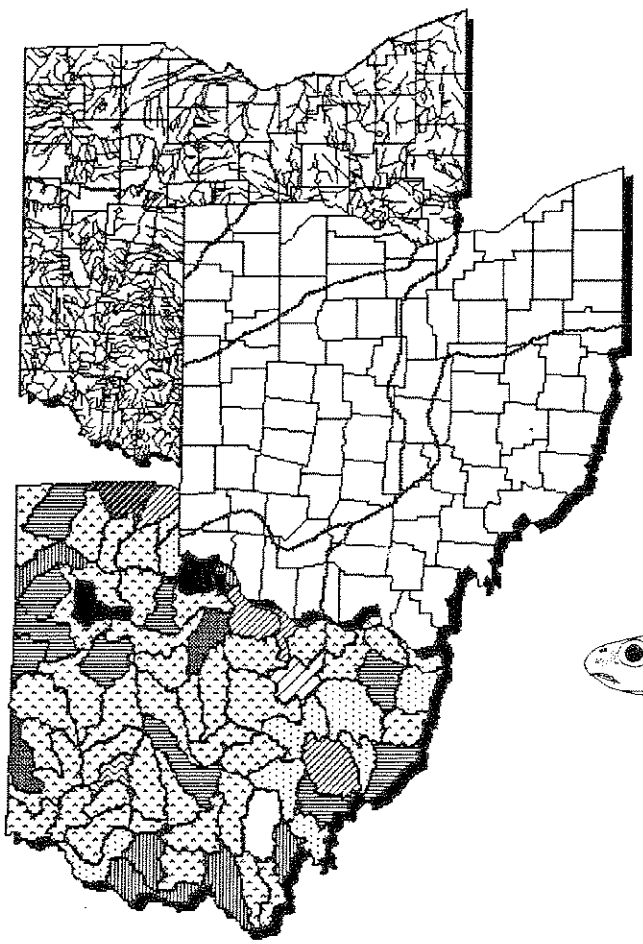
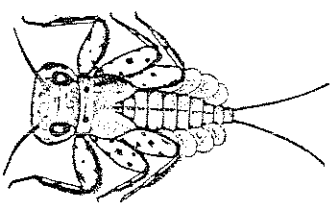
State of Ohio
Environmental Protection Agency

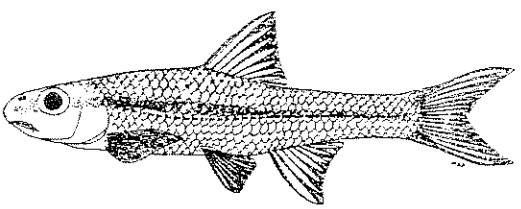
Ecological Assessment Section
Division of Water Quality
Planning & Assessment

Biological and Water Quality Study of Riley Creek and Little Riley Creek

Hancock, Allen, and Putnam Counties (Ohio)







August 31, 1992

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-0149

Biological and Water Quality Study of Riley Creek and Little Riley Creek

Hancock, Allen, and Putnam Counties, Ohio

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OEPA Technical Report EAS/1992-8-6

prepared by

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Division of Water Quality Planning and Assessment
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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. 1990c. 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
Ecological Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228
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Acknowledgements

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Biological and Water Quality Survey of Riley Creek and Little Riley Creek (Hancock, Allen, and Putnam Counties, Ohio)

State of Ohio Environmental Protection Agency
Division of Water Quality Planning and Assessment
1800 WaterMark Drive
Columbus, Ohio 43266-0149

Introduction

The Riley Creek study area extended from upstream from Bluffton, Ohio (RM 17.9) to downstream from Pandora, Ohio (RM 1.8).

Specific objectives of this evaluation were to:

1) monitor and assess chemical /physical water quality, habitat, and biological communities in Riley Creek to determine the degree to which the Bluffton WWTP and other sources affect the stream,

2) evaluate impacts from combined sewer overflows (CSOs) on Riley and Little Riley Creeks, and,

3) determine the attainment status of current 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 Riley Creek study area extended from RM 18.0 to RM 1.8 on Riley Creek and from RM 2.4 to RM 0.1 on Little Riley Creek. During the June to October sampling season, northwestern Ohio experienced an extended period of below normal precipitation and Riley Creek was periodically desiccated upstream from approximately RM 16.6. Downstream from this point, stream flow was in large part dependent on the discharges from quarrying operations upstream from the city of Bluffton and the Bluffton WWTP. Macrohabitats in Riley Creek were generally sufficient to support and maintain an aquatic community capable of achieving the Warmwater Habitat (WWH) biological criteria (Table 7). Biological attainment status shifted from non - attainment to full attainment in a downstream direction (Table 1). The upper 8.4 miles of Riley Creek (52% of the study area) was an area of non-attainment (**NON**) of the WWH use. In this reach either both fish and macroinvertebrate communities were considered to be in no better than fair condition or one of the biological indices scored in the poor or very poor range. Causes of **the** non-attainment included: 1) desiccation of the stream, as discussed above, 2) habitat alteration (channelization) which resulted in siltation, substrate embeddedness, and an absence of instream cover, and 3) organic enrichment downstream from the Bluffton WWTP and the numerous

combined sewer overflows (CSOs) located upstream from the WWTP. Based on the chemical sampling results, excess ammonia-nitrogen and oxygen demanding wastes in the Bluffton WWTP effluent appears to be primarily responsible for the impacted biological communities downstream from the discharge. Departures from the chemical water quality standards are listed in Table 4. Partial attainment of the biological criteria extended downstream from RM 9.6 for approximately 5.1 miles (31% of the study area). This segment represents an area of gradual recovery in the biological communities as the organic load contributed by the upstream point sources was assimilated. Full attainment is reached in the final 2.7 miles of the study area between RM 4.5 and 1.8, where all fish and macroinvertebrate scores exceeded their respective biological criteria for the WWH aquatic life use. This represents 17% of the study area.

Little Riley Creek was completely dry (no pools were present) near the mouth during a significant portion of the 1991 sampling period and both sites sampled were in not attainment of the current WWH use. There was flow at RM 0.1 in the latter portion of the study period; however, it appeared that much of the water was the result of CSO discharges following rain events. The CSO discharges to Little Riley Creek may be contributing an additional impact to Riley Creek that is presently masked by the effect of the Bluffton WWTP discharge.

The results of this survey demonstrate the adverse impact that the Bluffton WWTP was having on the biota of Riley Creek. The macroinvertebrate assemblage immediately upstream from the plant discharge was relatively diverse and pollution sensitive taxa were common. Downstream from the WWTP, the ICI score was in the poor range (a reflection of a severe enrichment impact) and tolerant midges predominated. Full recovery was not observed in the macroinvertebrate community until RM 7.1, a distance of 8.3 miles downstream. Impacts on the fish community attributed to the Bluffton WWTP and CSOs were reflected in the predominance of tolerant and omnivorous species that extended from RM 15.5 to at least RM 7.6. Instream chemical data identified ammonia-N and low dissolved oxygen levels as the primary water quality factors downstream from the discharge. As of the summer of 1991, the Bluffton WWTP NPDES permit contained no ammonia nitrogen limitation. Improvement in the attainment status of Riley Creek appears to be significantly linked to lessening the levels of ammonia-N and oxygen demanding wastes contributed by the Bluffton WWTP.

Conclusions

- Upstream from the city of Bluffton, the biota of Riley Creek was significantly limited by a minimal flow regime which periodically left portions of the stream completely dry during the 1991 sampling season.

- Between RM 17.9 and RM 13.2, a number of modified habitat influences, including moderate to high levels of silt and embeddedness and an absence of instream cover, were partially responsible for a depressed fish community within this segment of the study area. These factors did not appear to significantly affect the macroinvertebrate community, as evidenced by the presence of a relatively diverse and sensitive assemblage immediately upstream from the Bluffton WWTP (RM 15.5). Riley Creek has a sufficient gradient to promote the recovery of lost warmwater habitat attributes provided no further instream modifications take place.

- The fish community appeared to be impacted by the numerous combined sewer overflows (CSOs) located upstream from the WWTP. The macroinvertebrate community, however, appeared to be in good condition. This result suggests that CSO discharges have had a negative affect on the biota in the recent past from which the benthos have recovered. However, sufficient time has apparently not elapsed to allow for recovery of the fish community. A shortcoming of the present study was that the impacts from CSOs could not be completely evaluated due to less than desireable upstream control conditions and non-compliance of Bluffton in monitoring CSO discharges.

- Excessive levels of ammonia-N and oxygen demanding wastes appeared to be the primary causes of water quality degradation in Riley Creek downstream from the Bluffton WWTP. Ammonia-N, phosphorus and biochemical oxygen demand (BOD_5) increased, while dissolved oxygen decreased downstream. The most severe impact was exhibited in the macroinvertebrate community. However,fish sampling results demonstrated that a depression in the health of the community extended downstream beyond the point where the macroinvertebrates recovered.

- Geographically, Riley Creek crosses from the Eastern Corn Belt Plain ecoregion into the Huron Erie Lake Plain ecoregion. However, the stream retains the characteristics of an ECBP stream, thus the biological criteria for the ECBP ecoregion are appropriate for the entire study area.

Recommendations

Status of Aquatic Life Uses

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 Warmwater Habitat aquatic life use designation is appropriate for Riley Creek. The stream has been subjected to quarrying and low head dam construction. However, QHEI scores ranged from 53.0 to 73.5 (mean = 61.0) and indicated that these habitat alterations were not significantly affecting the ability of the stream to physically support warmwater biotas (Table 7). The WWH biological criteria were fully met at RM 1.8 which further demonstrated the potential of the stream to support the designated use in segments which are presently impaired.

- Little Riley Creek was subject to an intermittent flow regime that left significant portions of the stream completely dry during the summer sampling period. This factor limits the ability of the stream to support a "typical" warmwater fauna. However, QHEI scores of 57.5 and 60.5 at RMs 2.4 and 0.1, respectively, suggest that habitat is adequate to support an aquatic community during all except periods of extreme drought. Thus the current Warmwater Habitat aquatic life use is appropriate.

Status of Non-Aquatic Life Uses

- Currently, Riley Creek and Little Riley Creek are designated for Primary Contact Recreation (PCR) and Agricultural and Industrial Water Supplies. Based on the 1991 sampling effort, these uses should be retained with the exception that Little Riley Creek be designated for Secondary Contact Recreation (SCR). Maximum depth of pools in Little Riley Creek did not exceed three feet over a surface area of at least 100 square feet that is required for a PCR use.

Other Recommendations

- The results of this study strongly demonstrate the need for the inclusion of an ammonia nitrogen limit in the NPDES permit for the Bluffton WWTP. Inadequately treated effluent from the plant impaired the WWH use for approximately eleven miles.

Future Monitoring Needs

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

- Combined sewer overflow discharge quality and quantity needs to be characterized in order to define the pollution load contributed to both Riley and Little Riley Creeks.

- Long-term monthly fixed station chemical monitoring at Fett Road (RM 13.1) would provide information on trends in water quality of Riley Creek downstream from Bluffton and would be useful in monitoring instream chemical quality following the needed reductions in ammonia-N and nutrient loadings at the Bluffton WWTP.

Table 1. Aquatic life use attainment status for the existing Warmwater Habitat (WWH) use designations of Riley Creek and Little Riley Creek based on data collected during June - September, 1991.

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI[b]	Attainment Status	Comment
Eastern Corn Belt Plain - WWH Use Designation (Existing)						
Riley Creek (1991)						
17.9/17.9	23*	5.5*	0*	56.5	**NON**	Ust. Bluffton
- /17.1	-	-	F*	-	**NON**	
15.5/15.5	27*	7.3*	G	54.5	**NON**	Dst. CSOs
- /15.4	-	-	6	-	N/A	WWTP Mix Zone
15.3/15.3	29*	7.0*	8*	59.0	**NON**	Dst. Bluffton WWTP
13.2/11.7	25*	6.6*	24*	53.0	**NON**	
7.6/ 7.1	30*	6.8*	44	73.5	PARTIAL	
1.8/ 1.8	43	9.8	44	69.5	FULL	
Little Riley Creek (1991)						
2.4/ 2.4	18*	N/A	F*	57.5	**NON**	Ust. CSOs; intermittent
0.1/ 0.1	26*	N/A	P*	60.5	**NON**	Dst. CSOs

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8
ICI	36	46	22

[d] - 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] - Narrative evaluation is used in lieu of ICI for sites with qualitative samples only (G= Good, F= Fair, P=Poor).

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

Study Area

Riley Creek is a tributary to the Blanchard River draining 88.2 square miles of primarily agricultural land in northwest Ohio (ODNR 1960). From the headwaters in southwest Hancock County, Riley Creek flows northwest through northeastern Allen County before joining the Blanchard River in eastern Putnam County. Major tributaries to Riley Creek include Little Riley Creek and Cranberry Run. Urban areas in the Riley Creek watershed are Bluffton, Pandora, and Beaverdam. Table 2 presents the general characteristics of the streams in the study area. The study area includes a 17.9 mile segment of Riley Creek from the Hancock/Allen County border to the confluence with the Blanchard River in Putnam County, and a 2.4 mile segment of Little Riley Creek in northeast Allen County (Figure 1). Little Riley Creek flows northeast through Allen County farmland and joins Riley Creek on the north side of the city of Bluffton.

The Riley Creek watershed is situated in two ecoregions which are the Huron/Erie Lake Plain (HELP) and the Eastern Corn Belt Plain (ECBP)(Omernik 1988). Although the characteristics of each ecoregion are present in the watershed, the habitat found in Riley Creek is generally more representative of the ECBP ecoregion.

The HELP ecoregion is characterized by broad, almost level, lake plain craines and beach ridges. Local relief is generally only a few feet. Streams in the HELP ecoregion have very low gradients. The soils are poorly to very poorly drained. Many streams are extensively channelized to improve soil drainage.

Table 2. Stream characteristics and significant identified pollution sources in the Riley Creek watershed.

Stream Name	Length (Miles)	Average Fall (Feet/ Mile)	Drainage Area (Square Miles)	Nonpoint Source Pollution Categories	Point Sources Evaluated
Riley Creek	22.2	8.2	88.2	Agriculture Sanitary Sewers Hydromodification	Bluffton WWTP
Little Riley Creek	8.3	7.4	15.8	Agricultural Storm sewers Surface runoff Channelization Streambank modification	
Cranberry Run	8.7	7.6	11.2	Agriculture Streambank modification	

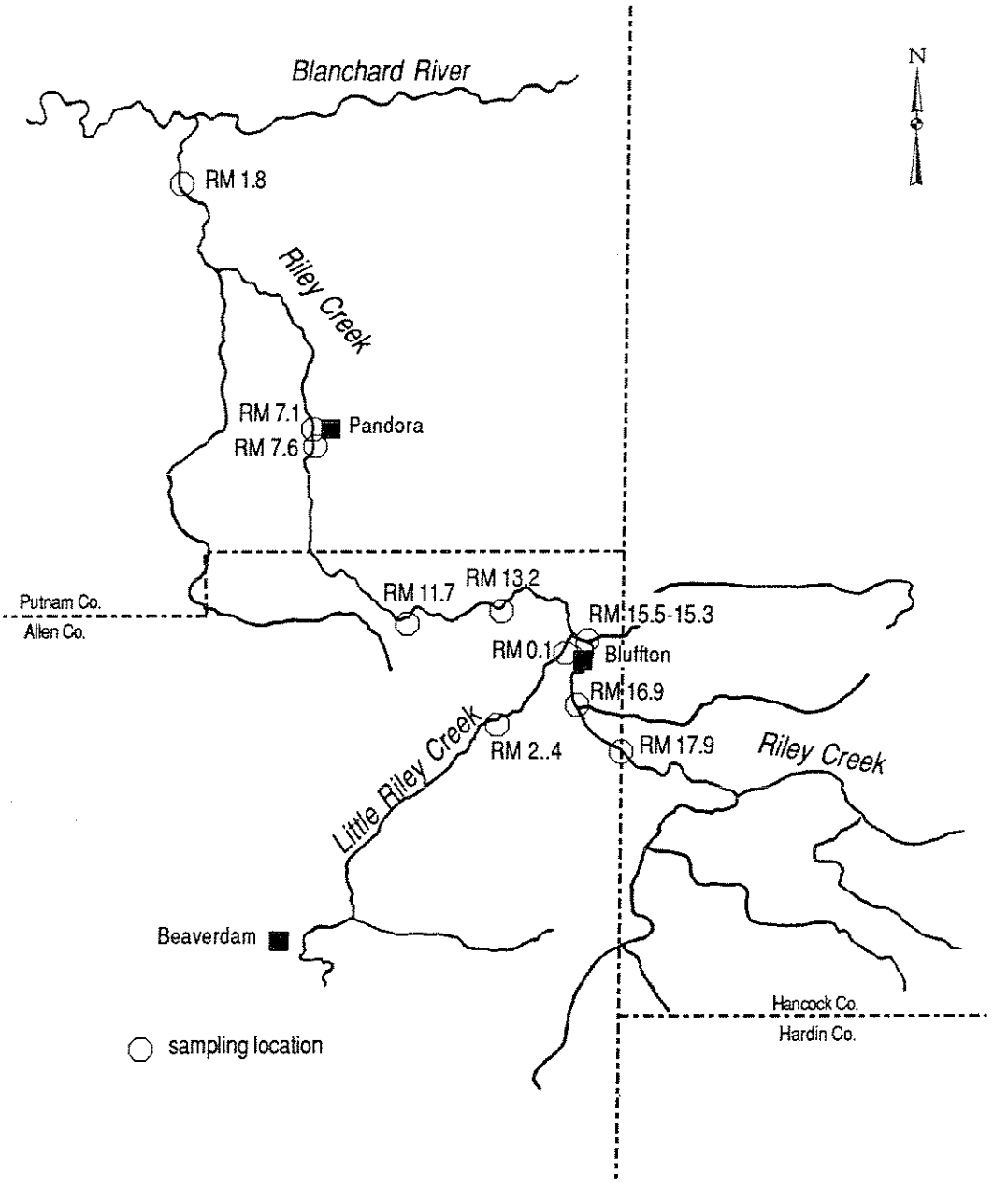

Figure 1. The Riley Creek study area showing principal streams and tributaries, population centers, and pollution sources.

The ECBP ecoregion is a rich agricultural plain which stretches south of the HELP ecoregion and encompasses much of the central and western portions of Ohio. The ECBP ecoregion is characterized by a gently rolling glacial till plain with moraines, kames and outwash plains. Local relief is generally less than 50 feet but may exceed 100 feet in some areas. Soils are derived from glacial till materials and soil drainage is often poor. Many of the streams in the ECBP Ecoregion have been channelized to improve soil drainage, but not to the extent of the HELP.

Over 90 percent of the Riley Creek watershed is used for farmland, most of the remainder is either urban or small woodlots. Corn and soybeans are the principal crops; other feed grains and hay for livestock are also grown. Hancock and Putnam counties are consistently among the top soybean, and wheat producing counties in Ohio.

Agriculture and channelization are the predominant types of nonpoint source (NPS) pollution in the watershed. Other types of NPS pollution known or suspected in the watershed include urban runoff and streambank modification (Ohio EPA 1990b).

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 1989c) and Biological Criteria for the Protection of Aquatic Life, Volumes II-III (Ohio Environmental Protection Agency 1987b, 1989a, 1989b), 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 primarily sampled using modified Hester/Dendy multiple-plate artificial substrate samplers supplemented with a qualitative assessment of the available natural substrates. Exceptions included RMs 17.1 and 15.4 of Riley Creek and RMs 2,4 and 0.1 of Little Riley Creek (qualitative sampling only).

Macroinvertebrate sites in the study area were also evaluated using an assessment tool currently in the developmental phase. This method utilizes the qualitative, natural substrate collections available from each site and relies on tolerance values derived for each macroinvertebrate taxon collected. These tolerance values, unlike other tolerance values used in common indices (e.g., the Hilsenhoff Biotic Index), utilizes the abundance data for a given taxon collected with artificial substrates at sites around Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected with artificial substrates are weighted by the abundance data of that taxon at those sites. The mean of the weighted ICI scores for the taxon results in the tolerance value of that taxon. Thus, a taxon's tolerance value represents its relative level of tolerance on the ICI's 0 to 60 scale. High tolerance values are calculated for the more intolerant taxa which tend to reach their greatest abundance at undisturbed sites (i.e., sites with highest ICI scores). Conversely, the more pollution tolerant taxa attain their greatest abundances at highly disturbed sites with low ICI scores, which results in a lower tolerance value. For the qualitative macroinvertebrate collections in the Riley Creek study area, the median tolerance value, based on all tolerance values of the organisms collected at a site, resulted in what has been termed the Qualitative Community Tolerance Value (QCTV). Though only in the developmental stage, the QCTV shows real potential as a method to supplement existing assessment methods using the qualitatively collected macroinvertebrate information. Its use in evaluating sites in the Riley Creek study area was restricted to relative comparisons between sites with no attempt to interpret quality of the sites or aquatic life use attainment status.

Fish were sampled 2-3 times using pulsed DC electrofishing gear using either the wading method (200 meter zones) or boat method (500 meter zones). With the exception of Little Riley Creek, which was electrofished 1 time using the wading method. 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 (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.

Table 3. Sampling locations (effluent sample - E, water chemistry - C sediment chemistry - S, benthos - B, fish - F, fish tissue - FT) in the Riley Creek study area, 1991.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Riley Creek				
17.9	B,F	40 52 30 /83 52 54	County line Rd.	Bluffton
16.9	B	40 52 07 /83 53 23	Dst. I-75	Bluffton
15.5	B,F,C,S	40 53 54 /83 53 20	Ust. WWTP	Bluffton
15.4	B,C,E,S	40 53 58 /83 53 26	Mix Zone	Bluffton
15.3	B,F	40 53 58 /83 53 28	Dst. WWTP	Bluffton
13.2	F	40 54 24 /83 55 04	Ust. Fett Rd.	Bluffton
13.1	C	40 54 23 /83 55 07	Fett Rd.	Bluffton
11.7	B	40 54 16 /83 56 12	Ust. Phillips Rd.	Bluffton
7.6	F	40 56 14 /83 57 56	Ust. TR 115	Bluffton
7.5	C,S	40 56 17 /83 57 56	TR 115	Bluffton
7.1	B	40 56 35 /83 57 48	Dst. TR 115	Bluffton
1.8	B,F,C,S	40 59 50 /83 59 36	Dst. CR 14	Bluffton
Little Riley Creek				
2.4	B,F	40 52 40 /83 55 05	Dst.Fett Rd.	Bluffton
0.1	B,F	40 53 56 /83 53 35	Ust. Riley St.	Bluffton

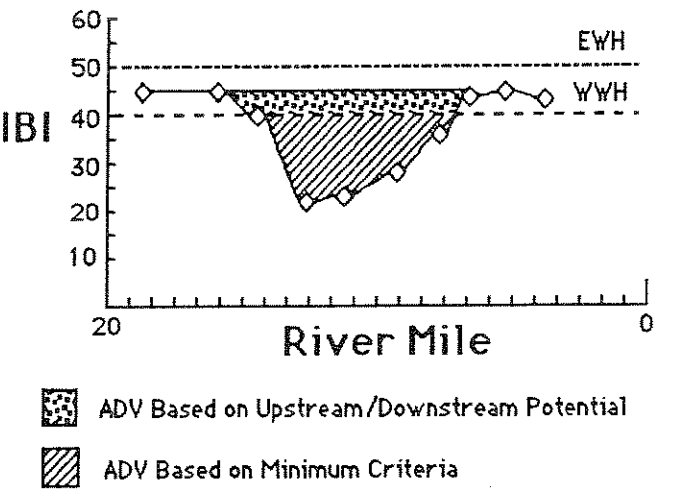

Figure 2. Graphic illustration of the calculation of Area of Degradation Values (ADV) based upstream potential and the ecoregion warmwater habitat use or minimum criteria (WWH Criteria for exceptional warmwater habitat use (EWH) is provided for reference.

Results and Discussion

Pollutant Loadings: 1976 - 1991

- The city of Bluffton operates an advanced secondary wastewater treatment system, OEPA permit number 2PC00005, which treats an average of 680,000 gallons per day (.68 MGD). The plant was originally constructed in 1952, and was last modified in July 1988. Final effluent from the plant discharges to Riley Creek at river mile (RM) 15.4.

- A review of the effluent loading data from 1976 to 1991 for the Bluffton WWTP reflects several trends (Figure 3). Nitrate-nitrogen loadings clearly decreased after 1986, while the ammonia-N loadings appear to be increasing. The increase in the ammonia-N load increases the potential for increased ammonia toxicity and oxygen demand downstream from the WWTP, with nitrification occurring in the stream, rather than in the WWTP. This is reflected in the instream chemical results by a gradual dissolved oxygen (D.O.) decline downstream of the WWTP in 1991.

- Biochemical oxygen demand loading (BOD_5) appeared to remain relatively stable prior to 1989. After 1989 a decline in BOD_5 is indicated However, the 1989-1991 loadings were calculated using reported carbonaceous oxygen demand values ($CBOD_5$) based on advanced secondary treatment. It appears likely that the calculated values underestimate the nitrogenous component of the total biochemical oxygen demand given the increase in ammonia-N loadings reported for the same time period. Phosphorus levels show little difference between the years for which information is available.

- The city of Bluffton is permitted to discharge, during wet weather periods, from 22 combined sewer overflows (CSOs) which have been identified on Riley Creek. The permit also requires monitoring of these overflows when discharging. Currently, the city of Bluffton is not in compliance with this requirement. As a result, no loadings information is available for CSOs. In a correspondence dated 28 April, 1992, the city stated that it was in the process of setting up a schedule to meet these requirements.

- The City of Bluffton has appealed the most recent NPDES permit renewal and requested a public meeting to discuss water quality based ammonia nitrogen and antidegradation based metals limits set in the permit which expired in May, 1991, are being enforced.

Chemical Water Quality

- RM 18.0 was selected initially as the upstream control site, but was intermittent during the entire study period. The site at RM 15.5 became a substitute control site, although it was located downstream from the Bluffton CSOs and immediately upstream from the WWTP discharge. The water in this substitute control site originated as groundwater, pumped from the Bluffton Stone Company (NPDES permit number 2IJ00018) at river mile 17.2-16.7 (OEPA 1985) The stone company permit indicates that there is an average discharge of 81,000 gallons per day to Riley Creek at RM 16.68. The diluting effect of this quarry discharge has been noted in past surveys (OEPA 1985). The Pandora WWTP discharge is located at RM 5.35. The Pandora WWTP (NPDES permit number 2PB00029) is a series of facultative lagoons and treats an average of 284,000 gallons per day. The Putnam Stone Company (NPDES permit number 2IJ00057) also has a groundwater discharge located on Riley Creek at RM 1.94. Flow from this outfall averages 150,000 gallons per day.

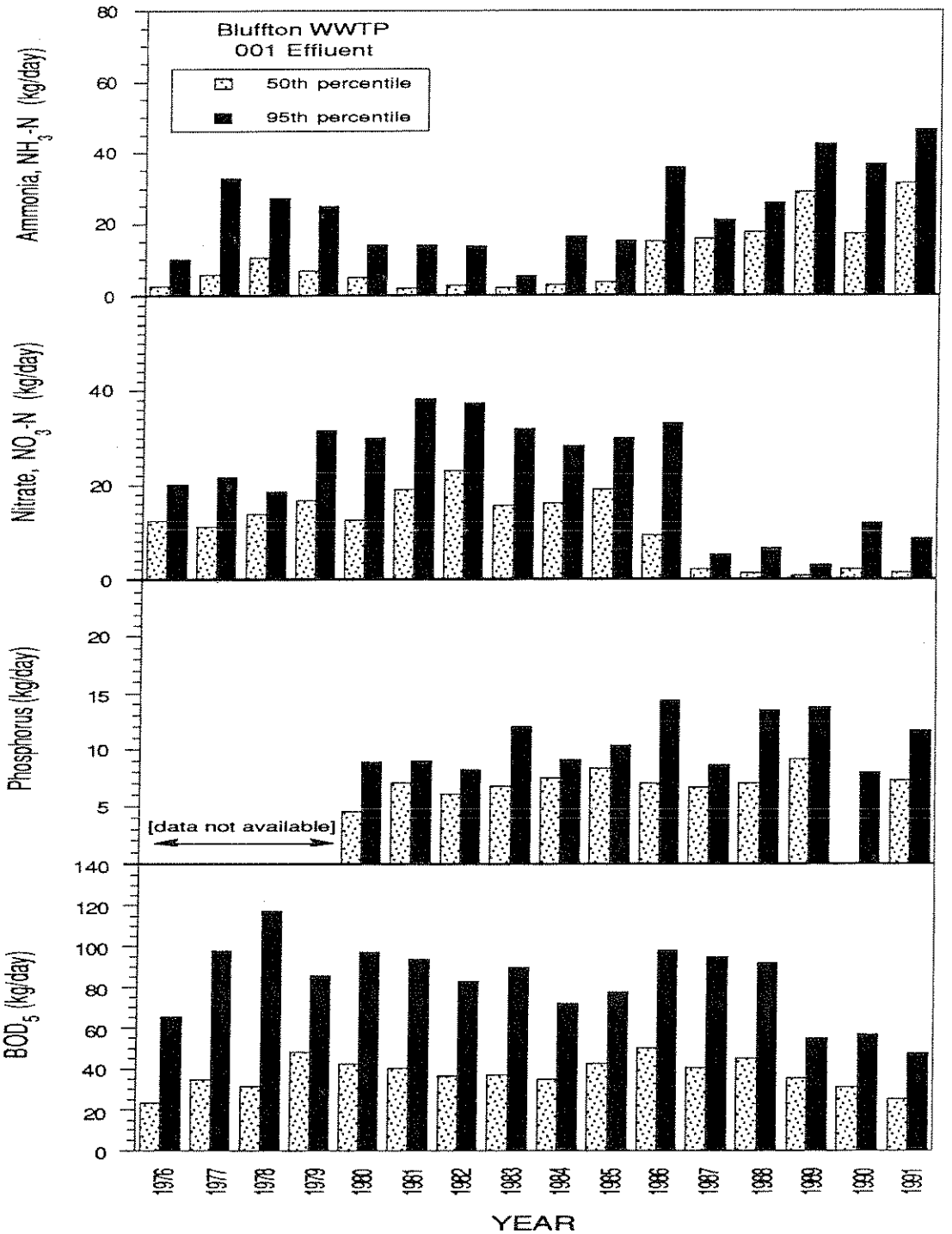

Figure 3. Annual loadings (kg/day) of ammonia, nitrate, phosphorus and five-day biochem Oxygen demand at the Bluffton WWTP. BOD_5 loadings for 1989-1991 are calcula based on reported five-day carbonaceous biochemical oxygen demand ($CBOD_5$) values.

- The Bluffton CSOs did not appear to adversely affect water quality at the control site at RM 15.5. Since sampling was conducted during a low flow period, the overflows were likely inactive. The next downstream site at RM 15.4 was located below the Bluffton WWTP discharge. Although considerable mixing of the WWTP effluent continues to occur at this site, outside mixing zone chemical criteria are applicable according to rules 3745-1-02 (E) and 3745 - 1-07 (A)(3) of the Ohio WQS. Warmwater Habitat criteria exceedences documented at this site included three for ammonia-N and one for fecal coliform bacteria (Table 4). The fecal coliform bacteria violation was minor, but the ammonia-N (NH_3-N) violations could contribute to toxic effects on aquatic organisms, as well as supplying a nutrient source (nitrates) for algal growth.

- Exceedences at RM 13.1 reflect the input of inadequately treated sewage from the Bluffton WWTP. There was one exceedence for ammonia-N, which indicates that nitrification was not yet complete. The D.O. violations were minor and were likely the result of algal respiration, but may also reflect sediment oxygen demand. The maximum D.O. concentrations for the study were also found here, indicating photosynthetic input. The single pH exceedence was associated with a high D.O. concentration.

Table 4. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in Riley Creek, 1991 (units are S.U. for pH, #/100ml for fecal coliform, and mg/l for all other parameters).

Stream Name	River Mile	Violation: Parameter (value)
Riley Creek	15.4	NH_3-N (1.65 *, 9.59 **, 8.74 *); Fecal coliform (2100 ◊)
	13.1	D.O. (4.7 ‡, 4.1‡); NH_3-N (1.26 *); pH (9.1 **)
	7.5	D.O. (3.2 ‡‡, 4.5 ‡)
	1.8	D.O. (4.7 ‡, 4.6 ‡)
		Iron (2 of 30 samples (6.7%) 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.

- The only exceedences noted further downstream were for dissolved oxygen at RM 7.5 and RM 1.8. While the lack of ammonia-N violations at RM 7.52 indicates near complete nitrification of the Bluffton WWTP effluent, the D.O. violations continue to reflect algal respiration affects, due to nutrient-induced growth. The same comment applies to river mile 1.8, although the data from this site are confounded by additional nutrient inputs from the Pandora WWTP.

- The graphs of the mean D.O., total phosphorus, and BOD_5 concentrations, along with maximum ammonia-N concentration indicate the effects of the Bluffton WWTP discharge on water quality in Riley Creek (Figure 5). D.O. concentrations show a general decreasing trend downstream. BOD_5, total phosphorus, and ammonia-N all increase immediately downstream from the Bluffton WWTP. These three parameters have a similar pattern of decline, downstream from the WWTP, with ammonia-N decreasing somewhat more rapidly. The continuous monitor D.O. graph (Figure 4), while it does not reflect ideal control site data, does show the effect of the Bluffton WWTP. The D.O. regime is affected not only due to direct oxygen demand, but also due to the effects of algal respiration, as indicated by the increased fluctuation in max/min values, and the lower median at RM 13.5.

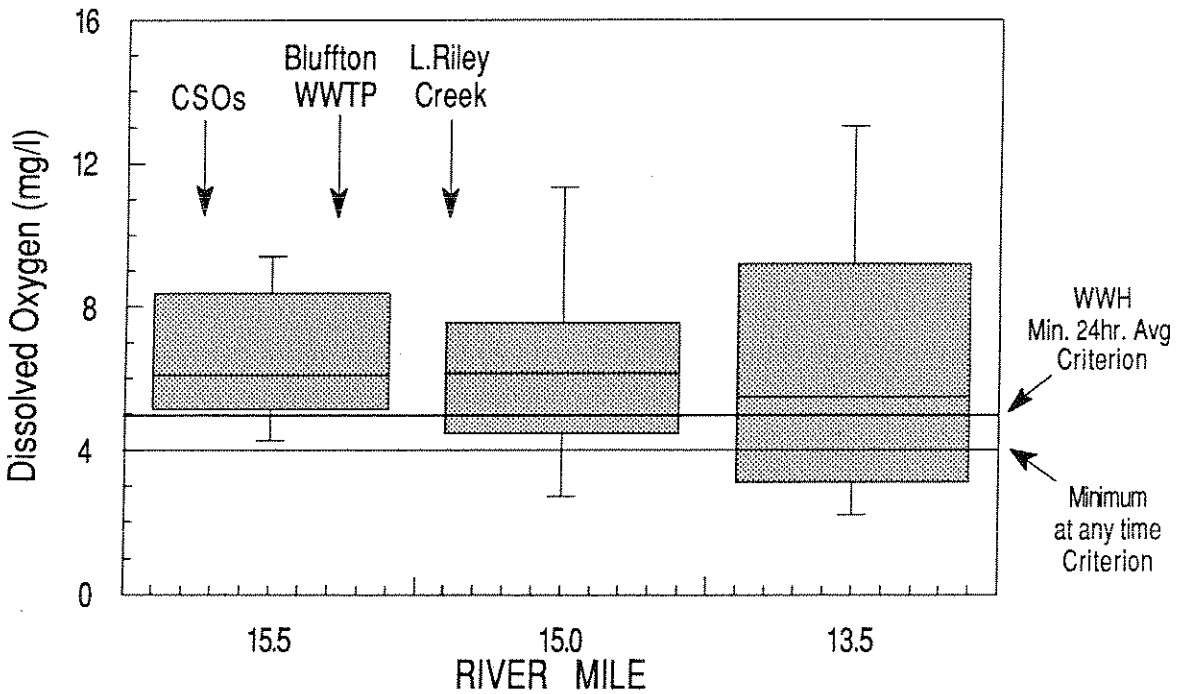

Figure 4 Boxplots of dissolved oxygen data recorded with Datasonde continuous monitors at selected locations in Riley Creek during the summer of 1991.

Sediment Chemistry

- Sediment samples for analysis of heavy metals were collected at RMs 15.5, 15.4, 7.5, and 1.8. In addition, a scan of priority organic pollutants was conducted on a sample from RM 1.8. Based on the Kelly and Hite (1984) system of classification, chromium, iron, lead and zinc were highly elevated at one or more of the sampling locations (Table 5). The highly elevated chromium, iron, and zinc concentrations are apparently the result of the Bluffton WWTP based on the proximity to the discharge where these values were recorded (RM 15.4). There are three known sources of zinc that send process water to the WWTP and two sources of chromium. Lead may also be contributed by the WWTP, but is commonly associated with urban runoff and combined sewer overflows and was present at a highly

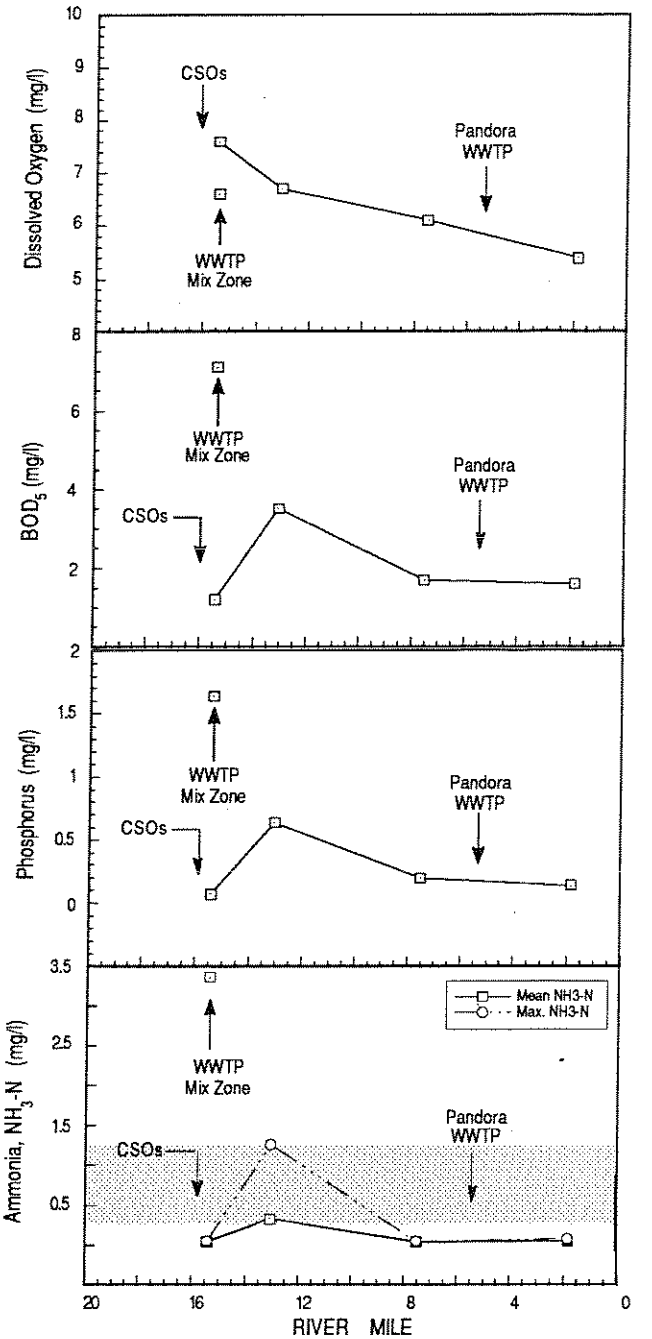

Figure 5. Longitudinal trend of mean dissolved oxygen, biochemical oxygen demand, phosphorus and mean/max. ammonia-nitrogen in the Riley Creek study area, 1991. Shaded area in ammonia-nitrogen plot represents the range of WQS criteria based on 95th and 25th percentile pH and temperature values from survey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

elevated level both upstream and downstream from the WWTP. Concentrations of pesticides and organics at RM 1.8 did not appear to reflect any significant problems, two priority pollutant compounds were detected; all other priority pollutants were below minimum detection limits (Table 6.)

Table 5. Concentrations of heavy metals in sediments of Riley Creek, 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
15.5	15.6[c]	0.758[b]	19.4[b]	34.7[a]	27900[c]	**74.3[d]**	19.5	162.0[c]
15.4	15.2[c]	1.160[c]	**50.6[d]**	65.6[c]	**40700[d]**	**84.1[d]**	18.9	**255.0[d]**
7.52	7.33[a]	0.320[a]	6.48[a]	12.0[a]	12600[a]	29.8[b]	10.3	41.3[a]
1.8	7.28[a]	0.538[b]	14.8[a]	23.1[a]	23700[c]	39.2[c]	20.3	105.0[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

Riley Creek

- Macrohabitats of Riley Creek were evaluated at a total of six fish sampling locations. The QHEI ranged from 53.0 at RM 13.2 to 73.5 at RM 7.6, with a mean value of 61.0. This value coupled with low MWH:WWH ratios (Table 7) less than or equal to 0.50 suggests that the habitat throughout the study area is of sufficient quality to support and maintain an aquatic community achieving Warmwater Habitat (WWH) biological criteria (Rankin 1989)(Table. 7).

- Riley Creek has been subject to significant past habitat modifications. The quarrying of limestone from the stream bed, coupled with the construction of several low head concrete dams, has resulted in a complex of impoundment-like segments throughout the study area (Clark and Allison 1966). The effects of the impoundments appeared to vary with gradient. Sampling stations that were low gradient contained extensive pooled areas upstream. Conversely, stations that were of a higher gradient possessed smaller pooled areas and regained relatively free flowing characteristics upstream. Though instream modifications of varying degrees were evident at the majority of sampling stations, significant impairment based solely on these alterations was not observed.

Table 6. Riley Creek sediment priority pollutant scan detections (mg/kg), 1991.

RIVER MILE	1.8
PARAMETER (mg/kg)	
PESTICIDES [1]	
d - BHC	4.27[f]
Dieldrin	0.57[a]
GC/MS LIBRARY COMPUTER MATCH [2] (non - priority pollutants)	
3 - Methoxy - 3 - Methyl 2 - Butanone	9.5
Nonacosane	3.4
Triacontane	2.8

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 Library matched chemical concentrations indicated are estimates within one order of magnitude reported

- River Mile 17.9, the most upstream site, is the only area truly impaired by poor habitat. During the 1991 sampling efforts it became evident that this reach of Riley Creek had intermittent flow. Examining the submerged substrate on 22 August 1991 the stream bed appeared cracked in the manner in which expanding clays behave upon desiccation. Though water was present during both sampling efforts, it was apparent that the stream had gone dry between 11 July and 22 August 1991.

- All remaining sites had substrates of glacial and native origin. Shelved limestone bedrock predominated which periodically resulted in rock ledge riffles and pools. Glacial cobble and gravel were found overlaying the bedrock in most areas and became quite abundant in the reach between RM 7.6 and RM 1.8. This segment contained the highest quality habitats of the study area, with numerous pool/run/riffle complexes, abundant instream cover, good channel development, and an abundance of aquatic macrophytes.

- In summary, Riley Creek has been subject to past habitat modifications. However, with the exception of RM 17.9, instream habitats recorded during the 1991 field sampling efforts indicate that Riley Creek, given no further modifications, is capable of supporting a biological community achieving WWH biological criteria.

Table 7. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the Riley Creek study area, July - September, 1991.

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 < 40 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. Riffle Embeddedness	No Riffle	**Total (Moderate Influence) MWH Attributes**	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
(04-168) – RILEY CREEK																																		
Year: 91																																		
17.9	56.5	6.25	■			■				■			3			●		1	▲▲			▲▲			▲▲▲					7	.50	2.25
15.5	54.5	7.14							■	■			3			●		1	▲▲			▲▲			▲		▲			6	.50	2.00
15.3	59.0	7.14	■■		■					■	■		5			●		1	▲			▲▲			▲▲					5	.33	1.17
13.2	53.0	3.29		■	■		■			■			4			●		1	▲▲			▲▲			▲▲				▲	7	.40	1.80
7.6	73.5	9.62		■	■	■				■	■	■	7					0	▲			▲▲			▲▲					5	.13	.75
1.8	69.5	3.45	■■		■	■				■	■		7					0							▲▲▲					3	.13	.50
(04-170) – LITTLE RILEY CREEK																																		
Year: 91																																		
2.4	57.5	6.25		■		■	■				■		5		●	●		2	▲▲			▲▲			▲▲▲					7	.50	1.67
0.1	60.5	6.58	■■			■	■			■	■		6					0				▲			▲▲				▲	4	.14	.71

Little Riley Creek

- Macrohabitats of Little Riley Creek were evaluated at two locations during the 1991 field sampling effort. QHEI scores were 57.5 at RM 2.4 and 60.5 at RM 0.1 (Table 7). These values suggest that the physical components of instream habitats within Little Riley Creek are of sufficient quality to support a biological community achieving WWH biological criteria. However, the stream was intermittent or nearly intermittent during the field sampling effort. The lack of consistent flow would greatly inhibit the formation of a permanent community of aquatic organisms and is likely the most significant limiting factor to biological community performance in Little Riley Creek.

- At RM 2.4 the stream was nearly intermittent. The natural substrate consisted of hardpan, pea gravel, and sand. There was evidence of past bank and channel modification, but the stream appeared to be in the process of recovery. Marginal habitat coupled with the lack of sustained flow would likely prevent this site from supporting a biological community achieving WWH criteria in the immediate future.

- Little Riley Creek at RM 0.1 was completely dry between June and July 1991. During the latter half of the field sampling effort there was sufficient water in the stream to allow the collection of biological samples, however, there was no discernable flow. The stream at this station consisted of a series of shallow pools, separated by exposed bedrock and dry cobble riffles.

Biological Assessment: Macroinvertebrate Community

Riley Creek

- RM 17.9 was originally selected as an upstream control site; however, the stream went completely dry during part of the sampling period. Precipitation prior to retrieval did put enough water in the stream to cover the artificial substrates but they were nearly devoid of organisms and scored an ICI value of zero (Table 8, Figure 6). In an attempt to define where sustained stream flow occurred, qualitative sampling was conducted at RM 16.9 on 6 September, 1991. This site was downstream from a quarry operation that pumps groundwater into the stream. A local landowner indicated that during much of the summer, flow within this reach was dependent on the quarry discharge. This intermittent flow regime apparently was periodically causing a die off of attached algae when the shallow bedrock substrate dried out. The result was that the bottom in slack water areas was covered with a thick layer of black decayed organic material. Qualitative sampling yielded a total of 16 taxa. The community was predominated by pollution intermediate and tolerant organisms of which flatworms were the most numerous. According to this same landowner, continuous flow was maintained beginning approximately 0.3 miles downstream. This point is 1.1 miles upstream from the Bluffton WWTP discharge.

- Qualitative sampling upstream from the Bluffton WWTP (RM 15.5) produced a diverse assemblage totaling 48 taxa. Pollution intermediate organisms predominated, but sensitive taxa were relatively common. Black silt that was present along the margins appeared to be decayed algae from upstream rather than sewage sludge from past CSO events. The presence of a relatively diverse macroinvertebrate community indicated that CSOs within the city of Bluffton were not having an observable impact on the macroinvertebrate community. This evaluation is somewhat tenuous, however, due to the lack of an adequate upstream control site with which to compare community changes. Based on a narrative evaluation, the benthic community was attaining the WWH biocriteria.

- Severe organic enrichment was impacting the benthic fauna within the Bluffton WWTP mixing zone and immediately downstream (RMs 15.4 and 15.3 respectively). Macroinvertebrate assemblages were similar at the two sites with the tolerant midge genera Chironomus and Cricotopus predominating on the artificial substrates. ICI scores were in the poor range (6 at RM 15.4 and 8 at RM 15.3). The artificial substrates at RM 15.3 were collected from less than 0.3 ft/second flow velocity, the minimum generally required for a direct evaluation of aquatic life use attainment. Given the overwhelming predominance of tolerant taxa, however, the ICI score of 8 at this site was an accurate reflection of the condition of the macroinvertebrate community immediately downstream from the Bluffton WWTP.

- The macroinvertebrate community at RM 11.7 was indicative of partial recovery from the organic loading contributed by the Bluffton WWTP discharge. The natural substrates provided good habitat and consisted of a series of bedrock pools and rubble riffles. One degraded habitat attribute was a sludge-like sediment layer in the pools. Fair water quality was indicated both in the ICI score of 24 and the organisms collected from the natural substrates. The midge genus Glyptotendipes and aquatic worms predominated on the artificial substrates. These two taxa are often found in large numbers in waters that are subjected to high level of organic enrichment. Additionally, significant amounts of blue-green algae, another indicator of moderate to severe organic enrichment were noted at this site.

- The water resource was much improved at the two downstream stations on Riley Creek. ICI scores of 44 at both RMs 7.1 and 1.8 were indicative of a near exceptional macroinvertebrate assemblage. The improvement in the index score was due in part to increased caddisfly densities and reduced numbers of tolerant taxa. The caddisfly Chimarra obscura and the aquatic moth genera Petrophila, two relatively sensitive taxa, were very common on the natural substrates at both sites.

- The longitudinal trend of the Qualitative Community Tolerance Value (QCTV) provides a good representation of the relative pollution tolerance of the macroinvertebrate fauna found at each of the sampling locations and demonstrates the adverse impact the Bluffton WWTP discharge was having on Riley Creek (Figure 6). It is especially helpful in this case where the ICI is not directly applicable upstream of the discharge for determining attainment/non-attainment.

Little Riley Creek

- Qualitative sampling was conducted at RM 2.4 and RM 0.1 on Little Riley Creek in order to assess the of impact CSOs. The stream was intermittent or nearly intermittent during much of the summer and the site near the mouth was completely dry on 10 June 1991. The upstream site (RM 2.4) supported a predominately pollution intermediate macroinvertebrate assemblage; twenty-five taxa were collected. Negative influences on the benthic community included the lack of sustained flow and predominance of fine substrate types. Benthic organisms were present in very low density and diversity at the site near the mouth of Little Riley Creek (RM 0.1); a total of eight taxa were collected. The fact that this site had been dry in the recent past obviously limited the development of a more diverse community. Additionally, CSO discharges were probably also having an impact and were potentially a source of impact on Riley Creek. Periodic CSO overflows were evidenced by an accumulation of human hygiene devices strewn along the stream margin of Little Riley Creek.

Table 8. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Riley Creek study area, July- August, 1991.

Quantitative Evaluation

Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Qual. EPT[b]	QCTV	ICI	Narrative Evaluation
Riley Creek							
17.9	4	3	14	0	23.3	0*	Poor
16.9	Qual. Only	-	16	0	28.7	-	Poor
15.5	Qual. Only	-	48	8	31.9	-	Good
15.4	1129	18	33	3	28.9	6*	Poor (Mix)
15.3	646	24	34	3	22.9	8*	Poor
11.7	1683	47	34	12	31.2	24*	Fair
7.1	521	46	36	9	37.1	44	Very Good
1.8	676	53	33	8	37.4	44	Very Good

Qualitative Evaluation

Stream River Mile	No. Qual. Taxa	QCTV	Qual. EPT[b]	Relative Density	Predominant Organisms	Narrative Evaluation[a]
Riley Creek						
16.9	16	28.7	0	Mod.	Flatworms Midges	Poor
15.5	45	31.9	8	Mod.	Midges	Very Good
Little Riley Creek						
2.4	25	34.9	1	Low	Isopods, Beetles	Fair
0.1	8	22.5	0	Low	Isopods, Riffle Beetles	Fair

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX	WWH	EWH	MWH[d]
ICI	36	46	22

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

[a] A qualitative narrative evaluation is based on best professional judgement is used when quantitative data is not available to calculate the Invertebrate Community Index (ICI) scores.

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

[c] QCTV derived as the median of the tolerance values calculated for each qualitative taxon collected.

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

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

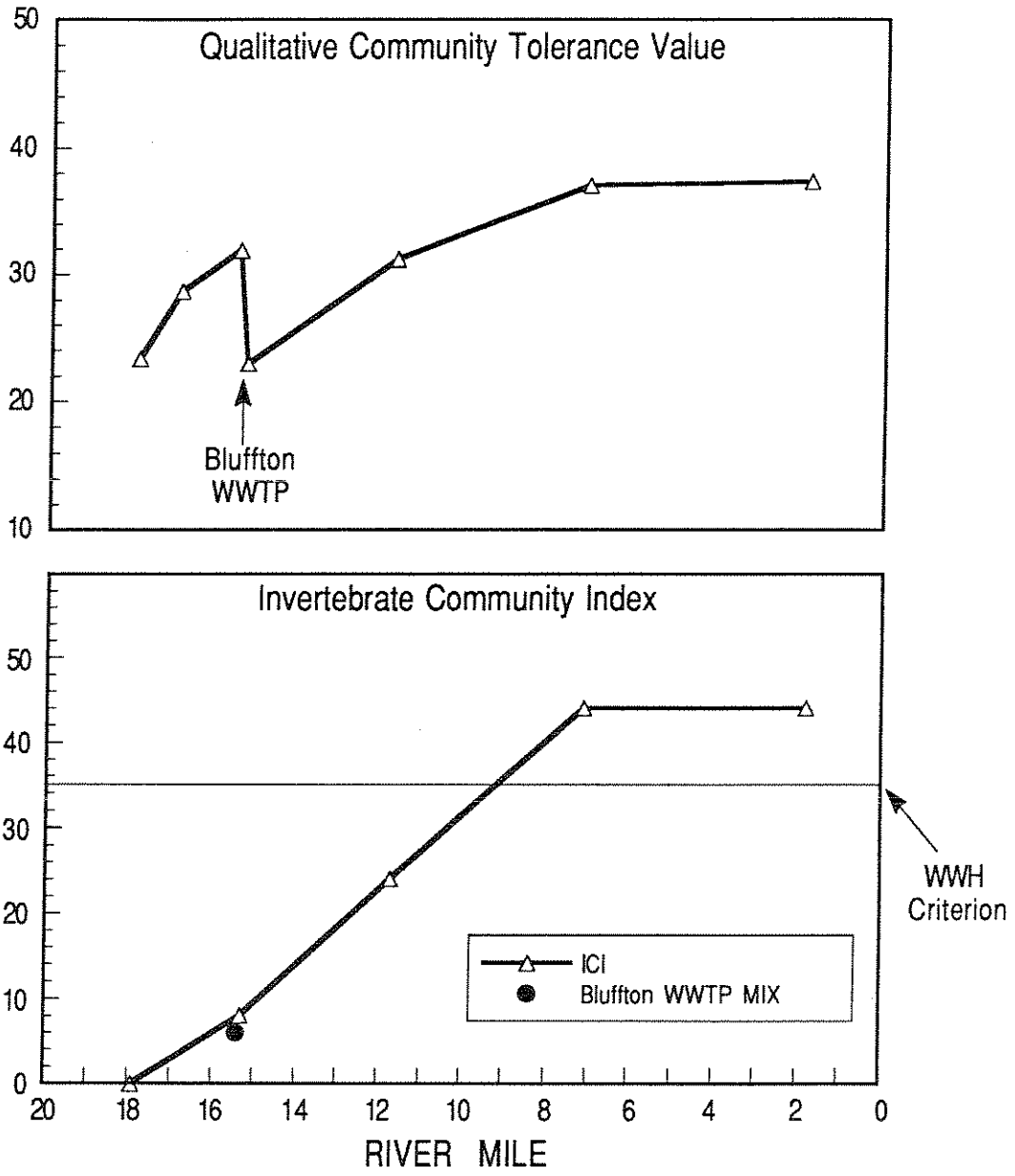

Figure 6. Longitudinal trend of the Qualitative Community Tolerance Value (QCTV) and the Invertebrate Community Index (ICI) in the Riley Creek study area, 1991.

Biological Assessment: Fish Community

Riley Creek

- A total of 11,005 fish comprised of 39 species and four hybrids were collected from Riley Creek between 10 July and 27 August, 1991. The sampling effort included a cumulative total of 25.9 km at six sampling locations between RM 17.9, upstream from the city of Bluffton, and RM 1.8, downstream from the village of Pandora.

- The fish community was predominated by numbers by bluntnose minnow (35%), central stoneroller (14%), creek chub (10%), green sunfish (9%), striped shiner (4%) and fathead minnow (3%). Species that predominated in terms of biomass were common carp (48%), green sunfish (16%), white sucker (8%), bluntnose minnow (3%), and yellow bullhead (3%). These predominate species are either highly pollutiontolerant, omnivorous, and/or generalist feeders.

- Based on IBI and MIwb scores and the accompanying narrative evaluation, fish community performance ranged from exceptional/good at RM 1.8 to poor at RM 17.9. No sites performed at fully exceptional or very poor levels (Table 9). Generally community performance in Riley Creek can be characterized as fair. The community was predominated by tolerant species with intolerant forms absent or in low abundance. All but one site (RM 1.8) failed to achieve the WWH IBI and MIwb criteria (Figure 7).

- The most upstream site, RM 17.9, demonstrated poor community performance. This was a result of the intermitent stream flow in the upper portion of Riley Creek. The lack of sustained flow significantly limits the development of a permanent, functionally organized fish community. The community consisted primarily of pioneering and tolerant species.

- The fish community downstream from the city of Bluffton between RM 15.5 and RM 15.3 appeared to be impacted by the combined influences of the Bluffton WWTP and the CSOs upstream from the treatment facility. Community assemblages upstream from the WWTP (RM 15.5) indicated an impact of the type associated with organic enrichment (IBI=27; MIwb=7.3). The low community performance observed is most likely a result of episodic overflows from the CSOs within Bluffton and subsequent organic enrichment (*i.e.* excess algal production, marginal D.O., etc.). Downstream from the Bluffton WWTP (RM 15.3), community performance demonstrated a modest improvement, but an impact was still evident (IBI=29; MIwb=7.0). The fish community response to the influences of the Bluffton WWTP and CSOs were manifest in specific functional attributes. Tolerant and omnivorous species predominated, while sensitive and carnivorous species were absent or in low abundance. This skewed trophic structure was apparent upstream as well as downstream of from the Bluffton WWTP (Figure 7)

- IBI and MIwb scores at RM 13.2 (IBI=25; MIwb=6.6) indicated a further decline in health of the fish assemblage in comparison to the sampling stations in the vicinity of Bluffton (Figure 7). The lower observed community performance most likely reflects the continued influence of the Bluffton WWTP and indicates the location of a dissolved oxygen sag in this vicinity. The community continued to be dominated by omnivorous and tolerant species.

- At RM 7.6 the fish community began to show signs of recovery (IBI=30; MIwb=6.8), and by RM 1.8 Riley Creek fully recovered, achieving WWH biological criteria (Table. 9. Figure. 7). The community at RM 1.8 consisted of typical association of warmwater species including the presence of pollution intolerant forms. Additionally, the frequency of omnivores and tolerant species demonstrated a marked decline, indicating an increased level of functional organization within the fish community.

Table 9. Fish community indices based on pulsed D.C. electrofishing samples at 8 locations sampled by Ohio EPA in the Riley Creek study area during July - August, 1991.

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[a]
Riley Creek								
17.9	12.5	16	16	2.1	56.5	5.5*	23*	Poor
15.5	19.0	23	23	10.2	54.5	7.3*	27*	Fair/Poor
15.3	19.5	21	21	5.2	59.0	7.0*	29*	Fair
13.2	15.5	19	19	103	53.0	6.6*	25*	Fair/Poor
7.6	18.0	22	22	19.9	73.5	6.8*	30*	Fair
1.8	24.0	28	28	18.9	69.5	9.8	43	Ex./Good
L. Riley Creek								
2.4	7	7	7	N/A	57.5	N/A	18*	Very Poor
0.1	10.0	10	10	N/A	60.5	N/A	26*	Poor

* 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.

NA Headwater site; MIwb is not applicable.

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8

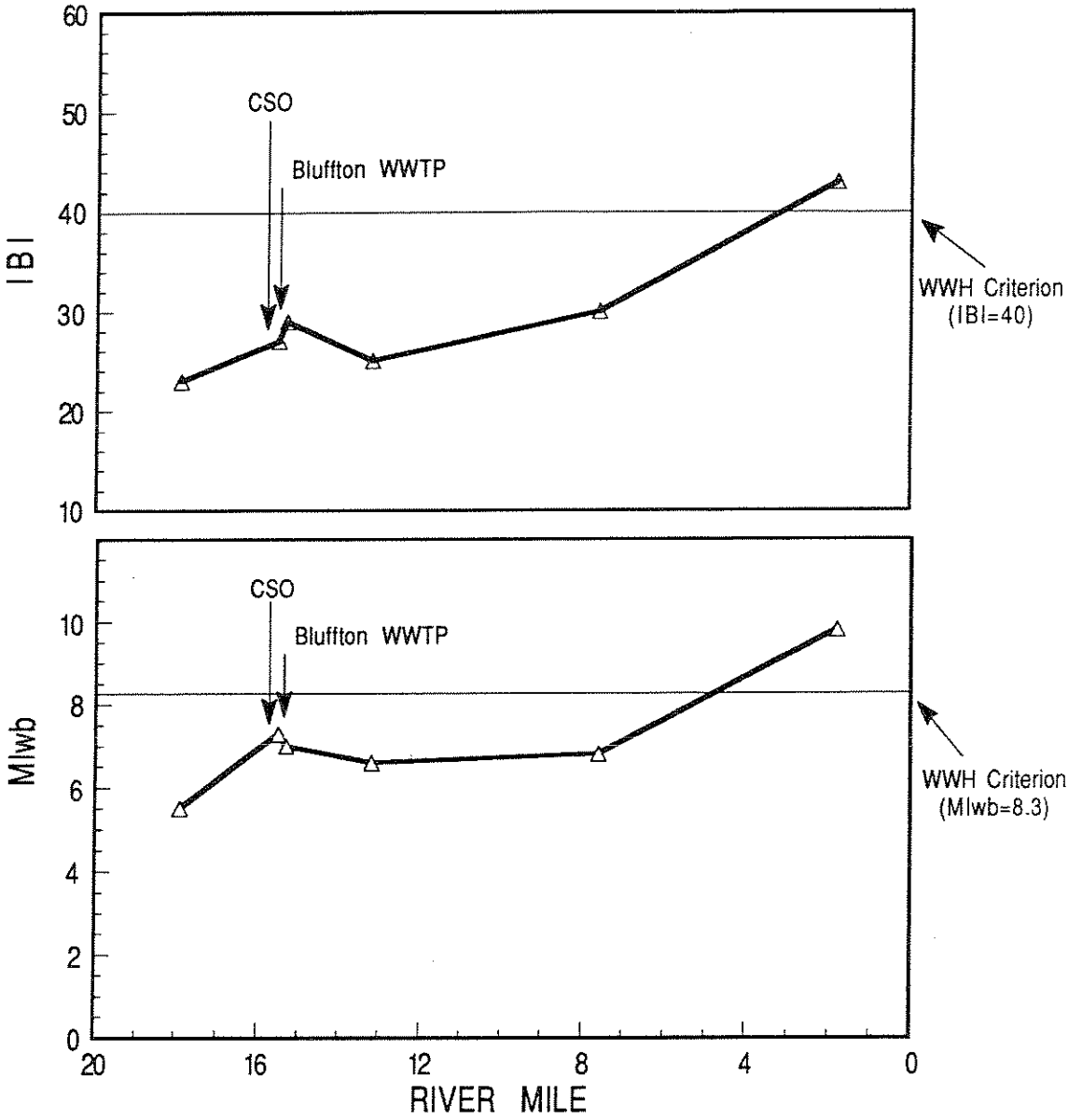

Figure 7. Longitudinal trend of the Index of Biotic Integrity (IBI; upper) and the Modified Index of Well-Being (MIwb; lower) in the Riley Creek study area, 1991.

Little Riley Creek

- Two fish community samples were collected from Little Riley Creek at RM 2.4 and RM 0.1 during 1991. The primary objective was to evaluate the impact of CSOs. Community performance ranged from poor (IBI=26) at RM 0.1 to very poor (IBI=18) at RM 2.4 (Table 9). The primary factors inhibiting community performance in Little Riley Creek were the lack of sustained flow and, at the downstream site, CSO impacts. The uppermost site, RM 2.4, was intermittent or nearly intermittent during much of the summer, and the station at RM 0.1 was dry between June and July of 1991. This lack of flow likely exacerbated the impact of past CSO discharges.

- The fish community at RM 2.4 lacked typical headwater species; consisting almost entirely of tolerant forms, most of which were pioneering species. At RM 0.1, downstream from the CSOs, community performance improved but still failed to achieve WWH biological criteria (Table 9). The community at this station was predominated by tolerant forms and pioneering species, very similar in composition to the upstream site. It appears that Little Riley Creek is significantly impaired by intermittent flow, and is unable to support and maintain a permanent fish community achieving WWH biological criteria.

Trend Assessment

Chemical Water Quality Changes: 1983 - 1991.

- Chemical water quality was studied in Riley Creek as part of the 1983 Blanchard River intensive survey (Ohio EPA, 1985). Upstream flow was also intermittent during the 1983 study period, but the Bluffton Stone Company quarry discharge was noted as being a source of flow augmentation in Riley Creek. The 1985 report indicated that, although the quarry discharge may have diluted some of the effects of the Bluffton WWTP, enrichment was evident downstream from the Bluffton discharge at RM 13.8. The report indicated that water quality recovery was evident at RM 8.8. An additional station was located at RM 4.2 to determine the effects of the Pandora WWTP. This site was downstream from a lowhead dam at RM 4.4, and was in an area of sediment deposition. Some decrease in D.O. and increase in nitrate-nitrogen was noted at this site. Improving water quality was noted at the last downstream site at RM 1.8, and the input of Riley Creek was not thought to be detrimental to the water quality of the Blanchard River.

- Chemical data for several parameters (nitrate, ammonia-N, phosphorus, and D.O.) from 1983 and 1991 sample collections were compared determine trends between the sampling periods (Figure 8). Direct comparisons are somewhat problematical, due to the different sampling sites used in the two surveys. The nitrate trend indicates that the increase in this parameter was considerably higher downstream from Bluffton in the 1983 survey. A longitudinal increase was also evident in the 1991 survey downstream from the WWTP, but the lower concentration peak indicates that less nitrification of ammonia-N was taking place at the Bluffton WWTP during the 1991 survey than in 1983. The 1983 data indicates a considerable increase in nitrate downstream from the Pandora WWTP, while this increase is hardly noticeable in the 1991 data, possibly as a result of differences in sampling location between the two surveys. The longitudinal trends for ammonia-N are similar for 1983 and 1991 (Figure 8), except for immediately downstream from the Bluffton WWTP in 1991, where a peak can be seen, reflecting the increased loading already noted above. The trends for phosphorus are also quite similar, although there is an indication of somewhat higher input from Bluffton in 1991, and more CSO inputs in 1983. There are slight differences in the curves for the area affected by the Pandora WWTP, but these are probably not very significant.

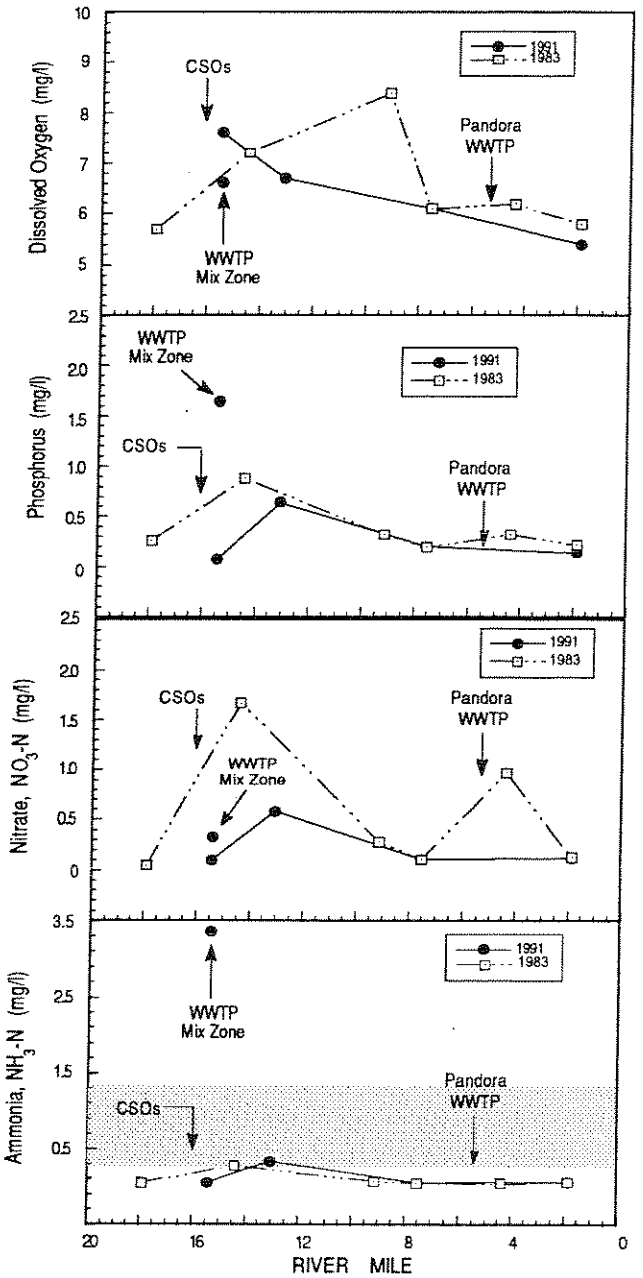

Figure 8. Longitudinal trend of mean dissolved oxygen, phosphorus, nitrate, and ammonia - nitrogen in the Riley Creek study area, 1983 and 1991. Shaded area in ammonia-nitrogen plot represents the range of WQS based on 95th and 25th percentile pH and temperature values for the survey data.

- The differences in the graphs for dissolved oxygen (Figure 8) cannot be simply explained, however, a number of circumstances are likely to have been contributing factors. It is probably a significant observation that 1991 was a drought year, in which no flow was noted at the upstream control site during the sampling period. Flow was noted on at least two sampling dates in 1983. It may be that a combination of upstream flow and quarry discharge contributed to a greater degree of aeration during the 1983 survey period. It is possible that since biochemical oxygen demand (BOD_5) appears to have decreased, the lower D.O. levels in 1991 compared to 1983, may reflect the adverse affects of the increased ammonia-N loadings from the Bluffton WWTP.

Changes in Biological Community Performance: 1953 - 1991

Riley Creek

- The only biological data available describing past conditions in Riley Creek is of the fish community from an unpublished manuscript produced by Darrel Allison (former Fisheries supervisor,ODNR District 4). This document (Allison, 1956) was written in the mid 1950s and evaluated the impact of the Bluffton WWTP before and after a treatment upgrade in 1954. Though community data was not collected in accordance with the Ohio EPA sampling protocols, considerable effort was made to ensure that the data was quantifiable. Reasonable comparisons can be made between the results of the Ohio EPA 1991 sampling effort and the data collected in 1953-55.

- Results of Allison's investigation indicated that in 1953 (pre-upgrade), the fish community downstream from the WWTP was severely degraded. A total of nine individual fish comprised of only one species (green sunfish), indicated that the discharge of relatively untreated municipal wastes into Riley Creek thoroughly impaired the instream fauna. Subsequent post - upgrade sampling in 1954 and 1955, demonstrated a marked improvement in fish community performance. Both structural and functional components of the fish community were markedly improved during this period. The observed improvements were manifested in increased diversity, biomass, and relative abundance; an dthe presence of moderately tolerant and intolerant species.

- In comparison, the fish community immediately downstream from the Bluffton WWTP (RM 15.3) has demonstrated little historical change since the upgrade of the treatment facility in 1954. The community is still predominated by omnivorous and tolerant species. Intolerant forms appeared more abundant in 1991, but this station is still impacted by the Bluffton WWTP and fails to achieve applicable WWH biological criteria.

- Area of Degradation Values (ADV) for the 1991 sampling effort (Table 10) provides a relative measure of performance of the IBI, MIwb, and ICI for Riley Creek and the IBI only for Little Riley Creek. The ADV/mile of the IBI demonstrates the more severe degradation in the fish community of Little Riley Creek versus Riley Creek. The high ADV/mile for Little Riley Creek is attributable in large part to the intermittent nature of the stream. The ADV/mile statistics for Riley Creek are within the range of values commonly encountered for streams that are impacted by organic enrichment. The zero score for the MIwb and the IBI score of 61 for the Poor/Very Poor ADV statistic is another reflection of the organic enrichment nature of the impact. The

ADV for the MIwb typically is less than for the IBI under enriched conditions because the occurrence of a large number and biomass of relatively tolerant fish species will improve the MIwb score but does not significantly affect the IBI.

Table 10. Area of Degradation (ADV) statistics for the Riley Creek 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
Riley Creek (1991)											
IBI	1.8	17.9	23	43	**1155**	71.7	61	3.4	4.8	8.1	5.4
MIwb			5.4	9.8	**715**	44.4	0				
ICI			6	44	**824**	51.1	56				
Little Riley Creek (1991)											
IBI	0.1	2.4	18	26	**346**	150.4	121	0.0	0.0	2.5	2.5

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Appendix Tables

Appendix Table 1. Results (mean/maximum-minimum)[a] of chemical/physical sampling in the Riley Creek study area during July-September, 1991. All conventional parameters are reported in mg/l; all metals and other substances are reported in ug/l, unless otherwise noted.

River Mile (n)	Dissolved Oxygen	Temperature (°C)	pH (S.U.)	Tot. Susp. Solids
15.5(6)	7.6(6.6- 9.0)	20.3(14.0-23.4)	8.1(7.9-8.2)	6(5-10)
BLUFFTON WWTP(6)	5.7(5.2- 6.6)	20.9(18.5-22.2)	7.8(7.6-7.9)	7(5-11)
15.4(6)	6.7(5.8- 7.3)	20.7(16.0-23.7)	8.1(7.9-8.4)	9(5-17)
13.1(6)	6.7(4.1-10.8)	21.5(14.0-24.4)	8.4(8.1-9.1)	24(16-31)
7.5(6)	6.1(3.2- 7.6)	22.2(15.5-25.2)	8.4(8.2-8.7)	9(5-11)
1.8(6)	5.4(4.6- 6.3)	21.1(14.0-24.1)	8.1(7.9-8.6)	12(8-15)

River Mile(n)	Specific Conductance	BOD5	COD	Total Phosphorus
15.5(6)	1182(1110-1250)	1.2(1.0- 1.6)	13(10-24)	0.07(0.05-0.11)
BLUFFTON WWTP(6)	2198(2030-2310)	9.9(4.2-19.0)	41(23-64)	4.48(3.03-8.53)
15.4(6)	1470(1110-1960)	7.1(1.0-17.0)	23(10-55)	1.64(0.05-6.59)
13.1(6)	1272(1010-1610)	3.5(2.6- 4.4)	18(10-33)	0.64(0.47-0.80)
7.5(6)	1088(603-1380)	1.7(1.0- 3.3)	16(11-26)	0.20(0.14-0.29)
1.8(6)	1035(695-1260)	1.7(1.0- 3.0)	17(11-27)	0.14(0.09-0.20)

River Mile (n)	Nitrate-Nitrite (N)	Nitrite (N)	Ammonia(N)	Tot. Kjeldahl Nitrogen
15.5(6)	0.10(0.10-0.10)	0.02(0.02-0.02)	0.05(0.05- 0.05)	0.2(0.2- 0.3)
BLUFFTON WWTP(6)	4.43(1.25-7.82)[b]	1.08(0.25-1.75)[b]	8.51(0.73-13.50)[b]	9.3(2.0-14.2)
15.4(6)	0.33(0.10-1.01)[b]	0.14(0.02-0.50)[b]	3.36(0.05- 9.59)	4.0(0.2-11.0)
13.1(6)	0.58(0.14-1.61)	0.15(0.02-0.60)	0.33(0.05- 1.26)	0.9(0.4- 1.7)
7.5(6)	0.11(0.10-0.18)	0.02(0.02-0.02)	0.05(0.05- 0.05)	0.6(0.5- 0.7)
1.8(6)	0.12(0.10-0.23)	0.02(0.02-0.02)	0.06(0.05- 0.09)	0.6(0.4- 0.8)

Appendix Table 1 cont.

River Mile (n)	Hardness (CaCO3)	Total Calcium	Total Magnesium	Lab pH (S.U.)
15.5(6)	642(607-690)	144(138-156)	69(63-73)	8.17(7.94-8.40)
BLUFFTON WWTP(6)	518(476-555)	124(113-135)	50(46-54)	7.79(7.58-7.99)
15.4(6)	597(512-670)	136(121-148)	63(51-73)	7.98(7.54-8.27)
13.1(6)	546(406-617)	125(95-140)	57(41-65)	8.34(8.05-8.77)
7.5(6)	420(221-511)	90(54-104)	48(21-61)	8.31(8.12-8.55)
1.8(6)	423(266-519)	88(62-109)	49(27-61)	8.07(7.89-8.14)

River Mile (n)	Total Cadmium	Total Chromium	Total Copper
15.5(6)	0.2(0.2-0.4)	30(30-30)	10(10-10)
BLUFFTON WWTP(6)	0.3(0.2-0.8)	30(30-30)	10(10-10)
15.4(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)
13.1(6)	0.2(0.2-0.2)	32(30-40)	10(10-10)
7.5(6)	0.2(0.2-0.4)	32(30-40)	15(10-40)
1.8(6)	0.2(0.2-0.4)	30(30-30)	10(10-10)

River Mile (n)	Total Iron	Total Lead	Total Nickel	Total Zinc
15.5(6)	253(170- 480)	2(2- 4)	40(40-40)	10(10- 10)
BLUFFTON WWTP(6)	100(50- 150)	4(2-10)	40(40-40)	25(10- 50)
15.4(6)	243(150- 460)	2(2- 4)	40(40-40)	19(10- 50)
13.1(6)	903(700-1290)	2(2- 4)	40(40-40)	13(10- 30)
7.5(6)	375(310- 520)	3(2- 6)	40(40-40)	13(10- 25)
1.8(6)	517(370- 680)	2(2- 2)	42(40-50)	38(10-135)

Appendix Table 1 cont.

River Mile (n)	Fecal Coliform (#/100 ml)	Total Residual Chlorine
15.5(6)	1013(440-1700)[c]	
BLUFFTON WWTP(6)	423(120- 900)[c]	0.29(0.12-0.45)
15.4(6)	867(160-2100)[c]	
13.1(6)	773(220-1600)[c]	
7.5(6)	470(40-1000)[c]	
1.8(6)	515(95-1000)[c]	

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

[b] n < 6 samples.

[c] n = 3 samples