UPPER KINNICKINNIC RIVER 2011 BIOASSESSMENT PROJECT

A report presented to the Kiap-TU-Wish Chapter of Trout Unlimited

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Objectives

The primary objective of this study was to use an invertebrate-based index of biotic integrity to determine the ecological condition of the Kinnickinnic River at selected upper-river (upstream from River Falls, WI) sites. Results from these sites complement data collected by the City of River Falls from three sites in/near the City, and data from selected lower-Kinnickinnic sites collected in conjunction with this study, but funded by the University of Wisconsin – River Falls (UWRF) Summer Scholar Program. This report primarily describes the upper-Kinnickinnic project, but also includes lower-Kinnickinnic results for comparison.

Purpose

Results from this study provide a baseline data set on ecological condition, invertebrate community, and benthic habitat. These data will be used as a benchmark to which future assessment data can be compared, so that changes in river condition can be detected over time.

Background and Rationale

This work builds on previous efforts by UWRF professor emeritus Clarke Garry to catalog the benthic macroinvertebrate community of the Kinnickinnic River. He collected macroinvertebrate specimens at 17 locations along the river, identified them to the species level, and recorded their presence and absence throughout an entire calendar year. His report (Garry, 2006) did not include bioassessment data or other quantitative analyses from his 2001 survey, but did include earlier bioassessment results from the Wisconsin Department of Natural

Resources (WDNR), and 2004-2005 bioassessment data from work sponsored by the City of River Falls.

In 2009 and 2010, we conducted studies of the benthic macroinvertebrate communities occurring at tributary-inflow sites on the Upper Kinnickinnic River. This work, funded by UWRF, focused on possible influence of the four named tributaries (Parker, Kelly, Ted, and Nye Creeks) on macroinvertebrate communities and biotic integrity of the main stem of the river. Sampling followed the methodology used for the City's annual monitoring program, and data analysis included traditional statistical analyses of invertebrate community composition, plus biotic-integrity analyses using the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1982; 1987), which is also used by WDNR and City programs (Garry 2006).

The present study was initiated because so few macroinvertebrate bioassessment data exist for the Kinnickinnic, despite its being a highly rated trout stream. Various stakeholders, including riparian landowners along the length of the river, have interests in maintaining and improving the ecological integrity of the river, so there is a need for assessment data from upper river reaches down to the river's mouth. Also, various parties are working to reduce negative impacts to the river, so an assessment of present condition that can serve as a benchmark for future comparisons will help in their work. Such future efforts will also provide a long-term data set that will help us understand the natural fluctuations in the river, which observations over the past few years suggest can be considerable.

Finally, we attempted to address a limitation of HBI-based bioassessment. The HBI is limited because it focuses solely on invertebrates collected in riffle habitats with their typical gravel/cobble substrate. It does so because such habitats generally have the highest diversity of macroinvertebrates, especially those that are considered to be good indicators of river condition. Also, such habitats are preferred by cold-water fish species as spawning and feeding habitat. However, gravel/cobble substrates are not the only, or even the most common, habitats in the Kinnickinnic River, so the HBI may tend to overestimate ecological integrity, especially by ignoring the abundant, but generally less-desirable, sand and silt habitats in the river. In order to improve our understanding of the actual condition of the river, we included a quantification of benthic habitat types in this study. Bioassessment tools generally do not include a weighting or scaling method to account for relative abundance of gravel/cobble habitats, so we hope to build a data set that may be used to try to develop such a method.

Methods and Materials

Sample selection

We selected four upper-Kinnickinnic sites for sampling. Selection criteria were that sites should be: 1) locations sampled by Dr. Garry in 2001, 2) not overlapping with City of River Falls sites, 3) relatively safe and easy to access from public roads and to work in, 4) as evenly spaced along the river as possible, 5) locations sampled by us in the last two years, where possible, and 6) having some gravel/rock substrate present. We initially scouted all the upper-Kinni sites from Dr. Garry's previous work, and selected four sites that seemed to best meet the selection criteria. Site locations, as well as their correspondence to Garry's 2001 sites, are indicated in Table 1. Downstream sites are also included in Table 1. Figure 1 shows all 2011 sample sites overlaid on Garry's 2001 map (reproduced from Garry, 2006).

Table 1. Sample sites upper- and lower-Kinni 2011 bioassessment projects, with corresponding site number from 2001 survey (Garry, 2006).

2011 Site #	2001 Site #	Site Location/Access	River mile fr. mouth
		Upstream Sites	
UP1	11	Immediately upstream fr. North River Road bridge and Ted Creek confluence	16.0
UP2	12	Immediately upstream from CTH JJ bridge	17.4
UP3	13	Immediately upstream from CTH J bridge and Kelly Creek confluence	18.0
UP4	15	Immediately upstream from CTH N bridge	20.6
		Downstream Sites	
DN1	2	Immediately upstream from CTH F bridge	2.1
DN2	btw. 3&4	Public access trail with parking on CTH FF, ¼ mile east of 1130th Street	4.9
DN3	6	Immediately upstr. fr. Rocky Branch confluence;via trail fr. River Ridge Rd.	8.4
DN4	n.a.	0.2 mi. downstr. fr. Lower Pool (Lake Louise) dam; via trail from Glen Park	8.8

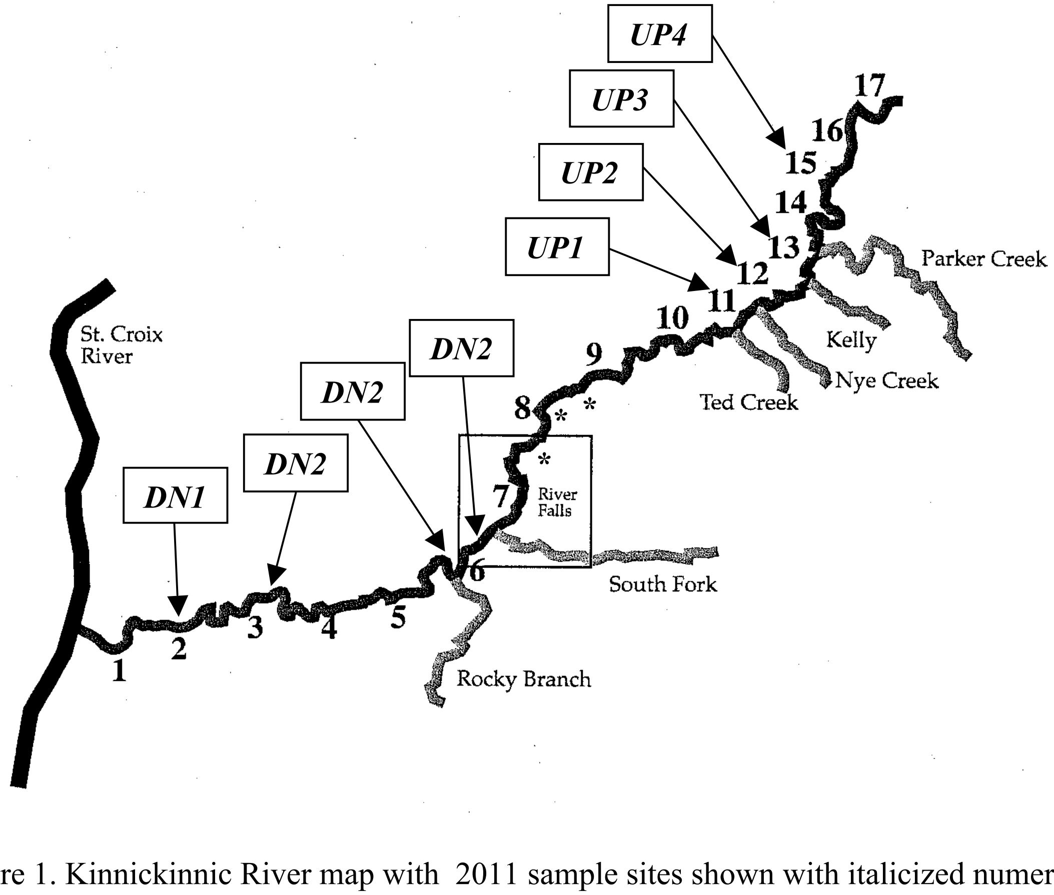

Figure 1. Kinnickinnic River map with 2011 sample sites shown with italicized numerals and arrows, and Garry's 2001 sample sites shown in normal type. Asterisks indicate locations of City of River Falls monitoring sites (data not included in this report).

Macroinvertebrate Sampling and Habitat Assessment

We collected macroinvertebrate samples in June, following the methodology used for the City monitoring program: three replicate, timed, D-net samples collected within a single gravel/cobble patch, with supplemental variables including current velocity, water depth, substrate type, channel width, and canopy coverage. Sample processing also followed City methods: laboratory picking of 150 invertebrates using random selection of squares in a gridded tray. To quantify benthic habitats, we walked a 50-meter length of river, locating, categorizing, and measuring dimensions of each non-sand habitat patch encountered during the survey walk.

Analysis

Analyses were based on identifications of specimens down to the lowest practical taxonomic level. For insects, this was usually the genus level, except in the case of the midge family, Chironomidae. It is very time-consuming to identify this family to the genus level, so this effort is often considered infeasible in bioassessment efforts such as this project. While it would be desirable to identify this very-diverse family to genus, the task was cost-prohibitive in this project. Some non-insect groups (e.g., segmented worms, roundworms, molluscs) were also identified only to higher taxonomic levels because of the difficulty of more-precise identifications. Fortunately, these groups provide relatively little useful information in bioassessment because they are, 1) not very abundant and/or diverse in most stream communities, and/or 2) poorly understood as indicators of stream ecological integrity, partly because few researchers have the technical ability to identify them reliably, so these groups have not been well studied.

We calculated the HBI for each sample, as well as several other metrics. HBI is a weighted average of the taxa comprising the community weighted by their “Tolerance” value, which is an indication of the degree to which the taxon can tolerate pollution and other disturbances. High Tolerance corresponds to lower sensitivity to habitat disruption, hence higher HBI values are obtained from communities that can withstand significant disruption. In short, lower HBI values are desirable, because a low-tolerance community can only be sustained in a relatively undisturbed habitat.

Shannon Diversity is a probability-based estimate of taxonomic diversity, and Simpson’s Diversity Index is similar, but tends to avoid excessive influence of rare taxa. Pielou’s Evenness assesses the degree to which different taxa are evenly distributed in terms of their relative abundance in a community; i.e., it indicates whether a community is largely dominated by one or two very abundant taxa, or whether no taxa have a distinct numerical advantage. Taxa Richness is a simple count of the number of different taxonomic groups found in a community. Richness and Evenness are the two components of taxonomic “diversity”, and otherwise rather abstract concept. The two diversity metrics and the evenness metric are unitless, so when viewed alone, they cannot be interpreted. They can only be used meaningfully as comparative measures among sites.

Finally, we used three metrics based on the three most-sensitive (least tolerant) insect orders: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The three are collectively referred to as “EPT”, and the metrics used were EPT Family Richness, EPT Genus Richness, and EPT %. The first two were simple counts of EPT families or genera in each sample, and the third was a calculation of the proportion of each sample comprised by all individuals in the three orders. We compared these metrics among sites using non-parametric statistical tests, because the small number of replicate samples meant that we could not assume the assumptions would be met for parametric analysis.

Results

Macroinvertebrates

We summarized the macroinvertebrate data using several metrics that are commonly used to indicate ecological integrity of streams. These values varied among the four upstream sites (Table 2), indicating varying community characteristics among the four sites. HBI at upstream sites UP2 and UP3 were lower (indicating greater ecological integrity) than those at UP1 and UP4 (Figure 2; statistically significant at 95% confidence level). However, both diversity metrics and Pielou's evenness were lowest at UP3 (significant at 95% confidence level), as were richness and all three EPT metrics (significant at 90% confidence level).

Table 2. Summary macroinvertebrate community metrics from upstream and downstream Kinnickinnic River sites, 2011. An asterisk (*) indicates the "best" value among the four upstream or four downstream sites, while a "-" symbol indicates the "worst".

Site ID	# EPT[1] families/ sample	# EPT[1] genera/sample	% EPT[1] individuals per sample	mean Shannon diversity[2]	mean Simpson diversity[2]	mean Taxa Richness[3]	mean Pielou's Evenness[2]	mean HBI[4]
Upstream Sites								
UP1	2	2.33	23*	1.22*	0.63*	7.67	0.63*	4.85
UP2	3*	3.33*	11	1.12	0.5	10.22*	0.48	3.82*
UP3	0.67-	0.67-	1-	0.16-	0.06-	3.33-	0.13-	4.00
UP4	1	1	12	0.84	0.43	6	0.47	5.28-
Downstream Sites								
DN1	6*	8.2*	55*	1.83*	0.74*	13.6*	0.7*	4.42
DN2	4.8	6.2	38	1.35	0.58	11.4	0.55-	4.97-
DN3	3.6	4.2	36	1.46	0.67	9	0.67	3.73*
DN4	3.2-	3.6-	28-	1.07-	0.53-	7-	0.57	4.87

[1] Larvae of insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies)
[2] Unitless value, for comparison among samples only
[3] Identified to lowest practical taxonomic unit
[4] Hilsenhoff Biotic Index; lower numbers correspond to higher ecological integrity

Comparing lower-Kinni sites to upper-Kinni sites, the lower-Kinni had collectively higher values of EPT family and genus richness, %EPT, diversity, taxa richness, and evenness than the upstream sites (significant at 95% confidence level), yet their HBI values were not significantly different from upstream sites. Comparing lower-Kinni sites to each other, there was less statistically significant among-site variation in the metrics for the lower-Kinni sites than occurred among the upper-Kinni sites. HBI was significantly lower (better) at site DN 3 than at the "worst" site, DN2 (Figure 3). Meanwhile, richness and Shannon diversity were lowest at DN4, and highest at DN1 (95% confidence level). Weak differences (90% confidence level) in taxa richness, EPT family richness, and EPT genus richness also occurred among the four sites (Table 2).

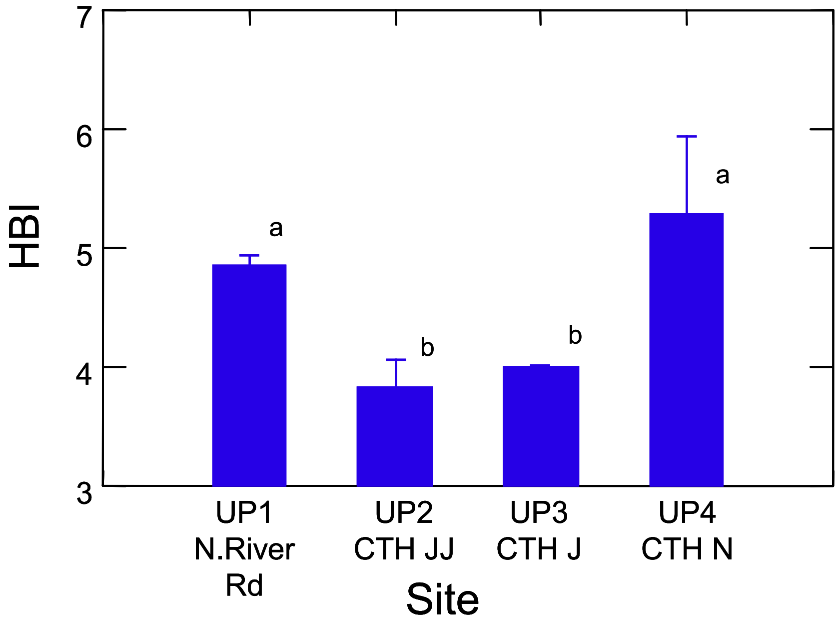

Figure 2. Comparison of mean HBI values at four upper-Kinnickinnic River sites from 2011 data. Error bars are standard errors. Values with different letters are significantly different at the 95% confidence level.

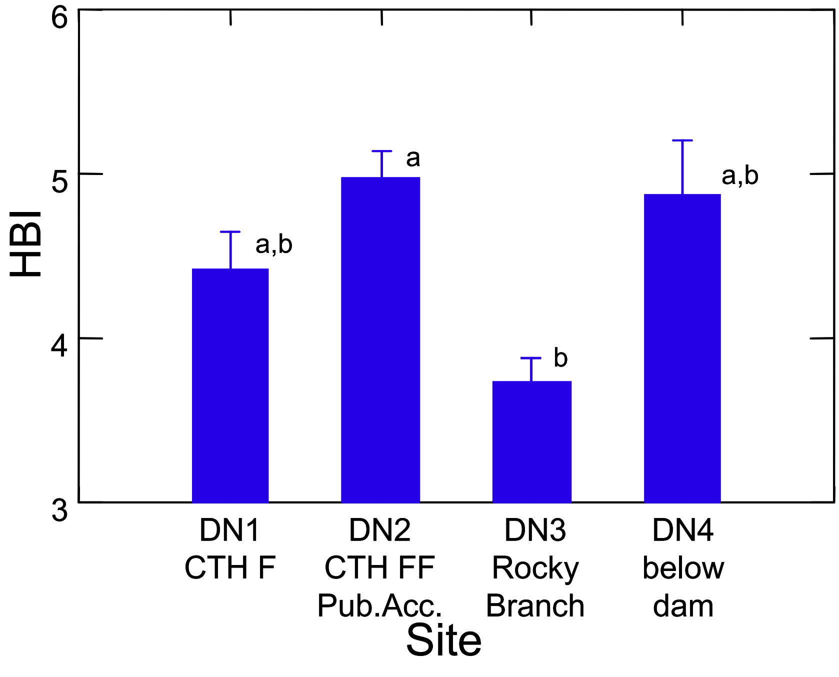

Figure 3. Comparison of mean HBI values at four lower-Kinnickinnic River sites from 2011 data. Error bars are standard errors. Values with different letters are significantly different at the 95% confidence level.

The HBI values calculated for three sites in this study were similar to those calculated for the same (or very near) sites in earlier work (Table 3), although the DN1 site had a substantially higher value than was found there in 1995, the HBI at DN2 was notably higher than the 1997 value, and the HBI at UP1 was higher than it was in 2009.

Table 3. Comparison of 2011 Kinnickinnic River HBI values to previous HBI values

Location	2011 HBI (this study)	2009 HBI (Gathman)	1995 HBI (WI DNR)	1996 HBI (WI DNR)	1997 HBI (WI DNR)
CTH F bridge (downstream)			3.300		
CTH F bridge (upstream)	4.42				
Rocky Branch confluence (downstream)			3.787		
Rocky Branch confluence (upstream)	3.73				2.965
North River Road (downstream)		4.56			
North River Road (upstream)	4.85	3.13			
CTH J bridge (downstream)		3.73	3.659[1]	4.243[1]	3.500[1]
CTH J bridge (upstream)	4.00	4.33			

[1] Average of three replicate samples

Habitat

Habitat quantification indicated that upstream sites were overwhelmingly dominated by sandy substrates, and that benthic habitat diversity was low in general. Only UP1 site had substantial benthic variability, with five non-sand substrate patches in a 50m length of river, plus a small amount of submergent vegetation and woody debris (Table 4). However, these five patches collectively only comprised 2.48% of the benthic area, and they were estimated to be from 0% to only 40% gravel in composition, with the remainder being silt. Site UP3 was the

Table 4. Non-sand substrate: number and type of substrate patches, plus coverage (as % bottom surface area) of substrate patches, submergent vegetation beds, and fallen coarse woody debris at sample reaches, upper-Kinnickinnic sites, 2011.

Site #	# non-sand patches	patch	patch area (m^2)	% bottom area	% cobble	% gravel	% silt	% covg. sub. veg.	% covg. woody
UP1	5	all combined	13.1	2.48	0	20	80	3	10
		1	*5.6*	*1.05*	*0*	*30*	*70*		
		2	*1.7*	*0.32*	*0*	*40*	*60*		
		3	*1.5*	*0.28*	*0*	*20*	*80*		
		4	*0.6*	*0.11*	*0*	*10*	*90*		
		5	*3.74*	*0.71*	*0*	*0*	*100*		
UP2	1	1	7.0	1.42	3	17	80	3	2
UP3	2	both combined	18.4	2.25	0	49	51	30	0
		1	*4.42*	*0.54*	*0*	*95*	*5*		
		2	*13.95*	*1.71*	*0*	*3*	*97*		
UP4	1	1	9	0.75	0	25	75	0	0

only site to have a substrate patch estimated to be predominantly gravel, and this patch comprised only 1.71% of benthic area. It was also the only site to have a substantial amount of submergent vegetation, comprising 30% of benthic area in the 50m survey reach.

Lower-Kinni sites, being part of a different project, were subjected to a different substrate-assessment methodology, so data in Table 5 are presented differently from those in Table 4. It is clear in the tables that the lower-Kinni sites had considerably more diverse benthic habitat, including greater coverages of the more-desirable gravel and cobble classes of substrate material. However, a large amount of bedrock occurred at DN 4, below the Lake Louise dam.

Table 5. Mean percentages of substrate classes at lower-Kinnickinnic sites, 2011.

Substrate type	all lower-Kinni sites	DN1	DN2	DN3	DN4
silt	21	23	30	17	13
sand	11	10	13	7	13
small gravel	13	17	10	13	3
large gravel	24	50	30	17	3
cobble	11	0	13	10	23
small boulder	4	0	0	17	0
bedrock	10	0	0	0	43
submergent vegetation	5	0	0	20	0

Interpretation

HBI values calculated for upper-Kinni sites were not very different from each other, or from earlier measures. Even though sites UP2 and UP3 were statistically significantly “better” than the other two sites, the mean values were not very different and caution must be exercised when interpreting HBI differences from a single year. However, the fact that several HBI values from various locations in the river were higher than previous values from various years may be meaningful, and should be kept in mind as future work is carried out. But the HBI, like all benthic, multi-metric bioassessment tools, is a rather coarse measurement instrument that can be affected by factors other than “impact” or degradation of habitats, such as interannual variations in weather, random fluctuations in species’ population sizes, etc. Also, benthic invertebrate communities are notoriously spatially variable. The replication of samples at each site is intended to compensate for small-scale variation within a sampling site, but cannot account for natural variation at somewhat larger scales.

The diversity-related metrics did not seem to agree with the HBI values, sometimes quite notably, as in site UP3, where the HBI indicated the best conditions of the four upstream sites, but the other measures were lowest. However, examination of the actual community compositions of the four sites (Appendix 1) explains this result. UP3 was overwhelmingly dominated by a single taxon, the amphipod genus *Gammarus*, which has a Tolerance value of 4. This highlights another limitation of the HBI method: when a community is highly dominated by one or two taxa (very low evenness), the HBI simply reflects that taxon’s Tolerance, and may not be at all useful. Coldwater stream communities are usually not particularly diverse, so they are vulnerable to this problem, and the upper-Kinni has recently been highly dominated by amphipods at many sites (personal observation). This was not the case at the lower-Kinni sites (Appendix 2), where a more-diverse community was observed at all sites.

The high dominance by amphipods at some sites is difficult to interpret or explain, because not enough is known about the factors that influence this animal's distributions or abundance. It is certainly not the case that amphipod abundance is a straightforward proxy for disturbance, because site UP4 had the lowest relative abundance of amphipods among upper-Kinni sites, yet was the most visibly impacted site, being shallow and wide with a silt-sand bottom, and having treeless banks with clear signs of cattle-grazing and trampling impacts.

The other highly abundant taxon was the midge family Chironomidae. This family can provide much useful information in biotic indices like the HBI, but it must be identified to the genus level for it to be useful. Unfortunately, it is especially time-consuming and technically demanding to perform this identification work. This effort is often sacrificed in bioassessment studies because identifying midge larvae to genus can take as long or longer than all the other work combined.

The upper-Kinni is very sandy, especially as compared to the lower-Kinni, which has more substrate diversity, including many rocky habitats. Therefore, it is not surprising that stoneflies (Plecoptera) occurred in lower-Kinni samples, and EPT measures were higher in general. Stoneflies are not uncommon in the upper-Kinni (personal observation; previous sampling), but did not occur in our samples for this project. In general, the benthic habitat in the upper Kinni is less conducive to diverse macroinvertebrate communities because the relative lack of rocky habitats provides little suitable habitat in the form of rock crevices. We have noted that the sands of the upper-Kinni shift considerably, especially after heavy-flow events. Shifting sands can smother invertebrates and fish eggs, and disrupt young aquatic plant beds that are trying to establish themselves. Considering this, perhaps the most surprising thing is that the upper river supports as much trout reproduction as it does.

Conclusions

This study has provided baseline data for the upper Kinnickinnic River, as intended. The community metrics are somewhat useful at present, but will be more helpful as future work is carried out in the same locations. Gaining an understanding of the natural variations in the Kinni, as well as determining whether overall condition is changing over time, will require considerably more study over a number of years.

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Appendix 1. Relative abundances of each taxonomic group in upper-Kinni samples, 2011.

Taxonomic groups				**Percent of invertebrates in all samples at each site**				**HBI**
				UP1	**UP2**	**UP3**	**UP4**	**Tolerance**
Insects:	**Order**	**Family**	**Genus**					
	Coleoptera	Elmidae	*Optioservus*	2	1			4
	Diptera	Ceratopogonidae	*Bezzia*				<0.5	6
		Chironomidae	unidentified	14	17		73	
		Simuliidae	*Simulium*	2		1		5
		Tabanidae	*Chrysops*	<0.5	<0.5	<0.5	<0.5	5
		Tipulidae	*Dicranota*		2			3
			Pedicia		<0.5			4
	Ephemeroptera	Baetidae	*Baetis*	22	1		11	6
			Callibaetis	<0.5			<0.5	7
		Ephemerellidae	*Ephemerella*		3			1
			Serratella	<0.5				2
	Megaloptera	Sialidae	*Sialis*			<0.5		4
	Trichoptera	Brachycentridae	*Adicrophleps*			1		2
			Brachycentrus		7			1
		Hydropsychidae	*Hydropsyche*	<0.5				4
Non-Insects: **miscellaneous taxonomic levels**								
	Crustacea	Asellidae (isopods)	*Caecidotea*		<0.5			8
		Gammaridae (amphipods)	*Gammarus*	51	65	97	11	4
	Annelida	Hirudinea (leeches)			<0.5			8
		Oligochaeta (segmented worms)		7			3	8
	Mollusca	Physidae (snails)			2			8
		Planorbidae (snails)		1				7
		Pisidiidae (fingernail clams)			1			6
	Nematoda	(roundworms)					1	

Appendix 2. Relative abundances of each taxonomic group in lower-Kinni samples, 2011.

Taxonomic groups				**Percent of invertebrates in all samples at each site**				**HBI Tolerance**
				DN1	**DN2**	**DN3**	**DN4**	
Insects:	**Order**	**Family**	**Genus**					
	Coleoptera	Elmidae	*Optioservus*	6	2	4	1	4
			Stenelmis	<0.5	<0.5	<0.5		5
	Diptera	Simuliidae	*Simulium*	1	9	1	5	5
		Ceratopogonidae	*Probezzia*	1	<0.5			6
		Chironomidae	*Chironomidae*	31	45	46	64	
		Tipulidae	*Tipula*	<0.5		<0.5		6
			Antocha		<0.5	1	1	3
		Empididae	*Hemerodromia*	<0.5				6
	Ephemeroptera	Baetidae	*Baetis*	28	24	7	15	6
			Plauditis	8	5	1	4	4
		Ephemerellidae	*Serratella*	2	2			2
			Timpanoga	2	1			1
			Ephemerella	5	1			1
		Heptageniidae	*Stenonema*	1	<0.5		<0.5	3
		Leptohyphidae	*Tricorythodes*			8		4
	Plecoptera	Perlidae	*Paragnetina*	<0.5				2
			Perlesta	1	2	2		4
		Pteronarcyidae	*Pteronarcys*	1	<0.5			<0.5
	Trichoptera	Hydroptilidae	*Hydroptila*	2	2		3	6
		Hydropsychidae	*Ceratopsyche*	2	1	18	7	3
		Brachycentridae	*Brachycentrus*	3	<0.5	<0.5	<0.5	1
Non-Insects: **miscellaneous taxonomic levels**								
	Crustacea	Asellidae (isopods)	*Caecidotea*		<0.5			8
		Gammaridae (amphipods)	*Gammarus*	5	1	10	1	4
		Talitridae (amphipods)	*Hyalella*	<0.5				8
	Annelida	Oligochaeta (segmented worms)			<0.5			8
	Mollusca	Pisidiidae (fingernail clams)			3	<0.5	<0.5	6
	Nematoda	Nematoda (roundworms)				1		