) 4	III
Oligochaete (segmented worm) 1	III
Ephemeroptera (mayfly) 5	I
Hemiptera (water strider) 6	

INDUSTRIAL

Site 1

Oligochaete (segmented worm) 4	III
Hemiptera (water strider) 7	
Ephemeroptera (mayfly) 1	I
Coleoptera (beetle larva) 2	II

Site 2

Oligochaete (segmented worm) 8	III
Diptera (chironomid/midge larva) 4	III
Gastropoda (snail) 3	III

Site 3

Ephemeroptera (mayfly) 2	I
Diptera (chironomid/midge larva) 1	III
Oligochaete (segmented worm) 1	III
Coleoptera (beetle larva) 1	II

Site 4

Oligochaete (segmented worm) 2	III
Hemiptera (water strider) 6	
Ephemeroptera (mayfly) 1	I

Appendix 2. Raw data, continued. M.I. indicates macroinvertebrate index as calculated using the EPA guidelines listed in table 1. Habitat score was tabulated using the EPA worksheet shown in appendix 1.

PARK	**M.I.**	**Habitat Score**	**RESIDENTIAL**	**M.I.**	**HS**	**INDUSTRIAL**	**M.I.**	**HS**
Site 1			**Site 1**			**Site 1**		
Group I	10		Group I	5		Group I	5	
Group II	6.4		Group II	0		Group II	3.2	
Group III	2.4		Group III	1.2		Group III	1.2	
total	**18.8**	**0.685**	**total**	**6.2**	**0.645**	**Total**	**9.4**	**0.75**
Site 2			**Site 2**			**Site 2**		
Group I	10		Group I	5		Group I	0	
Group II	0		Group II	0		Group II	0	
Group III	6.6		Group III	3.6		Group III	3.6	
total	**16.6**	**0.69**	**total**	**8.6**	**0.735**	**Total**	**3.6**	**0.705**
Site 3			**Site 3**			**Site 3**		
Group I	5		Group I	5		Group I	5	
Group II	0		Group II	0		Group II	3.2	
Group III	0		Group III	1.2		Group III	2.4	
total	**5**	**0.84**	**total**	**6.2**	**0.645**	**Total**	**11**	**0.66**
Site 4			**Site 4**			**Site 4**		
Group I	5		Group I	5		Group I	5	
Group II	0		Group II	0		Group II	0	
Group III	1.2		Group III	2.4		Group III	1.2	
total	**6.2**	**0.865**	**total**	**7.4**	**0.615**	**Total**	**6.2**	**0.69**