Biological and Water Quality Study of the St. Marys River

Auglaize and Mercer Counties, Ohio

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prepared by

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NOTICE TO USERS

Ohio EPA adopted biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (Effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish, and the Invertebrate Community Index (ICI), which is based on macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the chemical and whole effluent toxicity evaluation methods, figure prominently in the assessment of Ohio's surface water resources.

Several documents support the adoption of the biological criteria by outlining the rationale for using biological information, the specific methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results. These documents are:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989a. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1990a. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale,methods, and application. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

These documents and this document can be obtained by writing to:

Ohio EPA - WQP&A
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Acknowledgements

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Biological and Water Quality Survey of the St. Marys River (Auglaize and Mercer Counties, Ohio)

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Introduction

The St. Marys River study area extended from upstream of the city of St. Marys (RM 100.5) to upstream of the village of Mendon (RM 75.1).

Specific objectives of this evaluation were to:

1) monitor and assess chemical/physical water quality, habitat, and biological communities in the St. Marys River,

2) evaluate impacts from the St. Marys WWTP and combined sewer overflows (CSOs),

3) assess and document nonpoint source impacts,

4) determine the attainment status of current aquatic life and non-aquatic life use designations,

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (*e.g.* NPDES permits, Director's Orders), the Ohio Water Quality Standards (OAC 3745-1), and eventually be incorporated into the State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Water Resource Inventory (305[b] report).

Summary

The 1991 St. Marys River study area extended from RM 100.5 (upstream of the city of St. Marys) to RM 75.1 (upstream the village of Mendon). Biological, chemical/physical and sediment sampling was conducted at 14 sampling stations, between June and September, 1991. The sampling efforts included a total of 25.4 river miles.

A total of 19 miles (74.8% of the study area) failed to attain the current WWH use designation (**NON-**attainment); where either or both fish and macroinvertebrate community performance was considered to be no better than fair, or where poor or very poor community performance was recorded in one of the organism groups. PARTIAL attainment was recorded for 6.4 miles (25.2% of the study area); where at minimum, one of the community indices achieved WWH biological criteria and at least fair community performance was recorded in the other biological indices. FULL attainment of the current WWH use designation was **not** recorded at any sampling station within the St. Marys River study area. The **NON**-attainment of 19 miles occurred in two reaches; the upper reach between RM 100.5 and RM 91.6 and the lower reach between RM 85.2 and RM 75.1. The middle 6.4 miles between RM 91.6 and RM 85.2 was in PARTIAL attainment of the

WWH use designation. Water quality standards and attainment status of designated and recommended aquatic life uses in the St. Marys River study area are found in Table 1.

The predominant causes for **NON**-attainment included: 1) organic and inorganic loadings from St. Marys WWTP, CSOs and equalization basin discharge; 2) habitat alterations (surface and subsurface hydromodifications) that have resulted in extensive siltation, substrate embeddedness, and relatively homogenous channel development; and 3) possible impacts due to sediments contaminated with metals (lead, arsenic and zinc) in elevated or highly elevated concentrations.

Biological and chemical point source impacts in the study area are primarily the city of St. Marys WWTP and CSOs. Water column and sediment chemistry supported the assertion that **NON**-attainment of the biological communities relative to these point source issues is valid. Ammonia-nitrogen and BOD loadings from St. Marys WWTP resulted in numerous dissolved oxygen (D.O.) violations. Diminished biological community performance was recorded in response to water quality perturbations downstream of the St. Marys WWTP. Additional evidence of chronic stress within the fish community was an increase in the incidence of deformities, eroded fins and/or barbels, lesions, and tumors (DELT) anomalies downstream of the city of St. Marys.

A total of 18 D.O. violations of the daily average and/or minimum criteria were recorded within the St. Marys River; all chemical sampling stations within the study area exhibited at least one violation. The vast majority of D.O. violations were recorded downstream of the St. Marys WWTP. Four fecal coliform counts exceeding primary and secondary contact criteria occurred between RM 100.5 (upstream of St. Marys) and RM 98.1 (downstream of St. Marys WWTP). A single ammonia-nitrogen exceedence of the criteria for the prevention of acute toxicity was recorded immediately downstream of the St. Marys WWTP within the mixing zone (RM 98.6). An additional 14 ammonia-nitrogen violations in exceedence of the criteria for the prevention of chronic toxicity were recorded downstream of St. Marys WWTP between RM 98.6 (St. Marys WWTP mixing zone) and RM 95.1 (downstream Glynwood Rd.).

Sediment samples revealed the presence of arsenic throughout the study area at concentrations ranging from slightly elevated to highly elevated. Arsenic concentrations generally increased longitudinally (upstream to downstream), with highly elevated levels occurring at RM 95.1 (downstream Glynwood Rd.) and RM 75.1 (downstream Gallman Rd). The highly elevated levels of arsenic recorded in the lower reach most likely reflected increased deposition of finer clayey contaminated sediments due to the reduced gradient. The source of arsenic contamination is most likely the result of past application of herbicides, defoliants and insecticides that contained inorganic arsenic. The use of agricultural chemicals that contained bio-available arsenic was phased out in 1967; however, once incorporated into the soils arsenic compounds are converted into arsenate, which is strongly held by the clay fraction of the soil (Novotny and Chesters 1981; Brady 1990). The erosion and subsequent deposition of clays and silts from cultivated lands containing arsenic from past applications would likely show up in depositional parts of the study area. It is not clear that the observed arsenic contamination is of immediate concern; benthic macroinvertebrate samples (qualitative and quantitative) did not indicate toxic conditions at sampling stations that contained arsenic at highly elevated concentrations. However, in the lower reach of the study area (RM 89.0 to RM 75.1) the fish community demonstrated a significant increase in the incidence of DELT anomalies, an indication of chronic stress (Ohio EPA 1987[b]). Lead was found at highly elevated concentrations in the sediment sample collected at RM 98.7, downstream of the city of St. Mary's CSOs. The elevated concentration of lead in the sediments is most likely a result of urban runoff. Elevated levels of zinc were recorded from RM 98.7 and RM

75.1. The source of zinc contamination is unknown at this time, but could have an instream fate and transport patterns similar to that just described for arsenic.

Nonpoint source perturbations were evident throughout the study area and were largely associated with row crop agriculture. Agriculture is the predominant land use within the St. Marys River basin and has resulted in significant alterations to aquatic habitats. Habitat modifications of the type associated with agricultural activities included: previous and frequent channelization of the mainstem and tributaries; subsurface drainage modifications; and extensive siltation. These activities have had a tremendous impact to physical habitats of the St. Marys River, which can limit overall biological potential. The problem of limited habitat was most evident in the upper reach at and upstream of RM 100.5, and the lower reach between RM 89.0 and RM 75.1. In contrast, the middle reach between RM 98.7 and RM 95.1 contained relatively good habitat and, in the absence of water quality disturbances, should be capable of supporting a biological community capable of attaining the WWH use designation.

Additional nonpoint source impacts included D.O. violations and fecal coliform exceedences recorded upstream of the St. Marys WWTP at RM 100.5, and an active landfill situated along the St. Marys River between RM 95.5 and RM 95.2. Leachate out-breaks from this site have been reported in the recent past, and may have contributed to the elevated metal contamination (zinc and arsenic) of the bottom sediments; however, more discrete follow-up sampling is required to further discern the influence of the landfill in the St. Marys River.

Given the prevailing basin-wide habitat disturbances, the ability of the St. Marys River to support a diverse and highly organized fish community is in question. However, the response of the resident fish community relative to point source impacts did represent a further departure from ecoregional biocriteria than can be attributed poor habitat *alone*. The response of the benthic macroinvertebrate community to observed habitat disturbances is less pronounced than that of the fish samples collected. Given the use of artificial substrate samplers, quantitative benthic samples tend to reflect water quality disturbances and were generally less sensitive to overall macrohabitat quality. As a consequence, in areas of greatly diminished instream habitat the benthic macroinvertebrate community tended to better delineate *point source impacts* and subsequent areas recovery than did the fish community.

Conclusions

- **NON**-attainment of the WWH use designation in the uppermost reach of the St. Marys River study area at RM 100.5 (upstream of the city of St. Marys) was attributed to instream channel modification and agricultural NPSs. Physical habitat for aquatic life was generally poor and moderate organic and nutrient enrichment was evident. Two violations of the daily average and one violation of the minimum D.O. criteria were recorded. A single fecal coliform count in exceedence of the primary contact criteria was also recorded. Benthic macroinvertebrate and fish community performance were poor/fair being reflective of modified habitats and agricultural nonpoint source enrichment.

- **NON**-attainment of WWH use designation was recorded downstream of CSOs in the city of St. Marys. Sediment samples revealed elevated concentrations of lead and slightly elevated concentrations of zinc and arsenic. Two violations of the minimum D.O. criterion and two violations of average D.O. criterion indicate enrichment from sewage inputs. Biological

community performance at RM 98.7 can be characterized as poor/fair, with low relative abundance and reduced species richness reflecting the depressed D.O. and sediment contamination. An elevated incidence of DELT anomalies further indicated chronic stress within the fish community, which is a common response pattern in areas impacted by CSOs.

- Near-field impacts were detected downstream of St. Marys WWTP at RM 98.6. Three ammonia-nitrogen exceedences of the criteria for the prevention of chronic toxicity, one exceedence of the criteria for the prevention of acute toxicity, and one fecal coliform count exceeding primary contact was recorded within the mixing zone. Both benthic macroinvertebrate and fish community performance was diminished immediately downstream of St. Marys WWTP.

- **NON**-attainment of the WWH use designation downstream from the St. Marys WWTP and the equalization basin discharge, between RM 98.5 and RM 98.1, was attributed to increased loading of oxygen demanding wastes and ammonia-nitrogen. Water chemistry sampling at RM 98.1 revealed greatly elevated BOD and four ammonia-nitrogen violations, one exceeding the criteria for the prevention of acute toxicity. Three violations of the daily average D.O. and one violation of the minimum D.O. criteria demonstrated that current loadings frequently exceed the assimilative capacity of the St. Marys River. Fish community performance was improved at RM 98.5; however, this station still failed to attain the WWH biological criteria.

- **NON**-attainment of the WWH biological criteria at RM 95.1 was attributed to the continued influence of the St. Marys WWTP and most likely represents the D.O. sag point. Four ammonia-nitrogen violations exceeding the criteria for the prevention of chronic toxicity, and elevated BOD resulted in two violations of the average daily D.O. and one violation of the minimum D.O. criteria. Sediment samples revealed arsenic in highly elevated concentrations; however, it is not clear if the arsenic is a major factor in the **NON**-attainment. Additionally, this station is also impacted by an active landfill adjacent to the St. Marys River between RM 95.2 and RM 95.5. Despite improved habitat quality at RM 95.1, the fish community still performed at a poor level. However, the macroinvertebrate community demonstrated improvement.

- Instream biological communities and water chemistry data indicated that the area of recovery began at RM 89.0 and extended longitudinally to RM 75.1. Although full recovery of the instream biota was not recorded, significant improvement was recorded within benthic macroinvertebrate assemblages. No ammonia-nitrogen exceedences were measured within this reach and the frequency of D.O.violations recorded was greatly reduced. However, sediment samples revealed arsenic at highly elevated concentrations. The reach between RM 91.6 and RM 85.2 is the only segment of the St. Marys River study area of PARTIAL attainment where WWH biological criteria was observed.

Table 1. Aquatic life use attainment status for the Warmwater Habitat (WWH) use designation in the St. Marys River based on data collected during June - September 1991.

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI	QHEI[a]	Attainment Status	Comment
St. Marys River (1991)						
Eastern Corn Belt Plains WWH Use Designation (Existing)						
100.5/100.4	31*	6.6*	22*	44	**NON**	Ust. St. Marys
98.7/98.7	22*	6.0*	28*	62	**NON**	Dst. CSO
98.6/98.6	21*	5.0*	16	-	N/A	Mixing Zone
98.4/98.5	29*	5.9*	16*	60	**NON**	Dst. St. Marys WWTP
95.1/95.1	22*	6.1*	36	73	**NON**	
89.0/89.4	26*	8.4[ns]	44	52	PARTIAL	
Huron Erie Lake Plain WWH Use Designation (Recommended)						
80.6/80.5	26*	7.8*	20*	41	**NON**	
75.1/75.1	22*	6.9*	42	43	**NON**	Ust. Mendon

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWH[b]
IBI - Headwaters/Wading	40	50	24
IBI - Boat	42	48	24
Mod. Iwb - Wading	8.3	9.4	6.2
Mod. MIwb - Boat	8.5	9.6	5.8
ICI	36	46	22

Ecoregion Biocriteria: Huron Erie Lake Plain (HELP)

INDEX - Site Type	WWH	EWH	MWH[b]
IBI - Boat	34	48	20
Mod. Iwb - Boat	8.6	9.6	5.7
ICI	34	46	22

[b] - Modified Warmwater Habitat for channel modified areas.

* - significant departure from interim biocriteria; poor and very poor results are underlined.

[ns] - nonsignificant departure from interim biocriteria for WWH or EWH (4 IBI or ICI units; 0.5 Iwb units).

a - Qualitative Habitat Evaluation Index (QHEI) values based on the new version (Rankin 1989).

Recommendations

Status of Aquatic Life Uses

Several of the streams evaluated during this study were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. Therefore, because this study represents a first use of this type of biological data to evaluate and establish aquatic life use designations, several revisions are recommended. While some of the changes may appear to constitute "downgrades" (*i.e.* EWH to WWH, WWH to MWH, etc.) or "upgrades" (*i.e.* LWH to WWH, WWH to EWH, etc.), any changes should not be construed as such because this constitutes the first use of an objective and robust use evaluation system and database. Ohio EPA is under obligation by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus some of the following aquatic life use recommendations constitute a fulfillment of that obligation.

- The current WWH use designation is appropriate for the St. Marys River. The headwaters (East and Center Branches of Clear Fork) and the station at RM 100.5 have been channelized, providing less than optimal habitat for aquatic life. Despite this habitat deficit and moderate agricultural nutrient enrichment, community performance upstream of St. Marys, though only fair, was generally better in comparison to segments under the influence of CSOs and the St. Marys WWTP (RM 98.7 to RM 95.1) which contained habitats of significantly higher quality. The data illustrates that the poor performance of the biological communities downstream from the city of St. Marys can not be solely attributed to habitat.

- The reach between RM 80.6 and RM 75.1 represents the entry of the St. Marys River into the HELP ecoregion. This ecoregion contains the most widespread agricultural impacts in the state. The habitat problems observed are typical of this ecoregion and reduced biological expectations are recognized by the Ohio EPA's use of ecoregional biological criteria (Ohio EPA 1987[a,b]; 1989[a]).

Status of Non-Aquatic Life Uses

- Currently, the St. Marys River is designated for Primary Contact Recreational (PCR), Agricultural and Industrial Water Supplies. Based on the 1991 sampling effort, these should be retained.

Other recommendations

- The results of this study strongly suggest the need for the inclusion of an ammonia-nitrogen limit in the NPDES permit for the St. Marys WWTP.

Future Monitoring Needs

- A complete re-evaluation should be conducted in 1996 (or following any further plant upgrades) as provided in the Five Year Monitoring Basin Approach to monitoring and NPDES permit reissuance.

- Combined sewer overflow discharge, quantity and quality, needs to be characterized in order to define the pollutant load contributed to the St. Marys River.

- The St. Marys landfill situated between RM 95.5 and RM 95.2 requires further investigation to determine the extent of chemical inputs to the St. Marys River. Reported leachate outbreaks need to be characterized in order to determine how much the landfill is contributing to the **NON**-attainment of the lower reach of the study area.

- The results from the sediment metals scan and the biological survey suggest the need for a more detailed investigation to determine the source(s) and character of heavy metal contamination (particularly arsenic) within the study area.

- Long-term monthly monitoring would provide information on trends in water quality of the St. Marys River downstream of the city of St. Marys and the St. Marys Landfill. This could be accomplished by locating a monthly fixed station sampling and a triennial macroinvertebrate fixed station site at Glynwood Rd (RM 95.1).

Study Area

- The St. Marys River is a major tributary to the Maumee River draining 816.7 square miles (458 in Ohio) of predominantly agricultural land in west central Ohio and Indiana. The headwaters are in Auglaize County. The river flows in a northerly direction and turns northwest through Mercer and Van Wert counties before crossing the Ohio-Indiana state line The average gradient of the St. Marys River is 2.8 feet per mile (Ohio DNR 1960). The study area includes a 25.4 mile segment from upstream of the city of St. Marys (RM 100.5) in Auglaize County to RM 75.1 in Mercer County (Figure 1).

- The study area is situated in the Eastern Corn Belt Plain (ECBP) and Huron Erie Lake Plain (HELP) ecoregions. The primary land use in the ECBP region is extensive cropland agriculture. Local relief is generally less than 50 feet. Soils are derived from glacial till materials and soil drainage is often poor. Many of the smaller streams in the ECBP ecoregion have been channelized to improve soil drainage (Whittier *et. al.* 1987; Omernik and Gallant 1988).

- The primary land use in the Huron Erie Lake Plain (HELP) is row crop agriculture. Soils are primarily derived from poorly drained fine lake sediments and some glacial till. This region has the most widespread and severe agricultural impacts of any region of the state, which is related to the lack of a wooded riparian, channelization, high percentage of clayey soils, and low stream gradient which virtually precludes any recovery of pre-channelization stream habitats (Whittier *et.al.* 1987; Omernik and Gallant 1988).

- Land uses in the watershed are predominantly agricultural. Corn and soybeans are the principal crops; other feed grains and hay for livestock are also grown. Agriculture and channelization are the predominant types of nonpoint source (NPS) pollution in the study area. Other types of NPS pollution known or suspected include urban runoff and on-site wastewater treatment (Ohio EPA 1990). Table 2 presents the general physical characteristics of the St. Marys River and principal pollution sources.

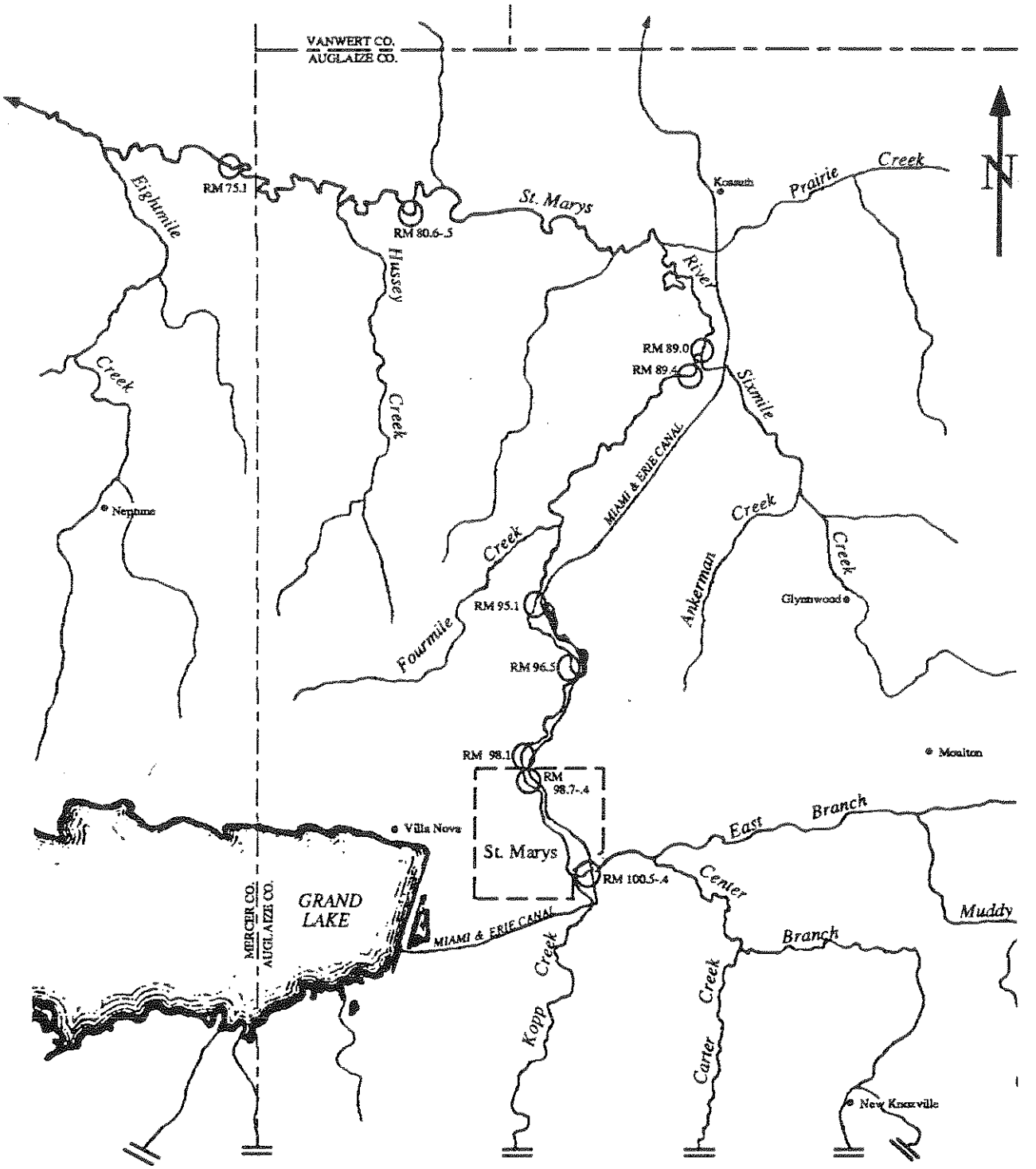


Figure 1. The St. Marys River study area showing principal streams and tributaries, population centers, pollution sources, and sampling stations (stations marked by open circles and associated River Miles).

Table 2. Stream characteristics and significant identified pollution sources in the St. Marys River study area.

Stream Name	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Nonpoint Source Pollution Categories	Point Sources Evaluated
St. Marys River	59.2	2.8	816.7	Agricultural CSOs Hydromodification	St. Marys WWTP

Methods

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes II-III (Ohio Environmental Protection Agency 1987, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment.

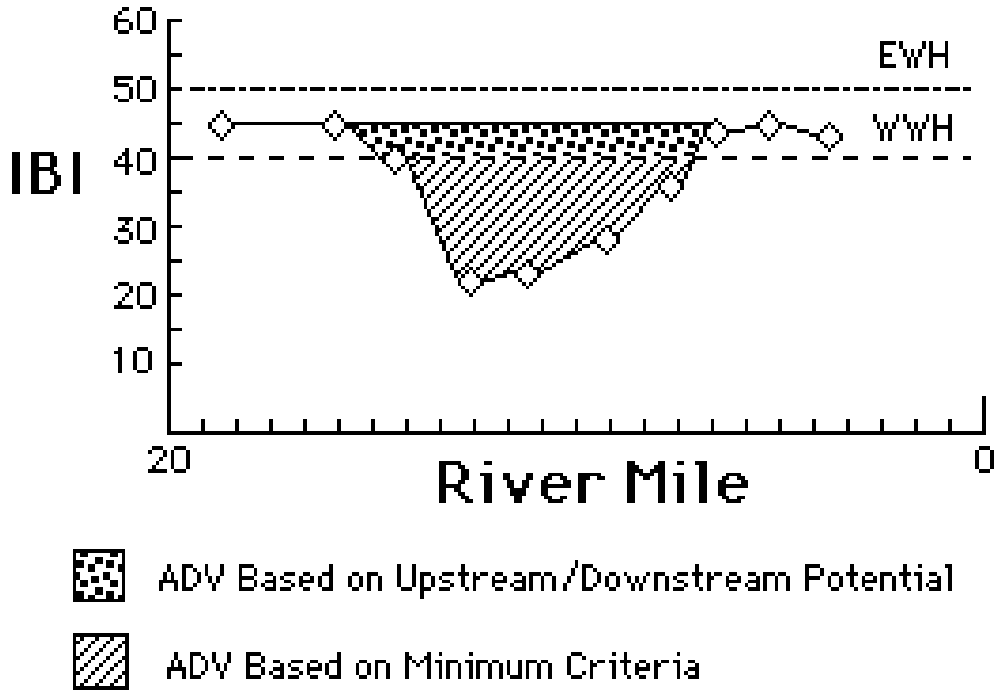
Attainment/non-attainment of aquatic life uses is determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and the Modified Index of Well-being (MIwb), both of which are based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. IBI and ICI are multi-metric indices patterned after an original IBI described by Karr (1981) and Fausch et al. (1984). The MIwb is a measure of fish community abundance and diversity using numbers and weight information; it is a modification of the original Index of Well-Being applied to fish community information from the Wabash River (Gammon 1976, Gammon et al. 1981).

Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes *et al.* 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is **FULL** if all three indices (or those available) meet the applicable criteria, **PARTIAL** if at least one of the indexes does not attain and performance does not fall below the fair category, and **NON** if all indices either fail to attain or any index indicates poor or very poor performance.

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to determine the QHEI score which generally ranges from 20 to 100. The QHEI is used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much poorer physical

habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values higher than 60 are generally conducive to the establishment of warmwater faunas while those scores in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

During this survey, macroinvertebrates were sampled using modified Hester/Dendy multiple-plate artificial substrate samplers supplemented with a qualitative assessment of the available natural substrates.



(Figure 2). The magnitude of impact refers to the vertical departure of each index below the criterion. The total ADV is the area beneath the ecoregional criterion when the results for each index are plotted against river mile. This is also expressed as ADV/mile to normalize comparisons between segments and other areas.

Fish were sampled 2-3 times using pulsed DC electrofishing gear using either the wading method (150 meter zones) or boat method (500 meter zones). All chemical/physical and biological sampling locations are listed in Table 3.

An Area Of Degradation Value (ADV; Rankin and Yoder 1991) was calculated for the study area based on the longitudinal performance of the biological communities. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, and ICI) departs from the stream criterion or the upstream level of performance

Table 3. Sampling locations (effluent sample - E, water chemistry - C, sediment chemistry - S, benthos - B, fish - F) in the St. Marys River study area, 1991.

Stream/ River Mile	Type of a Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
St. Marys River (1991)				
100.5	F	40˚32'07"/84˚22'44"	Ust. Aquaduct Rd.	St. Marys
100.4	B,C,S	40˚32'06"/84˚22'44"	Dst. Aqueduct Rd.	St. Marys
98.7	F,B,C,S	40˚33'03"/84˚23'26"	Ust. St Marys WWTP	St. Marys
98.6	F,B,E,C	40˚33'04"/84˚23'35"	WWTP Mix Zone	St. Marys
98.5	F,B	40˚33'09"/84˚23'35"	Dst. St. Marys WWTP	St. Marys
98.4	B	40˚33'10"/84˚23'34"	Dst. St. Marys WWTP	St. Marys
98.1	C,S	40˚33'41"/84˚23'41"	Dst. St. Marys WWTP	St. Marys
96.5	S	40˚34'21"/84˚22'55"	Ust. St. Marys Landfill	St. Marys
95.1	F,B,C,S	40˚35'00"/84˚21'03"	Dst. Glynwood Rd.	St. Marys
89.4	B,C	40˚39'16"/84˚21'09"	Salem-Noble Rd	Spencerville
89.0	F	40˚37'47"/84˚21'03"	Dst. Salem-Noble Rd.	Spencerville
80.6	F	40˚39'17"/84˚25'09"	Dst./dst. SR 116	Elgin
80.5	B,C	40˚39'16"/84˚25'13"	SR 116	Elgin
75.1	F,B,C,S	40˚39'53"/84˚27'54'	Dst. Gallman Rd.	Elgin

Results and Discussion

Pollutant Loadings: 1976-1991

- The City of St. Marys operates a secondary trickling filter wastewater treatment system, OEPA permit number 2PD00026, which treats an average of 990,000 gallons per day (0.99 MGD). Final effluent from the plant discharges to the St. Marys River at RM 98.6. The plant was originally constructed in 1948, and was expanded to a capacity of 2 million gallons per day (MGD) in 1969. The City of St. Marys completed a bypass/overflow elimination project on December 21, 1989. This project eliminated two CSOs and included the construction of a 2 MG capacity stormwater flow equalization basin.

- Effluent BOD_5 loadings were only available for the period through 1988, at which time monitoring requirements were changed to $cBOD_5$. Carbonaceous BOD_5 data collected between 1989 and 1991 were converted to BOD_5 to allow trend analysis. The graph for this parameter indicates a fairly regular pattern between 1976 and 1988; and reduced annual loadings between 1989 and 1991.

- Ammonia-nitrogen loadings indicated that there was a substantial increase in this parameter, starting in 1983 and continuing through the study period in 1991 (Figure 3).

- Total phosphorus loadings indicated a considerable decrease in loadings, starting in 1985 and continuing through the study period (Figure 3).

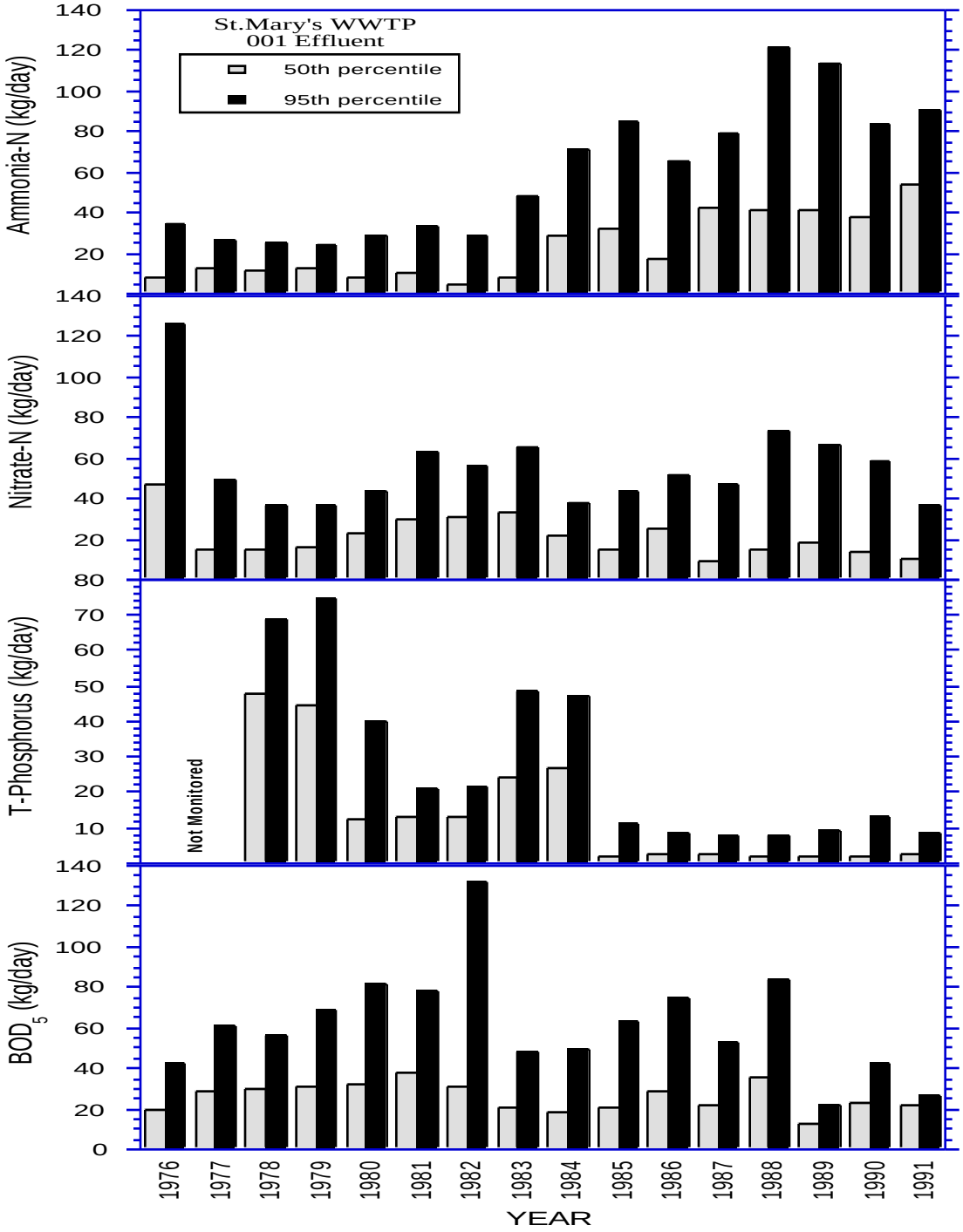


Figure 3. Annual loadings (kg/day) of ammonia, nitrate, phosphorus and five-day biochemical oxygen demand at the St. Marys WWTP. BOD_5 loadings for 1989-1991 were calculated based on reported five-day carbonaceous biochemical oxygen demand ($cBOD_5$) values ($cBOD_5$ x 1.3=BOD_5).

- The loadings for nitrate-nitrogen might have been expected to fluctuate in a manner more related to the ammonia-nitrogen loadings, however it appears that little nitrification is occurring within the treatment facility. The annual loadings for nitrate-nitrogen seem to be fairly regular for the monitored period (Figure 3).

- The City of St. Marys also monitors sewer system bypasses and overflows when discharging during wet weather periods. Occurrences of discharges from CSOs have declined from four/month in 1989, 0.6/month in 1990, to none reported for 1991. However, since completion, the equalization basin has discharged at a frequency of four/month in 1990 to 1.4/month in 1991. This discharge is located on a tributary which meets the St Marys River at RM 98.5. It contributed 57% of the total point source BOD_5 load to the St.Mary's River in 1990 and 25% in 1991 (Figure 4). Contributions for total non-filterable residue (total suspended solids) were 21% in 1990 and 7% in 1991 and for total phosphorus, 25% in 1990 and 6% in 1991.

- Effluent samples from St. Marys WWTP were tested for acute toxicity in October, 1991 (Bioassay Report Number 91-911-NW). Results of the test indicated that no acute toxicity to *P. promelas* or *C. dubia* was demonstrated. A previous bioassay conducted in November, 1987 (Bioassay Report Number 87-545-NW), indicated only slight toxicity to *C. dubia.*

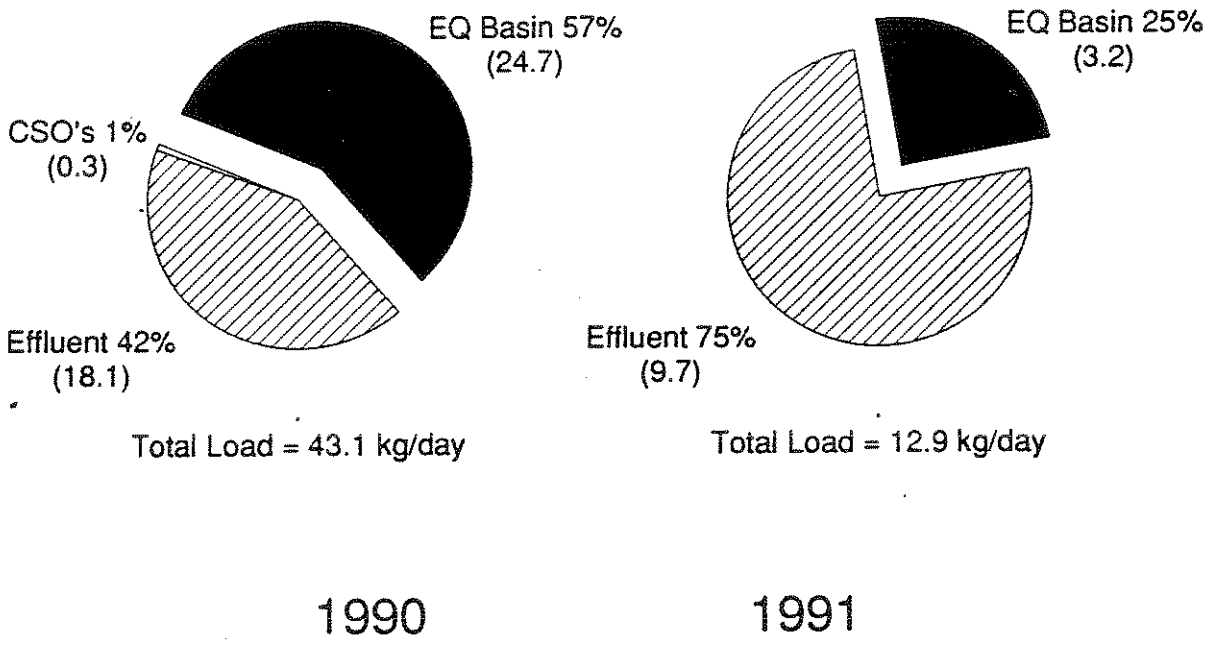


Figure 4. Pie graphs of the total mean cBOD5 loading (kg/day) from CSOs, St. Marys WWTP, and Equalization Basin (EQ) basin to the St. Marys River for 1990 and 1991.

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Chemical Water Quality

- There were three dissolved oxygen (D.O.) violations at the upstream site (RM 100.47) as well as a single fecal coliform bacteria exceedence. The study was conducted during a relatively low rainfall period, and the St. Marys River is primarily impacted by agricultural nonpoint sources, thus the exceedences are probably related to this impact. The next downstream site (RM 98.65) was located to detect the effects of combined sewer overflows (CSO) from the city of St. Marys. There were no CSO inputs reported during 1991, although discharges were noted in 1990. Four of the six D.O. measurements made at this site were violations, which may have reflected a continuing influence of the upstream nonpoint sources and/or oxygen demand from organic material deposited on the bottom from past CSO inputs.

- The site at RM 98.59 was located in the mixing zone of the St.Marys WWTP discharge. While there were no D.O. violations, all sample measurements for ammonia-nitrogen were exceedences, which indicated a potential for toxicity and nutrient enrichment at and downstream from this station. The site at RM 98.09 was located to detect the effects of overflows from the St. Marys flow equalization basin, as well as the impact of the WWTP effluent. All of the ammonia-nitrogen concentrations at this site were in violation of the Warmwater Habitat criteria; there were also four exceedences of the D.O. criteria and two elevated fecal coliform bacteria samples. The remaining sample sites on the St. Marys River were located to track water quality recovery. The site at RM 95.12 reflected a continued influence of the St. Marys WWTP, with four ammonia-nitrogen exceedences and three D.O. violations. Chemical water quality improved between RM 89.4 and RM 75.1. Two D.O. violations were measured at RM 89.42 and single D.O. violations occurred at RM 80.51 and RM 75.1. Departures from chemical water quality standards are listed in Table 4.

- Mean D.O. of grab samples reflected an impact on chemical water quality from the City of St. Marys. The decrease in mean D.O. from RM 98.7 to RM 98.65 is the result of oxygen demand from CSO-related benthic deposits. The WWTP effluent apparently contributes some oxygen to the river through aeration (see RM 98.59), but the mean D.O. again decreased to a point (at RM 98.09) even lower than that at RM 98.65. This decrease is probably due to the effects of the WWTP effluent, but the overflows from the equalization basin may also affect water quality at this site. From January-April 1991, 17 occurrences of overflows from the equalization basin were reported, totaling 19.5 MG. Reported loadings of total suspended solids, total phosphorus, and $cBOD_5$ from the equalization basin overflows suggest the possibility of sludge deposits downstream from the basin. The mean D.O. at RM 95.12 continued to reflect water quality problems and likely represents the D.O. "sag" associated with the organic enrichment. Recovery is indicated at the most downstream sampling station, with a steady increase in mean D.O., to a point where no depletion was evident (Figure. 5).

- Diurnal D.O. concentrations from datasonde™ continuous monitors reflected a similar pattern of D.O. depletion downstream of CSOs, St. Marys WWTP, and the equalization basin discharge. The data from the site at RM 95.1 also indicates D.O. depletion, but a wider range of D.O. concentrations were measured, possibly reflective of the high flows encountered during the period that continuous monitors were set.(Figure. 6).

- The mean BOD_5 concentration decreases from the upstream site to RM 98.65; however, the levels are low throughout this segment. There is a definite increase in BOD_5 downstream from the WWTP, which declined downstream from RM 98.09, and then stabilized (Figure 5).

- Mean ammonia-nitrogen concentrations from grab samples clearly reflected inputs from the St. Marys WWTP. Background levels at RM 100.47 and RM 98.65 are quite low, but the mean concentration increased dramatically at RM 98.59. The mean concentration decreased rapidly from RM 98.59 to RM 89.42 and then reached levels similar to those upstream (Figure. 5).

- Mean phosphorus concentrations reflected inputs from St Marys WWTP and agricultural NPS. The input of the St. Marys WWTP was evident at RM 98.59. Agricultural inputs most likely contributed to the elevated levels found in the lower reach. Total phosphorus concentrations were low and varied over a narrow range. This data only suggests general trends.(Figure. 4).

Table 4. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in the St. Mary's River, 1991 (units are #/100 ml for fecal coliform, and mg/l for all other parameters).

Stream Name	River Mile	Violation: Parameter (value)
St. Mary's R	100.5	D.O. (4.3 ‡, 3.5 ‡‡, 4.8 ‡); Fecal coliform (4000 ◊)
	98.7	D.O. (4.2 ‡, 3.5 ‡‡, 4.5 ‡, 3.8 ‡‡)
	98.6	NH_3-N (5.80 *, 6.68 *, 7.05 *, 3.77 *, 13.60 **, 2.28 *); Fecal coliform (2500 ◊)
	98.1	D.O. (4.7 ‡, 4.2 ‡, 4.3 ‡, 3.8 ‡‡); NH_3-N (4.78 *, 4.05 *, 4.32 *, 2.44 *, 1.88 *); Fecal coliform (44000 ◊◊, 3500 ◊)
	95.1	D.O. (4.0 ‡, 3.5 ‡‡, 4.2 ‡); NH_3-N (2.24 *, 3.45* 3.63 *, 1.89 *)
	89.4	D.O. (4.2 ‡, 4.5 ‡)
	80.5	D.O. (4.9 ‡)
	75.1	D.O. (4.9 ‡)
		Iron 44 of 48 samples (91.7%) exceeded 1.0 mg/l in the study area.

* indicates an exceedence of numerical criteria for prevention of chronic toxicity (CAC).
** indicates an exceedence of numerical criteria for prevention of acute toxicity (AAC).
‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
◊ exceedence of the Primary Contact Recreation criterion.
◊◊ exceedence of the Secondary Contact Recreation criterion.

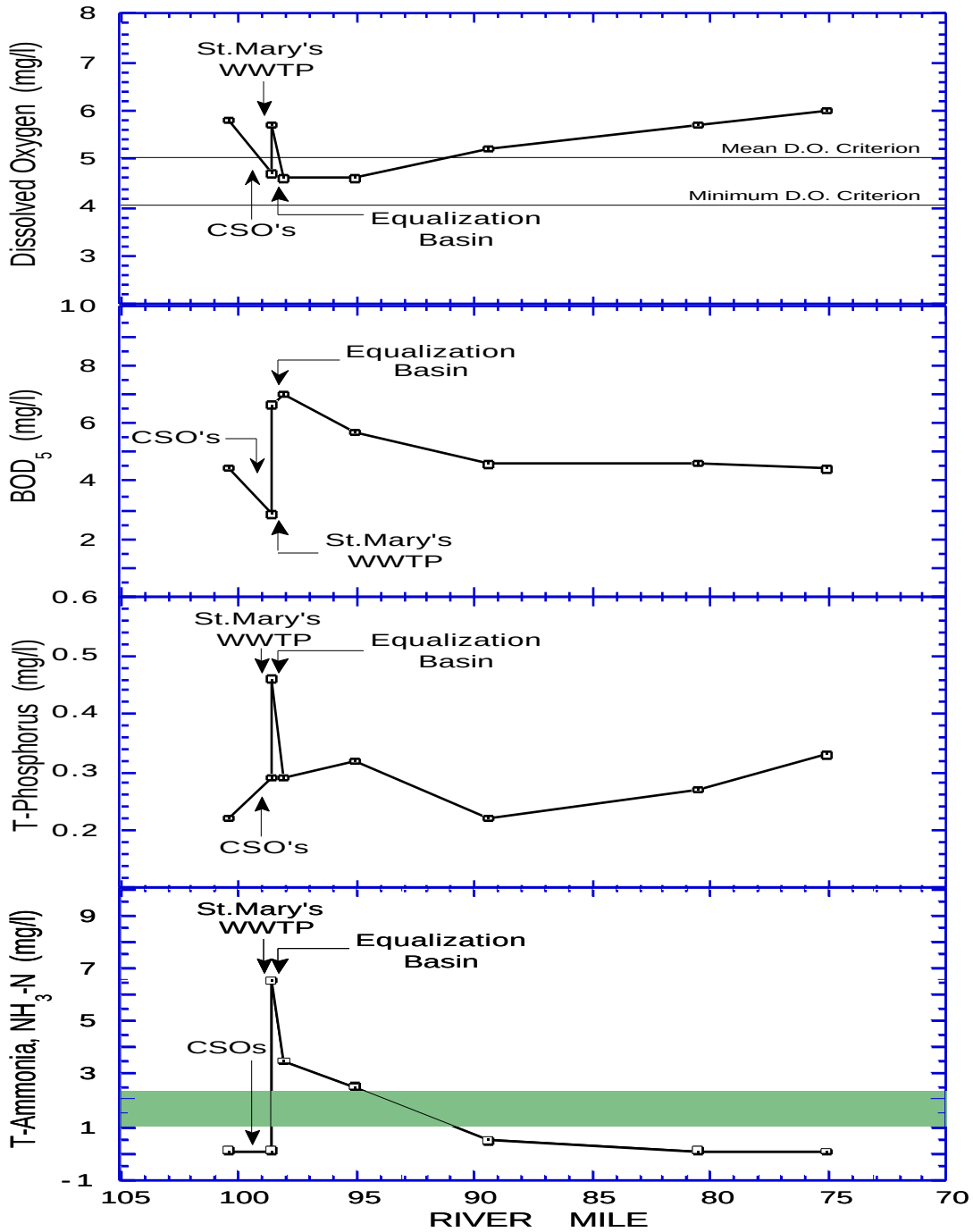

Figure 5. Longitudinal trend of mean dissolved oxygen, biochemical oxygen demand, phosphorus and ammonia-nitrogen in the St. Marys River study area, 1991. Shaded area in the ammonia-nitrogen plot represents the range of WQS criteria based on the 95th and 25th percentile, pH and temperature values from survey data.

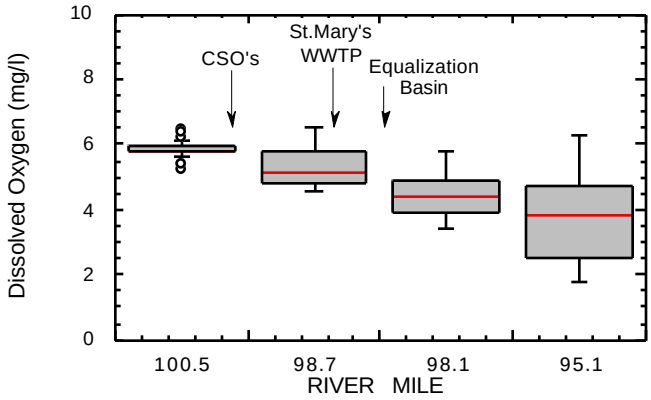

Figure 6. Box and whisker plots of dissolved oxygen data recorded with Datasonde™ continuous monitors at selected locations in the St Marys River during the summer of 1992.

Sediment Chemistry

- The concentrations of organic compounds, as noted in the sediment samples, did not seem to reflect any particular problems. The presence of pesticides appears to be related to agricultural nonpoint sources (Table 5).

- The concentrations of arsenic in the sediment samples have not been related to any known source, at this time. However, a review of the literature suggests the possible source as past agricultural applications. CSO inputs appear to be the source of several metals, particularly zinc and lead, at RM 98.65. The relatively elevated concentrations of several metals at RM 75.07 may be related to increased deposition of finer sediments due to the reduced gradient of the lower reach of the study area. A summary of sediment metal concentrations can be found in Table 6.

- The sediment site at RM 96.5 was added as an upstream reference for the detection of impacts from the St. Marys Landfill, which is located adjacent to the St. Marys River between RM 95.5 and RM 96.5. Reports indicate that leachate has been pumped into the river from disposal trenches in the past. Minor leachate outbreaks are also present at the site. At RM 96.5, upstream of the landfill, arsenic levels were 8.31 mg/kg (slightly elevated); Downstream of the landfill, at RM 95.12, arsenic levels increased to 17.9 mg/kg classified as highly elevated by Kelly and Hite (1984). Leachate outbreaks may have been an additional source of these elevated arsenic levels.

Table 5. St. Mary's River sediment priorty pollutant scan detections during 1991. Corrected method detection limits, based on weight and dilutions of sample, for non-detected (ND) priority pollutants are presented in parenthesis.

PARAMETER	RM 96.5	RM 95.1
PESTICIDES (ug/kg) [1, 2]		
d - BHC	9.62 [f]	6.76 [f]
Dieldrin	6.56 [c]	1.77 [a]
Endrin	5.31 [f]	ND (0.64)
Endosulfan II	15.17 [f]	1.13 [f]
Methoxychlor	19.91 [f]	ND (3.18)
DDT (sum)	19.17 [c]	4.08 [a]
GC/MS LIBRARY COMPUTER MATCH (mg/kg) [3]		
SEMI-VOLATILE ORGANICS		
Octacosane	1.6	1.3
Tetradecanal	2.0	ND
Nonacosane	7.0	2.6
Hexadecanal	1.5	ND
Triacontane	3.7	1.5
Octadecanal	1.7	ND
D : A - Friedooleanan - 2 - One	2.0	ND
Bis (2 - Ethylhexyl) Ester	ND	2.7
Hexanedioic Acid		

1. All pesticide concentrations, unless indicated, were ranked with the following stream sediment classification system described by Kelly and Hite (1984). NOTE: The Kelly and Hite classification system addresses relative concentrations, but does not directly assess toxicity.
   [a] Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**;
   [f] Not evaluated by Kelly and Hite
2. Sum DDT is the total of 4, 4' - DDE, 4, 4' - DDD, and 4, 4' - DDT.
3. Library matched chemical concentrations indicated are estimates within one order of magnitude reported

Table 6. Concentrations of heavy metals in sediments of the St. Mary's River, 1991. All parameter concentrations, excluding nickel, were ranked based on a stream sediment classification system described by Kelly and Hite (1984).

River Mile	Sediment Concentration (mg/kg. dry weight) As	Cd	Cr	Cu	Fe	Pb	Ni	Zn
100.5	10.9[b]	0.240[a]	7.86[a]	14.5[a]	21400[b]	25.5[a]	14.5	60.4[a]
98.7	71.7[c]	0.288[a]	15.8[a]	29.1[a]	21700[b]	**68.8[d]**	19.1	142.0[c]
98.1	3.8[c]	0.329[a]	10.4[a]	22.0[a]	18800[b]	36.2[b]	14.1	84.6[b]
96.8	5.31[b]	0.396[a]	9.54[a]	22.6[a]	22600[b]	29.8[b]	16.6	75.8[a]
95.1	**17.9[d]**	0.366[a]	12.5[a]	21.8[a]	23600[c]	30.2[b]	18.1	86.6[b]
75.1	**17.8[d]**	0.434[a]	22.1[b]	28.7[a]	**32100[d]**	30.2[b]	26.9	107.0[c]

[a]Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**

Note: The Kelly and Hite classification system addresses relative concentrations but does not directly assess toxicity.

Physical Habitat for Aquatic Life

- Macrohabitats of the St. Marys River were evaluated at seven fish sampling locations. QHEI values ranged from 41.0 at RM 80.6 to 72.5 at RM 95.1, with a mean value of 53.5. A mean reach QHEI value between 45 and 60 suggests that a more detailed evaluation of each QHEI attribute needs to be undertaken to determine suitability for supporting the WWH use designation (Rankin 1989). In order to elucidate stream reaches of relatively homogenous habitat, the study area was broken into three segments. Stream segments and reach average QHEI scores can be found in Table 7.

- The uppermost site within the St Marys River study area (RM 100.5; **Segment 1**), appeared to have been subject to significant past modification. This station demonstrated a predominance of high and moderate influence modified habitat attributes (Table 8). Past modifications were manifest in various components of instream habitats that included extensively embedded substrates (caused primarily by introduced silts and sand), poor channel development and low sinuosity. Log jams and woody debris provided abundant instream cover, but this component of physical habitat was functionally limited by the deposition of introduced sediments.

- Based on a review of the St. Marys Quadrangle USGS 7.5' topographic map it was evident that additional segments upstream of RM 100.5 have been modified, specifically the Center and East Branch of Clear Creek. Both of these tributaries had low to no sinuosity and possessed several right angle bends, a characteristic common to highly modified streams. Though documentation as to the extent and date of this modification was unavailable from Auglaize County Engineers, it was apparent that the headwaters of the St. Marys River basin have been subject to significant instream channel modification.

- The highest quality habitats of the study area were located within the reach extending from RM 98.7 to RM 95.1 **(Segment 2)** downstream from St. Marys CSOs. This segment demonstrated a predominance of warm water habitat attributes with a mean reach QHEI score of 66.8 (Tables 7 and 8). A mean QHEI value greater than 60 suggests that instream habitats are of a sufficient quality to support and maintain a biological community capable of attaining the WWH biological criteria (Rankin 1989). Generally this segment possessed substrates of glacial origin, good to fair channel development, and a diversity of instream cover types. Though this reach was significantly modified during the construction of the Miami-Erie Canal, (early 19th century), it appears to have recovered many free flowing characteristics.

- The reach between RM 89.0 and RM 75.1 **(Segment 3)** contained the poorest habitats of the study area. This segment demonstrated a predominance of high and moderate influence modified habitat attributes which was reflected in a mean QHEI score of 45.3 (Tables 7 and 8). The substrates of this area consisted primarily of clayey silts and sand overlying and embedding the natural substrate to a depth of one to two feet throughout each sampling station. The primary instream cover types were log jams, fallen timber, and woody debris. However, this component of physical habitat was functionally limited by the extensive siltation. From an inspection of USGS 7.5' topographic maps (Spencerville, Salem, and Noble Quadrangles), field observations and personal communications with Auglaize and Mercer County Engineers, the St. Marys River mainstem between RM 89.0 and RM 75.1 has been subject to only localized instream channel modifications (D. Bennet and K. Earley personal communication, Auglaize and Mercer County Engineer Office).

Table 7. Average QHEI scores for three relatively homogenous segments of the St. Marys River mainstem based on sampling conducted during June - September, 1991.

Sample Location: Segment Description		Sample		Segment
Upstream River Mile	Downstream River Mile	Location River Mile	QHEI	Average QHEI
Segment 1: Upstream from the city of St. Marys				
100.5	100.5	100.5	44.0	44.0
Segment 2: Upstream St. Marys WWTP to Downstream Glynwood Rd.				
98.7	95.1	98.7	64.0	66.8
		98.4	62.0	
		95.1	74.5	
Segment 3: Downstream Salem-Noble Rd. to Downstream Gallmon Rd.				
89.0	75.1	89.0	52.0	45.3
		80.6	41.0	
		75.1	43.0	

Table 8. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the St Marys River study area, June - September, 1992.

Key QHEI Components			WWH Attributes										MWH Attributes																	
													High Influence							*Moderate Influence*											
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	**Total WWH Attributes**	Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 4.0 cm (WD,HW)	**Total (High Influence) MWH Attributes**	Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Silt/Embeddedness	No Riffle	**Total (Moderate Influence) MWH Attributes**	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
(04-500) – ST. MARYS RIVER																																	
Year: 91																																	
100.5	44.0	4.00						■			■		2	●	●				2		▲		▲	▲			▲			▲	6	1.00	3.00
98.7	64.0	1.77	■	■		■	■	■		■	■	■	8						0	▲	▲		▲				▲	▲			5	.11	.67
98.4	62.0	1.77		■			■	■			■	■	5						0	▲	▲		▲	▲			▲	▲			6	.17	1.17
95.1	74.5	3.85	■	■		■	■	■	■		■	■	8						0									▲			1	.11	.22
89.0	54.0	1.85	■			■	■	■			■		5	●					1		▲		▲				▲	▲		▲	5	.33	1.17
80.6	41.0	.92									■		1	●			●		2	▲	▲		▲	▲			▲	▲		▲	7	1.50	5.00
75.1	43.0	1.09					■	■			■		3	●					1	▲	▲		▲	▲			▲	▲		▲	7	.50	2.25

- The pervasive siltation observed throughout the lower St. Marys River study area is most likely a result of channelization of tributaries and extensive field tiling of the surrounding watershed, which provides rapid delivery of fine sediments to the lower gradient mainstem reaches. Given the intensive agricultural land use within the St. Marys River basin theses activities would result in the introduction and deposition of eroded sediments. Compounding the agricultural NPS problems is the low gradient character of the lower St. Marys River. The low gradient increases retention time (suspended and bedload sediments) which allows fine sediments to be deposited in the river bed. The resulting bedload degrades instream habitat by reducing stream depth heterogeneity, embedding coarse substrates, and functionally limiting instream cover (Rankin 1989). The observed habitat deficit in the lower St. Marys River presently contributes to the limited instream biological potential. However, it should be noted that the reach between RM 80.6 and RM 75.1 represents the entry of the St. Marys River into the HELP ecoregion. The habitat characteristics observed are typical of this region and the lower biological expectations are accounted for in the Ohio EPA's ecoregional biological criteria (Ohio EPA 1987a;b; 1989a).

Biological Assessment: Macroinvertebrate Community

- Although the stream did not appear overly enriched, the macroinvertebrate community at RM 100.4 failed to achieve the WWH criteria due to limited habitat. The stream was shallow with an unstable sand and fine gravel substrate. The artificial substrates were covered with a heavy layer of silt and sustained flow velocity of greater than 0.3 ft/sec, which is necessary for WWH macroinvertebrate colonization, appears doubtful. The samplers were retrieved on September, 4 following heavy rain showers the previous 24 hours. Despite the recent rains, current velocity over the artificial substrates was only 0.31 ft/sec The artificial substrates produced an ICI score in the fair range (ICI=22). Relatively low overall density and high diversity on both the natural and artificial substrates did not suggest significant enrichment (Table 9; Figure 7).

- No impact in the macroinvertebrate community was discerned from CSOs within the city of St. Marys and nutrient levels continued to appear non-elevated. The ICI score increased somewhat compared to the upstream site, but remained in the fair range (ICI=28; Figure 7). The higher score is, in part, due to increased current over the artificial substrates. Habitat continued to limit the performance in the macroinvertebrate community due to the overwhelming predominance of sand and silt substrate types.

- The tolerant midge genera *Glyptotendipes sp.* predominated on the natural substrates within the St. Marys WWTP mixing zone (RM 98.6) and immediately downstream (RM 98.5). ICI scores at these locations were in the marginally fair range (ICI=16). Relative density was higher on both the natural and artificial substrates compared with the upstream sampling locations. The macroinvertebrate assemblage was indicative of significant organic enrichment.

- The macroinvertebrate community achieved the WWH criterion at RM 95.1 where the ICI scored 38. An enrichment effect was evident, the result of partial assimilation of the organic load introduced by the WWTP discharge. Large numbers of filter feeding caddisflies and midges were present on the artificial substrates. These taxa are commonly associated with areas of moderate to high enrichment. The natural substrates exhibited a higher degree of impact than did the quantitative sample, tolerant midges predominated, but only a limited degree of improvement was apparent.

- Recovery in the macroinvertebrate community was largely complete approximately nine miles downstream from the St. Marys WWTP. ICI scores at the remaining stations (RM 89.4, RM 80.5 and RM 75.1) were 44, 20 and 42, respectively (Table 9; Figure 7). Fine gravel, sand and silt continued to be the predominant substrate types. The reason for the low ICI values at RM 80.5 was heavy siltation of the artificial substrates. The particularly severe siltation at this site can be attributed to channel widening around the SR 116 bridge. The modifications of the stream bed at this site slowed current velocity and allowed for the increased deposition of fine silts. In an unaltered stream channel these silts are instead deposited on the flood plain during high flows. The ICI scores at RM 89.4 and RM 75.1 were indicative of very good community performance. It appeared that the WWTP discharge had an overall beneficial effect by providing additional flow volume. In particular, there was a marked increase in the diversity and numbers of caddisfly taxa. With this flow augmentation, it seems reasonable to expect that the benthic community could achieve the ecoregional criteria outside of the mixing zone (RM 98.5) if effluent quality can be improved.

Table 9. Summary of macroinvertebrate data collected from artificial substrate samplers (quantitative) and natural substrates (qualitative sampling) in the St. Marys River study area, June-September , 1991.

Quantitative Evaluation							
Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Qual. EPT[b]	Average Tol. Value[c]	ICI	Narrative Evaluation
St. Marys River							
Eastern Corn Belt Plain *(Existing Use Designation)*							
100.4	444	41	42	6	29.8	22*	Fair
98.7	400	36	26	3	27.7	28*	Fair
98.6	807	24	19	3	30.8	16*	Fair
98.5	732	29	20	2	27.8	16*	Fair
95.1	1171	36	23	4	30.3	36	Good
89.4	423	40	26	9	34.3	44	Good
Huron Erie Lake Plain *(Recommended Use Designation)*							
80.5	428	21	24	6	33.1	20*	Fair
75.1	355	33	21	8	37.0	42	Good

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX	WWH	EWH	MWH[d]
ICI	36	46	22

Ecoregion Biocriteria: Huron Erie Lake Plain (HELP)

INDEX	WWH	EWH	MWH[d]
ICI	34	46	22

d - Modified Warmwater Habitat for channel modified ares.

b EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).

c Average Tolerance Value calculated as the average of the weighted ICI for each taxa.

* Significant departure from ecoregion biocriteria (>4 ICI units); poor and very poor results are underlined.

ns Nonsignificant departure from biocriterion (<4 ICI units).

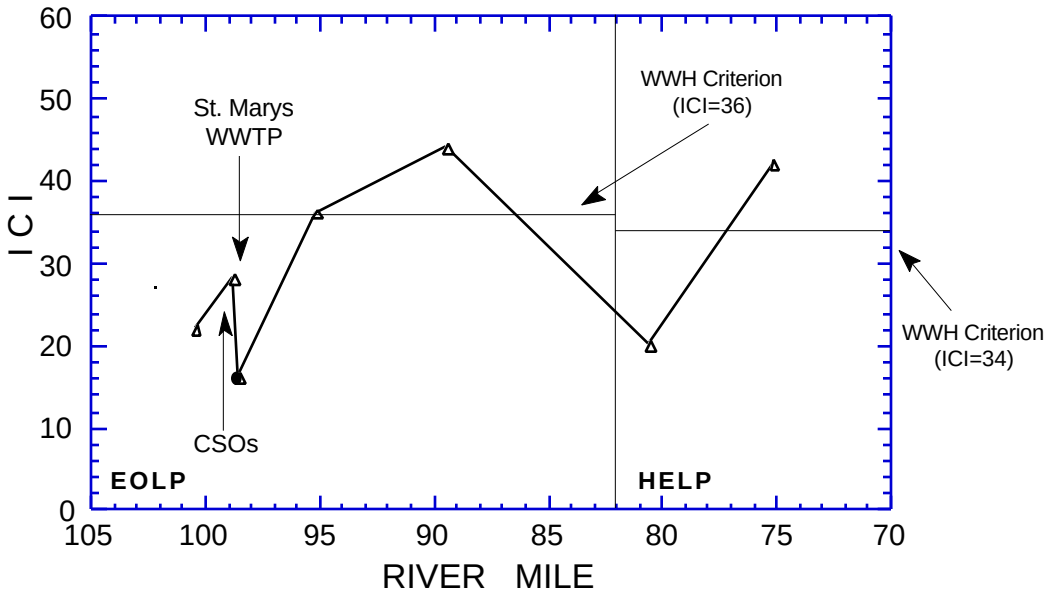

Figure 7. Longitudinal trend of the Invertebrate Community Index (ICI) in the St Marys River study area, 1991.

Biological Assessment: Fish Community

- A total of 3,448 fish comprised of 41 species and five hybrids were collected from the St. Marys River between July 17 and September 18, 1991. The sampling included a total of 40.9 km at eight sampling locations between RM 100.5, upstream of the city of St. Marys, and RM 75.1, upstream of the village of Mendon.

- The fish community was predominated by numbers by bluntnose minnow (17%), green sunfish (13%), white sucker (11%), creek chub (9%), common carp (8%) and spotfin shiner (4%). Species that predominated in terms of biomass were common carp (47%), white sucker (10%), quillback carpsucker (8%), spotted sucker (6%), channel catfish (5%) and freshwater drum (4%). Both in terms of relative abundance and relative weight the fish community appeared to be predominated by pollution tolerant, omnivorous and/or generalist feeders, and habitat generalists. Species intolerant of environmental disturbances were absent, reflecting degraded water quality, modified habitats, and agricultural NPS impacts on the St. Marys River.

- Based on IBI and MIwb scores and the accompanying narrative evaluations, overall the fish community performance ranged from fair (IBI=31; MIwb=6.6) at RM 100.5 to poor/fair (IBI=22; MIwb=6.0) at RM 98.7. No sampling stations fully achieved the WWH biological criteria (Table. 10).

- At RM 100.5, upstream of the city of St. Marys, the fish community performance was fair (IBI=31; MIwb=6.6). Though this station failed to achieve WWH biological criteria, it demonstrated the highest community performance recorded in the St. Marys River study area (Figure. 8). The failure of this sampling station to achieve WWH biological criteria is most likely a result of past channel modifications and agricultural NPS inputs.

- Despite improved habitat quality found within the St. Marys River between RM 98.7 and RM 95.1, this reach generally supported a degraded fish community. The sampling station under the influence of the CSO from the city of St. Marys (RM 98.7) contained a community that was characterized as poor/fair (IBI=22; MIwb=6.0) representing the lowest fish community performance recorded during the 1991 field sampling efforts (Figure 8; Table 10). Trophic and reproductive components of the community appeared greatly diminished, reflected in a predominance of omnivorous and tolerant species. Additionally, structural components of the community were suppressed; species richness and relative abundance demonstrated a significant reduction in comparison to the sampling station upstream. The percent occurrence of DELT anomalies reached 1.9%, indicating chronic stress within the fish community (Ohio EPA 1987[b]).

- A near-field impact was detected at RM 98.6, immediately downstream of the St. Marys WWTP within the mixing zone. A localized improvement in community performance was recorded further downstream from the WWTP (RM 98.4) under the influence of the treatment facility's equalization basin (Figure 8). The increase in community performance recorded at RM 98.4 demonstrated that well aerated organic effluent may not be immediately stressful to the fish community until instream decomposition further downstream lowers ambient dissolved oxygen concentrations; however this station failed to achieve the WWH biological criteria and the incidence of DELT anomalies increased to 2.3%, indicating additional stress within the fish community.

- The sampling station at RM 95.1 contained the highest quality instream habitat of the entire study area; however, this reach supported only a limited fish community (IBI=22;MIwb=6.1) The poor/fair community performance observed at RM 95.1 most likely reflects depressed dissolved oxygen associated with elevated BOD, and ammonia-nitrogen loadings from the St. Marys WWTP (Figure 8). Additionally, the station at RM 95.1 may also be impacted by the influence of an active landfill adjacent to the St. Marys River between RM 95.5 and RM 95.2. Reports indicate that leachate has been pumped into the St. Marys River from disposal trenches. Currently minor leachate outbreaks are presence on site. Sediment samples revealed the presents of arsenic occurring at highly elevated concentrations. It was not clear that the elevated concentrations of arsenic in the sediments contributed to the poor/fair performance.

- Community performance between RM 89.0 and RM 75.1 suggests a slight recovery from the impacts observed downstream from the St. Marys WWTP (Figure 8; Table 10). Though functional attributes remained diminished and DELT anomalies were significantly elevated, structural components of the fish community demonstrated improvement in comparison with stations upstream. Though full recovery within the fish community was not observed, it appears that the community is in the process of recovery. The reach between RM 80.6 and RM 75.1 represents the entry into the HELP ecoregion. This region has the most widespread and severe agricultural impacts of any of the Ohio ecoregions, which is related to extensive hydromodifications, delivering clayey silts in runoff (Omernik and Gallant 1988). As a consequence, this reach contains the poorest instream habitat recorded within the St.

Marys River study area. Poor habitat is undoubtedly contributing to non-achievement, but is not the sole determinant. The lower biological expectation of this region has been recognized by the Ohio EPA in the development of **ecoregional** biological criteria (Ohio EPA 1987[b]; Whittier *et. al.* 1987).

Table 10. Fish community indices based on pulsed D.C. electrofishing samples at eight locations sampled by Ohio EPA in the St. Marys River study area during June - September, 1991. All sites sampled with boat and wading methods.

Stream River Mile	Mean Number of Species	Cumulative Species	Mean Rel. No. (No./Km)	Mean Rel. Wt. (Kg/Km)	QHEI	Mean Modified Index of Well-Being	Mean Index of Biotic Integrity	Narrative Evaluation
St. Marys River								
	Eastern Corn Belt Plain - WWH Use designation(Existing)							
100.5	20.0	23	443	16.6	44	6.6*	31*	Fair
98.7	15.5	19	261	13.1	62	6.0*	22*	Fair/Poor
98.6	11.0	14	549	17.5	-	5.0*	21*	Poor
98.4	17.5	22	180	26.7	60	5.9*	29*	Fair
95.1	16.0	18	325	12.9	73	6.1*	22*	Fair/Poor
89.0	19.7	26	344	158.2	52	8.4[ns]	26*	Fair
	Huron Lake Plain- WWH Use designation (Recommended)							
80.6	15.7	22	174	48.0	41	7.8*	26*	Fair
75.1	14.3	19	173	55.2	43	6.9*	22*	Fair/Poor

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Headwaters/Wading	40	50	24
IBI - Boat	42	48	24
Mod. Iwb - Wading	8.3	9.4	6.8
Mod. MIwb - Boat	8.5	9.6	5.8

Ecoregion Biocriteria: Huron Erie Lake Plain (HELP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Boat	34	48	20
Mod. Iwb - Boat	8.6	9.6	5.7

* - Significant departure from applicable biological criterion (>4 IBI units or >0.5 Iwb units); underlined values are in the poor and very poor range.

ns - Nonsignificant departure from biocriterion (<4 IBI units or < 0.5 MIwb units)

a - Narrative evaluation is based on both MIwb and IBI scores.

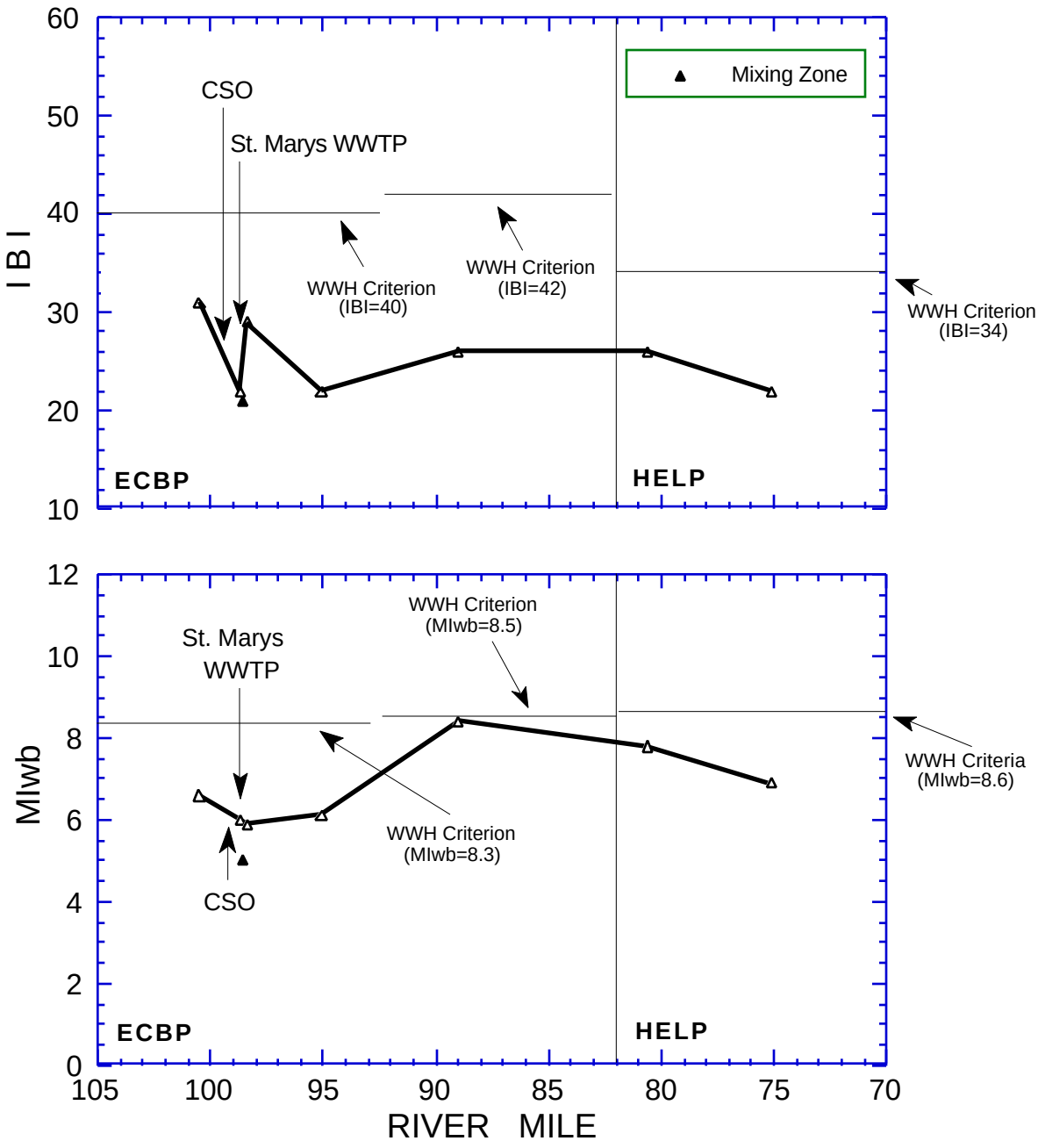

Figure 8. Longitudinal trend of the Index of Biotic Integrity (IBI; upper) and the Modified Index of Well-being (MIwb; lower) in the St. Marys River study area, 1991.

Area of Degradation Value (ADV) Statistics

- Area of Degradation Values (ADV) for the 1991 sampling effort provide a relative measure of the degradation portrayed by the IBI, MIwb and ICI from ecoregional expectation for the St. Marys River. The high ADV/mile from the St. Marys River reflects point, nonpoint, and habitat impacts within the study area. The ADV/mile results are within the range of values commonly encountered for streams that are impacted by organic enrichment from municipal sewage. The low MIwb and elevated IBI Poor/Very Poor ADV values are another reflection of the organic enrichment and diminished habitats. The ADV value for the MIwb is less than for the IBI under enriched conditions because of the increase in the relative abundance and biomass of tolerant and intermediate tolerant fish species. These shifts within the structural components of the fish community tend to improve the MIwb, but do not significantly affect the IBI. This information will provide the basis for a future trend analysis of the St. Marys River study area.

Table 11. Area of Degradation (ADV) statistics for the St. Marys study area, 1991 (calculated using ecoregion criteria as the background community performance).

	Biological Index Scores				ADV Statistics			Attainment Status (miles)			
Stream Index	Upper RM .	Lower RM .	Mini-mum	Maxi-mum	**ADV**	ADV/ Mile .	Poor/VP ADV	FULL	PARTIAL	**NON**	Poor/VP
St. Marys River (1991)											
IBI	100.5	75.1	21	31	**2638**	103.9	342	0.0	6.4	19.0	14.9
MIwb			5.0	8.4	**890**	35.1	1				
ICI			16	44	**745**	29.3	0				

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Appendix Tables

Appendix Table 1. Results (mean/minimun - maximun)[a] of chemical/physical sampling conducted in the St. Marys River study area during June - September, 1991. All conventional parameters are reported in mg/l; all metals and other substances are reported in µg/l, unless otherwise noted.

River Mile (n)	Dissolved Oxygen (Surface)	Temperature	pH	Tot. Susp. Solids
100.47(6)	5.8(3.5-8.8)	20.0(13.0-26.1)	8.1(7.8-8.8)	47(8-185)
98.65(6)	4.7(3.5-6.3)	20.7(13.5-25.2)	7.9(7.6-8.0)	32(25- 43)
98.60(6)	7.1(7.0-7.2)[b]	22.6(18.5-25.5)	7.2(7.0-7.4)	16(5- 33)
98.59(6)	5.7(5.1-6.8)	21.4(15.5-25.2)	7.6(7.5-7.8)	23(5- 38)
98.09(6)	4.6(3.8-5.7)	21.4(14.5-25.8)	7.7(7.2-8.0)	28(7- 55)
95.12(6)	4.7(3.5-5.6)	20.5(13.0-25.0)	7.7(7.1-8.0)	62(29-182)
89.42(6)	5.2(4.2-6.4)	20.9(13.0-25.4)	7.8(7.3-8.0)	64(44- 84)
80.51(6)	5.7(4.9-7.0)	21.2(13.0-25.8)	7.8(7.1-8.0)	94(40-128)
75.07(6)	6.0(4.9-7.7)	20.7(13.0-24.8)	7.7(7.1-8.0)	96(65-126)

River Mile (n)	Specific Conductance	BOD5	COD	Total Phosphorus
100.47(6)	953(579-1080)	4.4(1.4- 8.1)	20(10-29)	0.23(0.12-0.33)
98.65(6)	921(802-1270)	2.9(1.9- 4.6)	25(17-32)	0.29(0.22-0.33)
98.59(6)	1023(861-1230)	6.6(3.0-13.0)	33(21-42)	0.46(0.25-0.76)
98.09(6)	964(838-1240)	7.0(5.0-10.0)	29(18-35)	0.29(0.19-0.48)
95.12(6)	1003(828-1210)	5.7(1.2-11.0)	25(19-30)	0.32(0.18-0.62)
89.42(6)	1051(882-1340)	4.6(2.7-6.1)	19(14-25)	0.22(0.12-0.29)
80.51(6)	656(602- 735)[b]	4.6(3.3- 5.4)	24(17-28)	0.27(0.18-0.31)
75.07(6)	630(585- 701)	4.4(3.0- 5.6)	29(18-46)	0.33(0.20-0.56)

a = Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.

b= n<6 samples.

c= 3 samples.

Appendix Table 1. continued.

River Mile (n)	Nitrate-Nitrite (N)	Nitrite (N)	Ammonia (N)	Tot. Kjeldahl Nitrogen
98.65(6)	0.20(0.14-0.25)	0.03(0.02-0.03)	0.10(0.05- 0.16)	1.0(0.8- 1.2)
98.60(6)	1.28(0.10-4.77)	1.01(0.02-3.43)	10.61(3.50-14.10)	10.6(4.5-14.4)
98.59(6)	0.62(0.15-1.93)[b]	0.45(0.05-1.42)[b]	6.53(2.28-13.60)	7.1(3.5-12.8)
98.09(6)	0.52(0.25-1.11)	0.32(0.13-0.65)	3.49(1.88- 4.78)[b]	4.2(2.3- 5.6)[b]
95.12(6)	1.04(0.55-2.08)	0.31(0.18-0.52)	2.53(1.43- 3.63)[b]	3.9(1.5- 7.0)
89.42(6)	1.79(1.33-2.75)	0.23(0.12-0.36)	0.48(0.05- 1.10)	1.3(0.8- 2.1)
80.51(6)	0.59(0.35-1.25)	0.06(0.03-0.12)	0.11(0.05- 0.36)	1.2(1.0- 1.7)
75.07(6)	0.50(0.30-1.03)	0.04(0.02-0.06)	0.07(0.05- 0.14)	1.0(0.8- 1.1)

River Mile (n)	Hardness (CaCO3)	Total Calcium	Total Magnesium	Lab pH (S.U.)
100.47(6)	401(224-459)	88(50-103)	44(24-54)	7.99(7.84-8.18)
98.65(6)	275(251-332)	60(56- 72)	31(27-37)	7.81(7.50-8.09)
98.60(6)	275(249-297)	69(60- 76)	25(21-29)	7.27(6.81-7.57)
98.59(6)	279(261-318)	67(61- 73)	27(23-33)	7.58(7.05-7.80)
98.09(6)	273(225-312)	63(52- 69)	28(23-34)	7.70(7.62-7.78)
95.12(6)	304(284-323)	71(66- 80)	31(29-32)	7.74(7.65-7.82)
89.42(6)	371(345-396)	84(77- 91)	39(37-41)	7.89(7.75-8.02)
80.51(6)	248(223-267)	53(48- 58)	28(25-31)	7.87(7.73-7.99)
75.07(6)	239(224-249)	51(47- 57)	27(26-29)	7.86(7.74-7.93)

a = Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.

b= n<6 samples.

c= 3 samples.

Appedix Table 1. continued

River Mile (n)	Total Cadmium	Total Chromium	Total Copper
100.47(6)	0.2(0.2-0.4)	30(30-30)	10(10-10)
98.65(6)	0.2(0.2-0.4)	30(30-30)	10(10-10)
98.60(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)
98.59(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)
98.09(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)
95.12(6)	0.2(0.2-0.4)	30(30-30)	10(10-10)
89.42(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)
80.51(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)
75.07(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)

River Mile (n)	Total Iron	Total Lead	Total Nickel	Total Zinc
100.47(6)	2350(820-8170)	5(2-18)	40(40-40)	22(10-75)
98.65(6)	1508(1070-1890)	3(2-4)	40(40-40)	13(10-15)
98.60(6)	2430(400-6160)	2(2-2)	40(40-40)	23(10-45)
98.59(6)	1942(1340-3280)	2(2-2)	40(40-40)	21(10-60)
98.09(6)	1850(720-3340)	2(2- 3)	43(40-60)	19(10-35)
95.12(6)	4148(1610-15800)	2(2-3)	40(40-40)	26(10-60)
89.42(6)	2930(2440-3460)	2(2-2)	40(40-40)	19(10-35)
80.51(6)	5123(4450-6740)	4(3-6)	47(40-70)	21(15-30)
75.07(6)	4720(3820-5470)	4(3-5)	40(40-40)	20(15-25)

a = Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.

b= n<6 samples.

c= 3 samples.

Appedix Table 1. continued

River Mile (n)	Fecal Coliform (#/100 ml)	Total Residual Chlorine
100.47(6)	1570(290-4000)[c]	
98.65(6)	470(280-590)[c]	
98.60(6)	3103(10-9000)[c]	0.35(0.00-0.50)
98.59(6)	1000(20-2500)[c]	
98.09(6)	16367(1600-44000)[c]	
95.12(6)	390(280-530)[c]	
89.42(6)	353(240-440)[c]	
80.51(6)	493(300-800)[c]	
75.07(6)	530(140-1200)[c]	

a = Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
b= n<6 samples.
c= 3 samples.