

Large River Surveys: 2023 Data Collection Technical Summary

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BACKGROUND

The Susquehanna River Basin Commission (Commission) has been monitoring the larger rivers of the Susquehanna River Basin (basin) since the early 2000s (Hoffman, 2003). The focus of these surveys has varied over the years based on the data needs and interests of the Commission, other agencies, and stakeholders, and the evolution of sampling methodologies specific to large river ecosystems. Previous studies of the large rivers of the basin included:

- Basinwide documentation of water quality and biological conditions (2002, 2005, 2007–2011, 2013);
- Data collection in geographically underrepresented areas (2016–2019); and
- Assessment of the river/impoundment system in the lower 70 miles of the mainstem Susquehanna River (2012, 2014, 2020–2022).

In 2023, the Commission adopted a spatially balanced probability design to select large river survey sites. Each year, new sites are randomly chosen using a Generalized Random Tessellation Stratified (GRTS) design (spsurvey R package; Dumelle et al., 2023; Olsen et al., 2012). GRTS designs produce a representative sample of sites reflecting the spatial distribution of the medium and large rivers in the basin. The resulting dataset developed from these randomly chosen sites will allow the Commission to make inferences about basinwide conditions in large river ecosystems, and can also be used by state regulatory agencies in Clean Water Act 305(b) reporting.

STUDY DESIGN AND DATA COLLECTION

A GRTS design was used to randomly select 12 candidate sites, six each from two size classes: Medium Mainstem Rivers (1,000 to 5,000 square miles) and Large Rivers (greater than 5,000 square miles). Within each size class, three primary and three replacement sites were selected. If a primary site was inaccessible or unrepresentative (e.g., located in a backwater, reservoir, or side channel), a replacement site was targeted instead. Due to low flow conditions in the summer of 2023, only sites in the Large River size class were sampled. All three sites were located on the Susquehanna River. General information about each site can be found in Table 1. See Figures 1 through 3 for maps of the site locations.

Table 1. Site Names and Descriptions

SITE NAME	RIVER NAME	DRAINAGE AREA (MI ²)	SITE DESCRIPTION	STATE	LATITUDE	LONGITUDE
SUSQ 231.7	Susquehanna River	8,883	5 miles west of Tunkhannock	PA	41.53629	-76.03717
SUSQ 96.3	Susquehanna River	19,499	Adjacent to Fort Halifax Park	PA	40.47610	-76.93782
SUSQ 37.5	Susquehanna River	26,077	4.5 miles upstream of Safe Harbor Dam	PA	39.94563	-76.47133

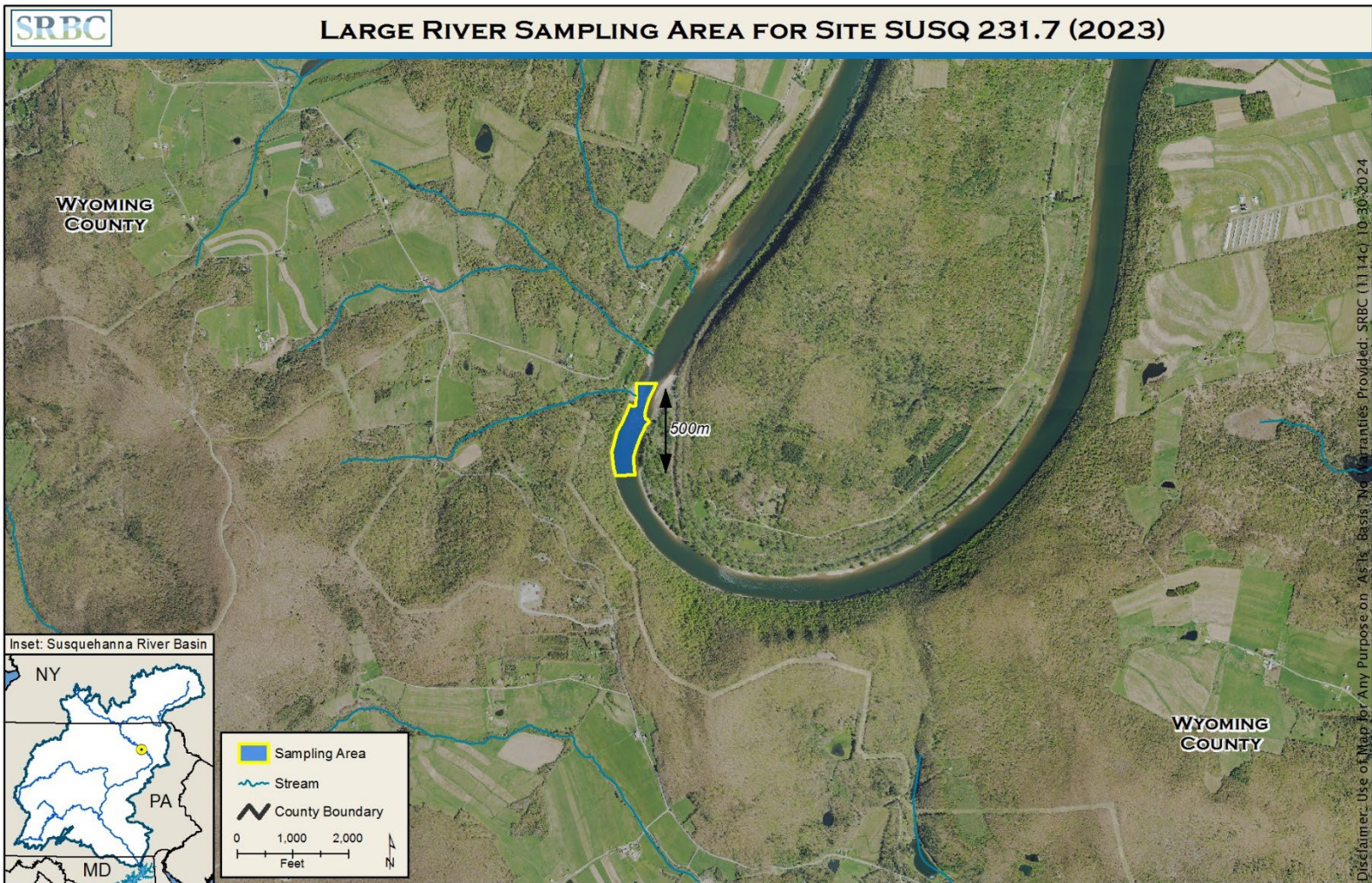


Figure 1. Aerial Imagery of the Sampling Area For SUSQ 237.1 (1:25,000 Scale); Inset Shows Location With the Susquehanna River Basin

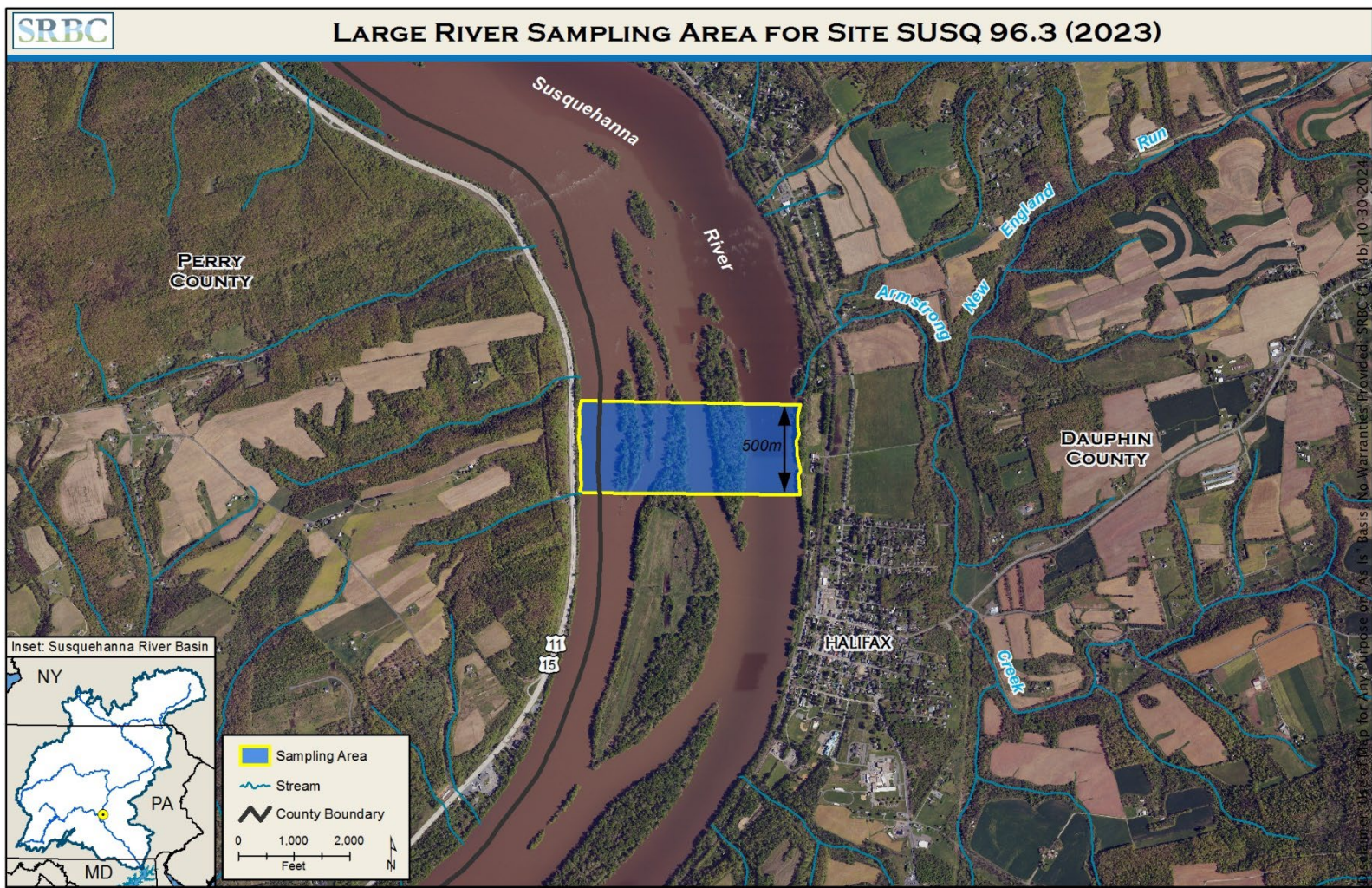


Figure 2. Aerial Imagery of the Sampling Area For SUSQ 96.3 (1:25,000 Scale); Inset Shows Location With the Susquehanna River Basin

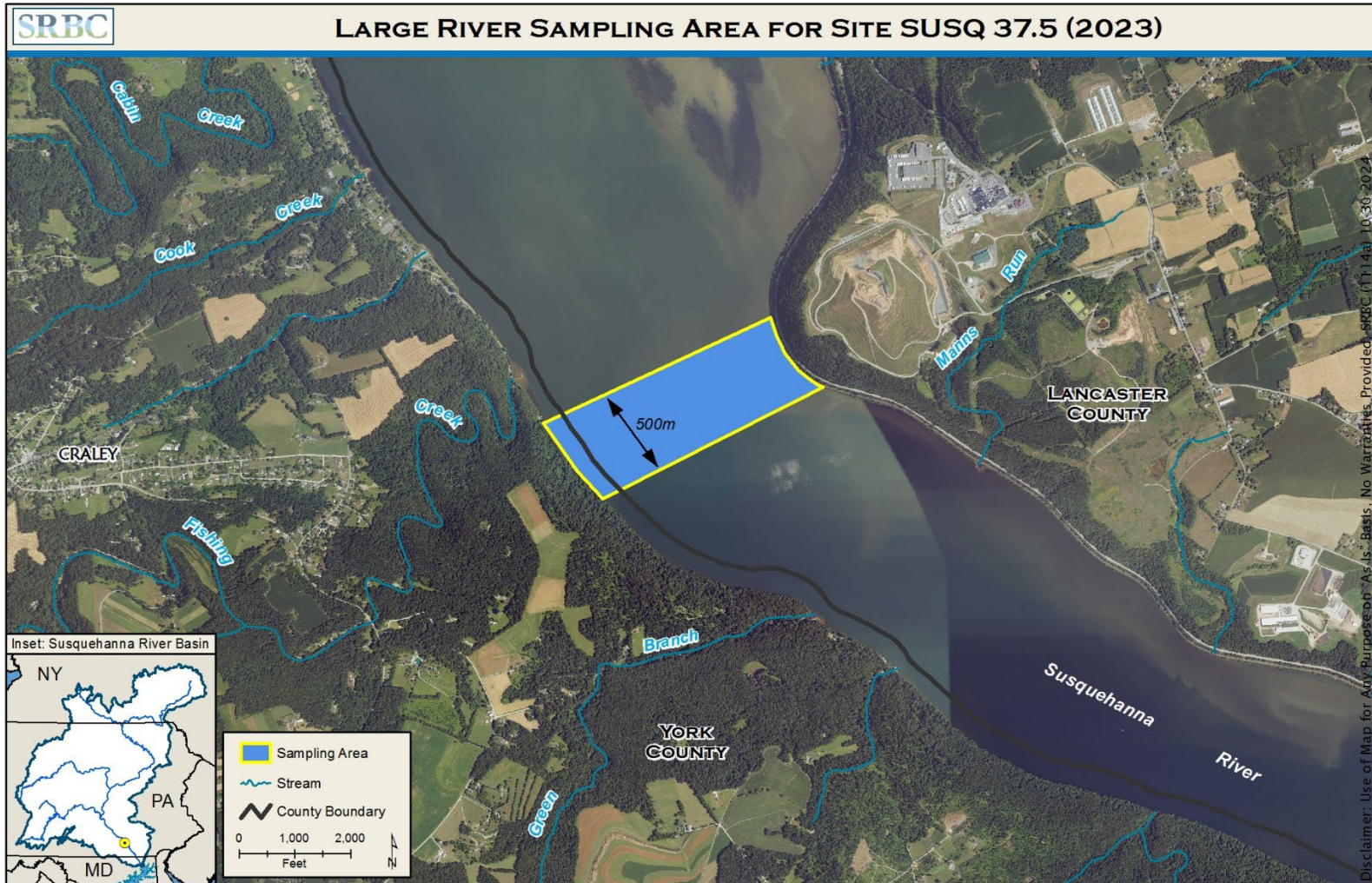


Figure 3. Aerial Imagery of the Sampling Area For SUSQ 37.5 (1:25,000 Scale); Inset Shows Location With the Susquehanna River Basin

Commission staff collected the following types of data at the three sites in late summer 2023:

- **Macroinvertebrates:** Benthic macroinvertebrate assemblages were sampled using the Pennsylvania Department of Environmental Protection’s (PADEP’s) Semi-Wadeable Large River Macroinvertebrate Data Collection Protocol (Shull, 2017).
- **Habitat:** Physical habitat was evaluated using a modified version of the habitat assessment procedure outlined by Barbour et al. (1999). Assessment criteria for riffle/run or glide/pool habitats were used depending on the dominant habitat type within the sampling reach.
- **Water quality:** Temperature, dissolved oxygen, pH, specific conductance, and turbidity were measured in the field using a YSI multimeter. Water samples were collected from six transects across the river channel using a depth-integrated sampler and composited into a churn splitter. These samples were sent to a lab and analyzed for alkalinity, metals (aluminum, calcium, iron, magnesium, manganese, potassium, sodium), nutrients (nitrate, phosphorus, total organic carbon), total suspended solids, and suspended sediment.
- **Fish community:** Fish surveys were conducted using boat electrofishing techniques adapted from the USEPA manual “Concepts and Approaches for Bioassessment of Non-Wadeable Streams and Rivers” (Flotemersch et al., 2006).

Details regarding sample collection methods are outlined in the Large River Quality Assurance Project Plan (QAPP; SRBC, 2023).

DATA ANALYSIS

Each Large River site receives condition category ratings of excellent, good, fair, poor, or very poor for macroinvertebrates, habitat, and water quality based on the numeric Semi-Wadeable Multimetric Index (SWMMI; Shull, 2017), Rapid Bioassessment Protocol (RBP; Barbour et al., 1999), and Water Quality Index (WQI; Berry et al., 2020) scores. Table 2 summarizes the scoring ranges and corresponding condition categories for each index.

Table 2. SWMMI, RBP, and WQI Scoring Ranges and Condition Category Ratings

CONDITION CATEGORY	SWMMI SCORE	RBP SCORE	WQI SCORE
Excellent	≥ 86	≥ 176	≥ 86
Good	70 - 85	121 - 175	62.01 - 84.99
Fair	49 - 69	66 - 120	42.93 - 62.00
Poor	34 - 48	≤ 65	30.99 - 42.92
Very Poor	0 - 33	—	≤ 30.98

PADEP’s SWMMI was used to assess the macroinvertebrate community (Shull, 2017). This index was developed for use in large (>1,600 mi²), free-flowing river systems and includes two sets of metrics specific to Summer (August – September) and Fall (November – December) collection timeframes. Scores from the individual metrics are incorporated into a single index score with values ranging from 0 to 100. Corresponding ratings were determined by PADEP (Shull, personal communication). Summer SWMMI values were calculated for the three sites sampled in 2023.

Physical habitat at each site was categorized based on 11 physical stream characteristics pertaining to substrate, instream cover, pool and riffle composition, shape of the channel, conditions of the banks, and the riparian zone on a scale of 0 - 20 (20 being optimal). These 11 scores are added together to produce a total RBP habitat score ranging from 0 to 220. Habitat assessment forms and detailed criteria used to evaluate both riffle/run and glide/pool stream types can be found in the QAPP.

The Commission’s Susquehanna River Basin Water Quality Index (WQI) was used to evaluate water quality conditions (Berry et al., 2020). The WQI produces three separate category scores for metals, nutrient enrichment, and development, which are then averaged to produce an overall water quality score between 0 and 100. Higher values indicate better water quality.

There is currently no biotic index for fish communities for the Susquehanna River Basin or its constituent states. General observations about the fish community were made based on community composition.

RESULTS & DISCUSSION

Table 3 summarizes SWMMI, RBP, and WQI scores and condition category ratings for the three Large River sites surveyed in 2023.

Table 3. SWMMI, RBP, and WQI Scores and Condition Category Ratings for the 2023 Large River Sites

SITE NAME	SWMMI		RBP		WQI	
	Score	Condition Category	Score	Condition Category	Score	Condition Category
SUSQ 231.7	28.21	Very Poor	177	Excellent	31.9	Poor
SUSQ 96.3	79.08	Good	155	Good	18.9	Very Poor
SUSQ 37.5	10.29	Very Poor	119	Fair	26.0	Very Poor

The macroinvertebrate communities at SUSQ 231.7 and SUSQ 37.5 received low SWMMI scores and were categorized as “Very Poor.” These low scores were primarily driven by low diversity (7 and 11 taxa, respectively) and dominance of tolerant taxa. *Gammarus* (scuds)

comprised 93% of the sample from SUSQ 231.7. Chironomidae (midges) and *Gammarus* made up 84% of the sample at SUSQ 37.5. SUSQ 96.3 was categorized as “Good” based on the SWMMI score. The sample from this site contained 29 unique taxa, including sensitive taxa from orders Ephemeroptera, Plecoptera, and Trichoptera. See Appendix A for macroinvertebrate assemblage data (taxa and counts) and Appendix B for SWMMI component metric scores.

Glide/Pool criteria were used to assess the habitat at SUSQ 231.7 and SUSQ 37.5. Habitat at the farthest upstream site, SUSQ 231.7, was considered “Excellent” based on the RBP score. This site is located in a rural area near Tunkhannock, PA. Riparian land use is primarily forested. Cobble substrates dominated, and this site scored high on parameters related to instream habitat. The farthest downstream site, SUSQ 37.5, received a habitat rating of “Fair.” Channel characteristics and flow regime at this location are influenced by the Safe Harbor Dam, which is located 4 miles downstream. SUSQ 37.5 received low scores for parameters related to substrate and sediment deposition due to the dominance of sandy substrates in the middle of the channel. The banks at this location are reinforced with rip-rap. SUSQ 96.3, located adjacent to the town of Halifax, PA, was the only site assessed using Riffle/Run criteria. This site is characterized by multiple islands, side channels, and braids, with frequent shallow riffles and cobble/gravel substrates between islands. Habitat at SUSQ 96.3 was considered “Good” based on the RBP score. The individual habitat parameter scores for each site can be found in Appendix C.

The WQI scores for all three sites were low, with SUSQ 96.3 and SUSQ 37.5 categorized as “Very Poor” and SUSQ 231.7 as “Poor.” Although all sites scored low for nutrients and development, higher metals concentrations are the primary driver for the low WQI scores at all three sites. Water chemistry data and WQI category scores for Nutrients, Development, and Metals can be found in Appendix D and Appendix E, respectively.

The fish communities at SUSQ 231.7 and SUSQ 96.3 were relatively diverse with 20 and 19 species, respectively. Diversity was lower at SUSQ 37.5 where 15 species were collected. Smallmouth bass (*Micropterus dolomieu*) was the dominant species at SUSQ 231.7. Minnow species dominated at SUSQ 96.3 and SUSQ 37.5. One flathead catfish (*Pylodictis olivaris*) was collected at SUSQ 37.5; no other invasive species were observed at any of the sites. No individuals with obvious disease, deformities, lesions, tumors, or parasites were noted. Fish community data can be found in Appendix F.

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APPENDIX A. MACROINVERTEBRATE ASSEMBLAGE DATA (TAXA AND COUNTS)

TAXONOMIC CLASSIFICATION			COUNTS		
Order	Family	Genus	SUSQ 231.7	SUSQ 96.3	SUSQ 37.5
Ephemeroptera	Baetidae	<i>Baetis</i>	3	31	
Ephemeroptera	Baetidae	<i>Labioabaetis</i>		40	
Ephemeroptera	Caenidae	<i>Caenis</i>		2	1
Ephemeroptera	Heptageniidae	<i>Leucrocuta</i>		22	
Ephemeroptera	Heptageniidae	<i>Stenacron</i>		1	
Ephemeroptera	Heptageniidae	<i>Stenonema</i>		12	9
Ephemeroptera	Isonychiidae	<i>Isonychia</i>		20	
Ephemeroptera	Potamanthidae	<i>Anthopotamus</i>		4	
Ephemeroptera	Siphonuridae	<i>Siphonurus</i>			1
Plecoptera	Chloroperlidae	<i>Sweltsa</i>		7	
Plecoptera	Leuctridae	<i>Leuctra</i>		1	
Plecoptera	Perlidae	<i>Acroneuria</i>		6	
Plecoptera	Perlidae	<i>Agneta</i>		10	
Plecoptera	Perlidae	<i>Attanella</i>	1		
Plecoptera	Perlidae	<i>Neoperla</i>		1	
Plecoptera	Perlidae	<i>Paragnetina</i>		1	
Trichoptera	Hydropsychidae	<i>Cheumatopsyche</i>		11	
Trichoptera	Hydropsychidae	<i>Hydropsyche</i>		8	
Trichoptera	Hydropsychidae	<i>Macrostemum</i>		2	
Trichoptera	Philopotamidae	<i>Chimarra</i>		1	
Odonata	Aeshnidae	<i>Boyeria</i>		1	
Odonata	Coenagrionidae	<i>Argia</i>		2	1
Odonata	Coenagrionidae	<i>Enallagma</i>			2
Odonata	Gomphidae	<i>Ophiogomphus</i>		3	
Megaloptera	Corydalidae	<i>Nigronia</i>		2	
Coleoptera	Elmidae	<i>Optioservus</i>		4	
Coleoptera	Elmidae	<i>Stenelmis</i>		31	1
Coleoptera	Gyrinidae	<i>Dineutus</i>		1	
Coleoptera	Psephenidae	<i>Psephenus</i>	1	13	
Diptera	Athericidae	<i>Atherix</i>		1	
Diptera	Chironomidae		5	10	63
Gastropoda	Hydrobiidae				1
Gastropoda	Viviparidae				1
Oligochaeta	Oligochaeta		2	1	2
Amphipoda	Gammaridae	<i>Gammarus</i>	141		34
Decapoda	Cambaridae	<i>Faxonius</i>	5		

APPENDIX B. SUMMER SWMMI COMPONENT METRIC DESCRIPTIONS AND SITE SCORES

METRIC NAME	DESCRIPTION	TYPE	SCORES		
			SUSQ 231.7	SUSQ 96.3	SUSQ 37.5
BCGpct5	Percent Tolerant Individuals (BCG 5)	Tolerance	6.58	38.68	57.76
PTVpct03	Percent Sensitive Individuals (PTV 0-3)	Tolerance	0.00	29.22	0.00
BCGindex2	Hilsenhoff Index (BCG Attributes Percent)	Tolerance	4.07	3.91	4.58
pctEbcg13	Ephemeroptera (BCG 1-3)	Composition	92.76	16.46	54.31
pctDOM	Percent Dominant Taxon	Dominance	0.00	35.39	0.00
richEPTbcg	EPT Richness (BCG 1-3)	Richness	0.00	9.00	0.00

APPENDIX C. SITE SCORES FOR RAPID BIOASSESSMENT PROTOCOL PARAMETERS

PARAMETER	SCORES		
	SUSQ 231.7	SUSQ 96.3	SUSQ 37.5
Epifaunal Substrate	17	15	10
Instream Cover	16	17	13
Embeddedness	n/a	14	n/a
Pool Substrate Characterization	15	n/a	12
Velocity/Depth Regimes	n/a	16	n/a
Pool Variability	13	n/a	13
Sediment Deposition	13	14	12
Channel Flow Status	15	18	17
Channel Alteration	19	16	8
Frequency of Riffles	n/a	15	n/a
Channel Sinuosity	18	n/a	10
Condition of Banks	18	12	16
Left Bank	9	6	8
Right Bank	9	6	8
Vegetative Protective Cover	16	11	10
Left Bank	9	6	5
Right Bank	7	5	5
Riparian Vegetative Zone Width	17	7	8
Left Bank	9	4	5
Right Bank	8	3	3

APPENDIX D. WATER CHEMISTRY DATA (WQI parameters in bold text)

PARAMETER	UNITS	CONCENTRATIONS		
		SUSQ 231.7	SUSQ 96.3	SUSQ 37.5
Alkalinity, Total	mg/L	60	52	52
Aluminum	mg/L	0.647	1.870	0.252
Calcium	mg/L	21.80		
Chloride	mg/L	19.6	22.1	21.2
Conductivity	µS/cm	201	193	226
Dissolved Oxygen	mg/L	8.18	8.39	7.43
Iron	mg/L	0.962	3.070	0.484
Magnesium	mg/L	4.19		
Manganese	mg/L	0.059	0.273	0.109
Nitrate as N	mg/L	0.33	0.35	0.52
Orthophosphorus	mg/L	0.40	0.40	0.40
pH		7.54	7.58	7.33
Phosphorus	mg/L	0.030	0.076	0.032
Potassium	mg/L	1.54		
Sodium	mg/L	13.5	13.3	12.2
Sulfate	mg/L	7.1	14.6	22.3
Temperature	°C	21.60	21.10	25.59
Total Organic Carbon	mg/L	4.0	4.1	3.4
Total Suspended Solids	mg/L		71	14
Turbidity	NTU	48.5	12.7	14.0

APPENDIX E. NUTRIENTS, DEVELOPMENT, METALS, AND OVERALL WQI SCORES

SITE NAME	SCORES			
	Nutrients	Development	Metals	WQI
SUSQ 231.7	38.8	42.5	14.4	31.9
SUSQ 96.3	29.1	27.7	0.0	18.9
SUSQ 37.5	35.6	25.3	17.1	26.0

APPENDIX F. FISH COMMUNITY DATA (SPECIES AND COUNTS)

TAXONOMIC CLASSIFICATION			Counts		
Order	Family	Genus and Species	SUSQ 231.7	SUSQ 96.3	SUSQ 37.5
Atheriniformes	Fundulidae	<i>Fundulus diaphanus</i>		5	
Clupeiformes	Clupeidae	<i>Dorosoma cepedianum</i>		1	7
Cypriniformes	Catostomidae	<i>Catostomus commersonii</i>	1	2	
Cypriniformes	Catostomidae	<i>Hypentelium nigricans</i>	24	13	1
Cypriniformes	Catostomidae	<i>Moxostoma macrolepidotum</i>			11
Cypriniformes	Cyprinidae	<i>Cyprinella spiloptera</i>	60	100	67
Cypriniformes	Cyprinidae	<i>Cyprinus carpio</i>	8	6	3
Cypriniformes	Cyprinidae	<i>Luxilus cornutus</i>		1	
Cypriniformes	Cyprinidae	<i>Nocomis micropogon</i>		4	
Cypriniformes	Cyprinidae	<i>Notropis amoenus</i>			295
Cypriniformes	Cyprinidae	<i>Notropis hudsonius</i>	26	37	4
Cypriniformes	Cyprinidae	<i>Notropis rubellus</i>	66	292	
Cypriniformes	Cyprinidae	<i>Notropis volucellus</i>	63	47	23
Cypriniformes	Cyprinidae	<i>Pimephales notatus</i>	13	29	
Cypriniformes	Cyprinidae	<i>Semotilus corporalis</i>	7	35	
Perciformes	Centrarchidae	<i>Ambloplites rupestris</i>	7	5	
Perciformes	Centrarchidae	<i>Lepomis auritus</i>	3	2	
Perciformes	Centrarchidae	<i>Lepomis cyanellus</i>	3	3	17
Perciformes	Centrarchidae	<i>Lepomis gibbosus</i>			2
Perciformes	Centrarchidae	<i>Lepomis macrochirus</i>	9		16
Perciformes	Centrarchidae	<i>Micropterus dolomieu</i>	90	35	21
Perciformes	Centrarchidae	<i>Micropterus salmoides</i>			4
Perciformes	Percidae	<i>Etheostoma blennioides</i>	3	1	
Perciformes	Percidae	<i>Etheostoma olmstedii</i>	4	1	
Perciformes	Percidae	<i>Etheostoma zonale</i>	2		
Perciformes	Percidae	<i>Percina peltata</i>	1		
Perciformes	Percidae	<i>Sander vitreus</i>	2		
Siluriformes	Ictaluridae	<i>Ictalurus punctatus</i>	11		3
Siluriformes	Ictaluridae	<i>Pylodictis olivaris</i>			1