# Biological and Water Quality Survey of the Licking River and Selected Tributaries

**(Licking, Muskingum, Knox, and Fairfield Counties, Ohio)**

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## Introduction

As part of the five year basin approach for NPDES (National Pollution Discharge Elimination System) permitting, ambient biological, water column chemical, sediment, and bioassay sampling was conducted within the Licking River and selected tributaries. The 1993 Licking River study area included: Licking River mainstem, Big Run, North Fork Licking River, Vance Creek, Sycamore Creek, South Fork Licking River, Ramp Creek, Raccoon Creek, and Lobdell Creek.

Specific objectives of this evaluation were to:

1) Monitor and assess the overall chemical, physical, and biological integrity of the water-bodies within the 1993 Licking River study area,

2) Evaluate the influence of the Newark WWTP (Wastewater Treatment Plant) on the Licking River mainstem,

3) Evaluate the influence of CSOs (Combined Sewer Overflow) from the city of Newark within the Licking River and the lower segments of the North Fork Licking River, Raccoon Creek, and South Fork Licking River,

4) Evaluate the influence of the Pataskala WWTP, Buckeye Lake WWTP, Hebron WWTP, and Heath WWTP on the South Fork Licking River,

5) Collect pre-installment ambient biological and water quality data downstream of the proposed Southwest Licking County WWTP (a new facility) on the South Fork Licking River,

6) Evaluate potential impacts to Ramp Creek from Koppers Co., Newark Air Force Base, Kaiser Aluminum Co., and Union Petroleum/Ashland Oil Co.,

7) Evaluate any additional improvements in ambient biological and water quality conditions since the 1981-1984 intensive surveys, and to expand Ohio EPA's data base for long term trend analysis (*e.g.* 305[b] report), and

8) Establish biological monitoring stations on selected tributaries to evaluate nonpoint source abatement activities within the Licking River watershed.

## Summary


***Licking River (mainstem)***

A total of 18.4 miles of the Licking River mainstem was assessed in 1993, excluding the Dillon Reservoir dam pool. The sampling effort included 15 chemical, physical, and biological sampling stations located between RM 28.6 (upstream Newark WWTP) and RM 3.4 (Dillon Falls Rd.). Based on ambient biological performance, 90.2% (16.6 miles) of the study area was considered to be in FULL attainment of the designated Warmwater Habitat (WWH) aquatic life use. The remaining 9.8% (1.8 miles) demonstrated PARTIAL attainment of the WWH use. The majority of the sampling stations within the Licking River study area contained fish and macroinvertebrate communities characterized as near exceptional. The assemblages were generally diverse and functionally well organized, with environmentally sensitive taxa well represented.

The area of PARTIAL attainment was limited to the reach immediately downstream from the Dillon Reservoir spillway (RM 5.5), and represented a failure of the benthic macroinvertebrate community to perform at a level consistent with WWH criteria (Table 1). Through the course of this study depressed dissolved oxygen concentrations, and elevated ammonia-N and BOD levels were recorded at RM 5.5, likely associated with the hypolimnetic discharge from the reservoir. These factors coupled with the disruption of normal riverine energy and nutrient cycling by large on-stream impoundments resulted in diminished performance within the macroinvertebrate assemblage. The response of the benthic invertebrate community to the unique conditions immediately downstream of large impoundments was fairly typical of that observed under similar circumstances within Ohio. The impact downstream of Dillon Reservoir was modest, and highly localized, as evidenced by rapid biological recovery further downstream at RM 3.4 (Dillon Falls Rd.), where the benthic macroinvertebrate community was again fully consistent with the WWH biological criteria.

The Newark WWTP is the only significant permitted point source discharger contributing conventional pollutant loads to the Licking River mainstem. No impact to the Licking River was evident downstream of the Newark WWTP in 1993. Though this facility was the source of fairly distinct nutrient inputs, oxygen demanding wastes appeared rapidly assimilated downstream, and adequate dissolved oxygen levels were generally maintained throughout the mainstem. The condition of the benthic macroinvertebrate and fish communities was characterized as near exceptional both up and downstream of the treatment facility. Recent acute bioassay tests conducted in April and September, 1993 provided additional evidence of the effective waste treatment currently provided by the Newark WWTP. No significant mortality or adverse effects were observed in the test organisms exposed to any effluent or instream water sample. Fecal coliform counts represented the only exceedence of Ohio Water Quality Standards encountered during the 1993 sampling effort. Four fecal bacteria counts in excess of the Primary Contact Recreational (PCR) standard occurred between RM 28.6 (upstream Newark WWTP) and RM 13.0 (adjacent Hill Rd.). Three of the exceedences occurred during distinct periods of elevated stream flow, a time at which urban and agricultural nonpoint , CSOs, and other diffuse and/or episodic pollutant sources are most active. The elevated level of fecal bacteria recorded during this time period was most certainly reflective of these diffuse sources. The remaining exceedence occurred at RM 28.6 (upstream Newark WWTP) and was not associated with elevated stream flow. This exceedence may have been a result of malfunctioning (dry flow) CSO(s) located upstream, within and around the city of Newark or other smaller diffuse sources. Regardless, fecal bacteria contamination documented within the Licking River was modest and episodic, and did not appear to constitute a pervasive threat to the PCR use.

Table 1. Aquatic life use attainment status for the Warmwater Habitat (WWH) use designation in the Licking River study area. Attainment status based on data collected between 1979 and 1993.

| River Mile Fish/Invert. | IBI | Modified Iwb | ICI[a] | QHEI | Attainment Status[b] | Comment |
|---|---|---|---|---|---|---|
| ***Licking River (1993)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use designation (Existing)* | | | | | |
| 28.6/28.6(B) | 50 | 9.9 | 40 | 79.5 | FULL | Reference Station |
| 28.5/28.5(mz,B) | 45 | 9.4 | 34 | - | - | Mixing Zone |
| 26.6/26.8(B) | 49 | 10.0 | 46 | 76.0 | FULL | Dst. Newark WWTP |
| | *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | |
| 18.7/18.9(B) | 46 | 9.8 | 52 | 75.5 | FULL | Toboso Rd. |
| - /14.8(B) | - | - | 54 | - | (FULL) | Dst. Hanby Trib. |
| 13.3/ - (B) | 39ns | 9.4 | - | 50.0 | (FULL) | Dillon Res. Backwater |
| 5.5/5.5(B) | 46 | 9.7 | 18* | 72.5 | PARTIAL | Dst. Dillon Res. |
| 3.4/3.4(B) | 48 | 9.9 | 38 | 76.5 | FULL | Dst. Dillon Falls |
| ***(1988)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use designation (Existing)* | | | | | |
| - /26.8 | - | - | 42 | - | (FULL) | Dst. Newark WWTP |
| | *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | |
| 3.6/3.6(B) | 40 | 9.1 | 34ns | 83.0 | FULL | Reference Station |
| ***(1985)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use designation (Existing)* | | | | | |
| 28.1/ - (B) | 38ns | 10.0 | - | 58.0 | (FULL) | Dst. Newark WWTP |
| 26.4/ - (B) | 40 | 9.4 | - | - | (FULL) | Dst. Newark WWTP |
| | *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | |
| 13.4/ - (B) | 32* | 8.3ns | - | - | (PARTIAL) | Dillon Res. Backwater |
| ***(1981)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use designation (Existing)* | | | | | |
| 30.1/28.6(B) | 33* | 7.1* | 32ns | - | PARTIAL | Ust. Newark WWTP |
| 27.5/26.8(B) | 29* | 7.0* | 40 | - | PARTIAL | Dst. Newark WWTP |
| 24.8/23.3(B) | 29* | 7.2* | 42 | - | PARTIAL | |
| | *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | |
| 20.0/18.9(B) | <u>24</u>* | 6.4* | 46 | - | **NON** | |
| 16.1/ - (B) | <u>27</u>* | 6.4* | - | - | (**NON**) | |

Table 1. continued.

| River Mile Fish/Invert. | IBI | Modified Iwb | ICI[a] | QHEI | Attainment Status[b] | Comment |
|---|---|---|---|---|---|---|
| ***Licking River (1981)*** | | | | | | |
| | *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | |
| 11.0/ - [(B)] | 25* | 5.4* | - | - | (**NON**) | Impounded (Dillon Res.) |
| ***(1979)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use designation (Existing)* | | | | | |
| - /26.8[(B)] | - | - | 28* | - | (**NON**) | Dst. Newark WWTP |
| ***Big Run (1993)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 5.0/5.1[(H)] | 30* | N/A | Fair* | 40.5 | **NON** | NPS Station |
| ***North Fork Licking River (1993)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 2.5/2.8[(B)] | 51 | 10.9 | 44 | 82.5 | FULL | Ust. Landfills |
| 0.2/0.2[(B)] | 46 | 9.4 | Fair* | 60.0 | PARTIAL | Near Mouth |
| ***(1985)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 0.9/ - [(B)] | 52 | 9.5 | - | - | (FULL) | Near Mouth |
| ***(1982)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 2.4/2.8[(B)] | 41 | 9.3 | 42 | 77.0 | FULL | Ust. Landfills |
| - /0.2 | - | - | 22* | - | (**NON**) | Near Mouth |
| ***(1981)*** | | | | | | |
| 2.0/ - [(B)] | 39[ns] | 8.6[ns] | - | - | (FULL) | |
| 0.7/0.2[(B)] | 31* | 7.7* | 38 | - | PARTIAL | Near Mouth |
| ***Vance Creek (1993)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 0.7/0.7[(H)] | 48 | N/A | Good | 59.5 | FULL | NPS Station |
| ***Sycamore Creek (1993)*** | | | | | | |
| | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 0.1/0.1[(H)] | 48 | 8.9 | Good | 80.0 | FULL | NPS Station |

Table 1. continued.

| River Mile Fish/Invert. | IBI | Modified Iwb | ICI[a] | QHEI | Attainment Status[b] | Comment |
|---|---|---|---|---|---|---|
| ***South Fork Licking River (1993)*** | | | | | | |
| *Eastern Corn Belt Plains WWH Used Designation (Existing)* | | | | | | |
| 31.5/31.6(H) | 47 | N/A | Good | 60.0 | FULL | Headwaters |
| 28.3/28.4(W) | 47 | 9.4 | 32ns | 64.5 | FULL | Ust. Pataskala WWTP |
| 27.6/27.6(W) | 49 | 9.6 | 36 | 83.0 | FULL | Dst. Pataskala WWTP |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 24.6/24.1(W) | 46 | 9.1 | 40 | 83.0 | FULL | |
| 21.3/21.1(W) | 52 | 9.6 | Good | 67.0 | FULL | |
| 15.3/15.4(W) | 49 | 8.6 | 50 | 59.5 | FULL | Ust. Buckeye L. WWTP |
| 13.1/13.0(B) | 37ns | 8.9 | 34 | 39.0 | FULL | Dst. Buckeye L. WWTP |
| 9.4/9.9(B) | 51 | 9.9 | 42 | 76.5 | FULL | Ust. Hebron WWTP |
| 8.8/8.9(B) | 51 | 9.8 | 42 | 75.0 | FULL | Dst. Hebron WWTP |
| 4.3/4.7(B) | 49 | 9.6 | 44 | 85.5 | FULL | Ust. Heath WWTP |
| 2.2/2.2(mz,B) | 48 | 9.6 | 44 | - | - | Mixing Zone |
| 1.7/1.7(B) | 52 | 10.2 | 46 | 82.5 | FULL | Dst. Heath WWTP |
| 0.5/0.4(B) | 53 | 10.2 | 36 | 60.5 | FULL | Near Mouth |
| ***(1988)*** | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 19.1/ - (B) | 54 | 10.1 | - | 75.0 | (FULL) | |
| 15.3/ - (B) | 48 | 8.4 | - | - | (FULL) | |
| ***South Fork Licking River (1984)*** | | | | | | |
| *Eastern Corn Belt Plains WWH Use Designation (Existing)* | | | | | | |
| 31.5/31.6(H) | 36ns | N/A | 40 | 64.0 | FULL | Headwaters |
| 28.5/28.5(H) | 42 | N/A | 30* | 70.0 | PARTIAL | Ust. Pataskala WWTP |
| 27.6/27.6(W) | 37ns | 9.9 | 42 | 69.0 | FULL | Dst. Pataskala WWTP |
| 26.2/ - (W) | 36ns | 8.2 | - | 68.0 | (FULL) | Ust. Jordon Manor WWTP |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 21.5/ - (W) | 47 | 10.1 | - | - | (FULL) | Dst. Jordon Manor WWTP |
| 21.3/21.3(W) | 44 | 10.2 | 42 | - | FULL | |
| 13.1/13.0(B) | 39ns | 9.0 | 22* | 42.0 | PARTIAL | Ust. Waste Weir Run[c] |
| 12.7/12.8(B) | 34* | 8.9 | 20* | - | PARTIAL | Dst. Waste Weir Run[c] |

Table 1. continued.

| River Mile Fish/Invert. | IBI | Modified Iwb | ICI[a] | QHEI | Status[b] | Attainment Comment |
|---|---|---|---|---|---|---|
| ***South Fork Licking River (1981)*** | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 7.2/ - (B) | 31* | 7.4* | - | - | (**NON**) | |
| - /5.6 | - | - | 38ns | - | (FULL) | Ust. Heath WWTP |
| 2.1/ - (B) | 33* | 7.3* | - | - | (**NON**) | Dst. Heath WWTP |
| 0.9/0.4(B) | 35* | 7.9* | 24* | - | **NON** | Near Mouth |
| ***Ramp Creek (1993)*** | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 2.0/2.0(H) | 53 | N/A | 42 | 80.5 | FULL | Heath Boundary Rd. |
| 1.4/1.4(H) | 53 | N/A | 42 | 76.5 | FULL | Dst. Kopper Co. |
| 0.7/0.7(H) | 51 | N/A | Poor* | 66.5 | **NON** | Dst. Kaiser Aluminum |
| 0.1/0.1(H) | 55 | N/A | 52 | 75.5 | FULL | Near Mouth |
| ***Raccoon Creek (1993)*** | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 5.6/5.8(B) | 43 | 10.0 | 46 | 77.5 | FULL | Ust. CSOs |
| 0.3/0.2(B) | 50 | 10.2 | M-Goodns | 65.0 | FULL | Dst. CSOs |
| ***(1981)*** | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 0.6/ - (B) | 31* | 7.6* | - | - | (NON) | Within Newark |
| ***Lobdell Creek (1993)*** | | | | | | |
| *Eastern Corn Belt Plains WWH Used Designation (Existing)* | | | | | | |
| 1.6/ - (H) | 40 | N/A | - | 51.5 | (FULL) | |
| 0.2/ - (H) | 48 | N/A | - | 70.5 | (FULL) | |

* - Significant departure from applicable biological criteria (>4 IBI and ICI units or >0.5 MIwb units), poor and very poor results are underlined.
ns - Nonsignificant departure from biocriteria (≤4 IBI and ICI units or ≤0.5 MIwb units).
N/A - Headwater station (MIwb not applicable).
a - Narrative evaluation based on qualitative benthic invertebrate sample.
b - Attainment based on one organism group are parenthetically expressed.
c - Former receiving waterbody for Buckeye Lake WWTP effluent.
*mz* - Mixing zone sample.
H - Headwater fish sampling station.
W - Wading fish sampling station.
B - Boat fish sampling station.

Table 1. continued.

**Ecoregional Biological Criteria:**

*Eastern Corn Belt Plains (ECBP)*

| Index - Site Type | WWH | EWH | MWH[d] |
|---|---|---|---|
| IBI - Headwater/Wading | 40 | 50 | 24 |
| MIwb - Wading | 8.3 | 9.4 | 6.2 |
| ICI | 36 | 46 | 22 |

*Erie Ontario Lake Plain (EOLP)*

| Index - Site Type | WWH | EWH | MWH[d] |
|---|---|---|---|
| IBI - Headwater | 40 | 50 | 24 |
| IBI - Wading | 38 | 50 | 24 |
| IBI - Boat | 40 | 48 | 24 |
| MIwb - Wading | 7.9 | 9.4 | 6.2 |
| MIwb - Boat | 8.7 | 9.6 | 5.8 |
| ICI | 34 | 46 | 22 |

*Western Allegheny Plateau (WAP)*

| Index - Site Type | WWH | EWH | MWH[d] |
|---|---|---|---|
| IBI- Boat | 40 | 48 | 24 |
| MIwb - Boat | 8.6 | 9.6 | 5.8 |
| ICI | 36 | 46 | 22 |

d - Modified Warmwater Habitat for highly channel modified areas.

Sediment samples were collected at two stations on the Licking River and were analyzed for heavy metal and organic chemical contamination. Sediment metals scans revealed elevated concentrations of arsenic and zinc at RM 28.6 (upstream Newark WWTP) and arsenic at 26.8 (downstream Newark WWTP). The arsenic contamination is likely an artifact of past agricultural use of arsenic based pesticides, herbicides, and defoliants. The source of the zinc contamination is unclear at this time, but may have been reflective of urban nonpoint source pollution from the city of Newark. Though the concentrations of both arsenic and zinc were ranked as elevated, ambient levels were below Effects Range Median (ER-M) values and no discernible impact was evident. A sediment scan for organic chemical contamination was conducted at RM 28.6. The results from the sediment analysis indicated that concentrations of most organic contaminants were near or below laboratory detection limits. Only Bis (2-ethylhexyl) phthalate was found above detection limits. This phthalate is used as a plasticizer for polyvinyl chloride and other polymers in large quantities and is likely released to the air and water during the production and disposal of these products. The level of phthalate contamination appeared very modest with no discernible impact.

Between 1979 and 1993 changes within the performance of fish and benthic macroinvertebrate communities, ambient concentrations of conventional pollutants, and entity generated pollutant loadings (MORs) data were all clearly reflective of improved wastewater treatment at the Newark WWTP, as well as reduced pollutant loadings from other upstream point sources within the Licking River basin.

The Newark WWTP has shown substantial decreases in pollutant loadings as a result of both improved pretreatment requirements and improvements to the waste treatment process. These actions were initiated to comply with the more stringent water quality standards defined by the Clean Water Act (CWA) amendments of 1984, and as a result of pervasive and severe pretreatment problems. The compliance history of Newark WWTP revealed numerous permit violations between 1979 and 1983. The contribution of toxic materials (including phenols and formaldehyde) and shock loadings of BOD and ammonia to the waste stream periodically inhibited or eliminated effective waste treatment by the Newark WWTP during this time. Due to excessive and poorly treated industrial influent loadings during 1983, the Newark WWTP was out of compliance for nearly a year. Water chemistry data from a 1981 water resource survey indicated elevated ambient concentrations of BOD and ammonia-N within the stream reach under the influence of Newark WWTP. Results of the 1993 investigations indicated improved water quality within the same stream reach . Both BOD and ammonia-N concentrations were reduced to background levels, while improved nitrification was evidenced by a modest increase in nitrate-N concentrations.

Ambient biological conditions during the early 1980s were clearly reflective of a significant water quality impact. In 1981, the 14.6 mile stream reach between RM 30.1 (upstream Newark WWTP) and RM 16.1 (upstream Dillon Reservoir) failed to fully support the WWH use designation. PARTIAL attainment was observed within 52.7% (7.7 miles) of the 1981 study area, while 47.3% (6.9 miles) were in **NON** attainment. In contrast, the results from the 1993 survey indicated FULL attainment of the WWH use (100%, 15.7 miles) within a nearly identical stream reach. The ambient conditions have so improved that the fish and macroinvertebrate assemblages are now performing at a level characterized as near exceptional (EWH), fully reflective of ecoregional expectations and available aquatic macrohabitats.

***North Fork Licking River***

Water column chemistry samples from the North Fork Licking River were collected at six locations between RM 23.9 (upstream Utica WWTP) and RM 0.2 (Fleek Ave). However, the primary objective of the sampling effort was to characterize the influence of the Owens Corning/City of Newark Landfills and CSOs (Newark WWTP) on the North Fork, and to that end ambient biological and sediment sampling was limited to the lower reach. In addition, entity generated self monitoring data from the Centerburg and Utica WWTPs was gathered to characterize gross trends in pollutant loadings within the subbasin.

Pollutant loads of conventional nutrients from both the Centerburg and Utica WWTPs have been reduced since the mid-1980s. The most significant reductions were achieved by the Utica WWTP. Exceedences of WQ standards encountered during the 1993 sampling effort within the North Fork were limited to fecal coliform. Fecal bacteria counts in excess of the PCR criterion were recorded at five stations between RM 17.1 and RM 0.2. All but one of the exceedences occurred on the same date in mid-July during a period of elevated stream flow, and likely reflected nonpoint sources. The remaining exceedence occurred at RM 0.2 and may have been reflective of modest dry flow CSOs from Newark. Regardless, the level of fecal coliform contamination appeared very modest in 1993 and did not constitute a significant threat to the PCR use. All other water chemistry parameters were comparable to background levels, and no water quality impact was evident from the Owens Corning/Newark Landfills.

To identify and characterize the potential sediment contamination from the Owens Corning/Newark landfills, sediment samples were collected from three locations, RM 2.28 (upstream Owens Corning/Newark landfills), RM 1.64 (downstream Owens Corning/Newark landfills), and RM 0.2 (adjacent Fleek Ave.). Analysis included selected heavy metals and semi-volatile organic compounds. Elevated concentrations of arsenic were detected both upstream and downstream of the Owens Corning/Newark landfills (RM 2.28 and RM 1.64), and were likely reflective of background levels associated with past agricultural use of arsenic based pesticides, herbicides, and defoliants. Though concentrations were ranked as elevated the ambient levels observed were below the ER-M value. A sediment organic scan for priority pollutants was conducted at three stations on the North Fork Licking River. The results from the analysis indicated that all organic parameters analyzed occurred at concentrations below laboratory detection limits. Sediment analysis demonstrated that the Owens Corning/Newark landfills did not contribute heavy metal or organic chemical contaminants to the North Fork Licking River.

The condition of the fish and benthic macroinvertebrate communities at RM 2.5/2.8 (upstream landfills) were characterized as very good/good, fully attaining the designated WWH use. Both assemblages were diverse, well organized with sensitive taxa well represented. However, further downstream at RM 0.2, PARTIAL attainment of the WWH use designation was observed (Table 1). PARTIAL attainment was a result of fair performance of the benthic invertebrate community. The fish assemblage at this station was characterized as near exceptional, but the benthic invertebrates appeared to integrate modest nutrient inputs from CSOs within the lower reach. Based upon ambient biological samples collected between 1981-85, the biological conditions within the lower segment of the North Fork in 1993 have not changed significantly. Only the performance of the fish community has improved near the mouth at RM 0.2.

***Raccoon Creek***

Water column chemical samples were collected at three stations from Racoon Creek in 1993 between RM 11.7 (upstream Granville WWTP) and RM 0.35 (near the mouth). The primary objective of the sampling effort was to characterize the influence of the numerous CSOs from the Newark WWTP within Raccoon Creek. As a result, sediment and ambient biological sampling was limited to the lower segment, and included only two stations located at RM 5.8 (upstream of CSO influence) and RM 0.20/0.35. In addition, entity generated self monitoring data from Granville WWTP, Johnstown WWTP, and Owens Corning Co. was gathered to characterize gross trends in pollutant loadings within the subbasin.

The Granville WWTP has clearly reduced pollutant loading through improved treatment, with a marked improvement in all parameters measured after 1986. Pollutant loads from Owens Corning Co. appeared fairly stable and modest through the period of record; though some difficulties in maintaining compliance with the TSS limit have been identified. Corrective actions are currently under investigation. The Johnstown WWTP has steadily increased conduit flow (discharge) since the mid-1980s, and a commensurate (though modest) increase of pollutant loads have occurred. Compliance problems have been identified with ammonia-N and BOD limits.

Exceedences of WQ standards were limited to the fecal coliform counts in excess of the PCR criterion within Raccoon Creek during the 1993 sampling effort. Elevated levels of fecal bacteria were recorded at all three sampling stations on the same date in late June. It appeared as though the fecal coliform exceedences observed on Raccoon Creek were reflective of urban and agriculture nonpoint sources, and CSO influences commonly associated with high flow events. All other water chemistry parameters were found to occur at background levels, and no significant water quality impact was evident from Newark CSOs.

To evaluate the extent of sediment contamination within the the lower reach of Raccoon Creek, sediment samples were collected at two locations. Sediment analysis included selected heavy metals and semi-volatile organic compounds. Of the metal parameters, only arsenic was detected at a level ranked as elevated at RM 5.7 (upstream CSOs). This was likely reflective of background levels associated with past agricultural use of arsenic based pesticides, herbicides, and defoliants, and the level observed was well below the ER-M value. Organic chemical analysis indicated that the majority of organic parameters were found to occur at concentrations near or below laboratory detection limits. Two PAH compounds and several organochlorine pesticide residues were found at concentrations above laboratory detection limits at at RM 0.35 (downstream CSOs). However, ambient levels were quite low and were ranked as non-elevated and/or well below the ER-M values. Given the prevailing agricultural land use within Raccoon Creek subbasin, the occurrence of organochlorine pesticide residues within the sediments is likely related to past agricultural application of these persistent compounds. No impact associated with sediment metal or organic chemical contamination was evident within Raccoon Creek.

The condition of the fish and benthic macroinvertebrate communities encountered within Raccoon Creek were fully consistent with the WWH criteria, and FULL attainment of the WWH aquatic life use designation was observed at both 1993 sampling stations (Table 1). No significant biological impact was associated with the influence of the Newark WWTP CSOs. Based upon ambient biological samples collected in 1981, conditions within the lower segment of Raccoon Creek in 1993 have improved. In 1981 the segment under the influence of the Newark WWTP CSOs failed to support a fish assemblage consistent with the WWH criteria, and was considered to be in **NON** attainment of the WWH use designation. As stated above, in 1993 the resident biological assemblages within the same stream reach demonstrated considerable recovery, fully achieving the WWH biological criteria. Given the compliance and treatment irregularities of the Newark WWTP through the mid-1980s, it was likely that numerous CSOs on Raccoon Creek from Newark WWTP were considerably more active in 1981 than that observed in 1993.

***South Fork Licking River***

A total of 31.7 miles of the South Fork Licking River was assessed in 1993. The sampling effort included 32 chemical, physical and ambient biological sampling stations located between RM 31.6 (Cable Rd.) and RM 0.3 (Second St.). Based upon ambient biological performance the entire study area (31.7 miles) was considered to be in FULL attainment of the designated WWH aquatic life use. The majority of the sampling stations within the South Fork Licking River contained fish and macroinvertebrate communities characterized as near exceptional. The assemblages were generally diverse and well organized, with environmentally sensitive taxa well represented.

Four municipal WWTPs were evaluated during the 1993 field sampling effort: Pataskala, Buckeye Lake, Hebron, and Heath. No *significant* ambient biological or chemical impact was evident downstream of these facilities in 1993. The majority of the conventional discharge constituents from these treatment facilities have generally been reduced through the period of record as a result of treatment improvements. Only nitrate-N loads have increased significantly from Buckeye Lake WWTP, as a result of improved nitrification. This facility contributed the majority (86.9%) of nitrate-N loading to the South Fork Licking River. Ammonia-N loads from Hebron and Heath WWTPs have been recently reduced, however, erratic 95th percentile values indicated treatment irregularities, and the vast majority (87.9%) of ammonia-N loading to the South Fork Licking River is contributed by these two facilities.

Results from the ambient water chemistry data collected in 1993 indicated eleven exceedences of the primary contact fecal coliform criterion at nine stations between RM 24.6 and RM 0.35. Eight of the exceedences were associated with elevated stream flow and likely reflected inputs from CSOs, bypasses, as well as nonpoint sources. The remaining exceedences were not associated with elevated stream flows, and occurred downstream of the Buckeye Lake WWTP (RM 12.9), downstream of the Heath WWTP (RM 1.9), and near the mouth (RM 0.35). These exceedences were likely attributable to variable effluent quality and possible modest dry flow CSOs. Ammonia-N concentrations in excess of the chronic WWH criterion were encountered at four stations within the lower portion of the South Fork (downstream of Buckeye Lake WWTP to the confluence). All of the exceedences appeared associated with waste treatment facilities, however, two samples were collected during elevated stream flows and possibly were reflective of CSOs, bypasses, nonpoint sources, or treatment disruption associated with increased influent from surface runoff. The remaining ammonia-N exceedences were detected downstream of the Buckeye Lake WWTP and the Hebron WWTP (Beaver Run) and were attributed to variable effluent quality. Other nutrient parameters (BOD, total phosphorus, TSS, and nitrate-N) generally increased longitudinally, with marked increases noted downstream of the Buckeye Lake, Hebron, and Heath WWTPs. Despite fairly distinct nutrient inputs, oxygen demanding wastes appeared rapidly assimilated downstream and adequate dissolved oxygen concentrations were generally maintained within the South Fork Licking River. However, dissolved oxygen levels were diminished (though typically above WQ standards during the summer sampling effort) downstream of the Buckeye Lake WWTP, and included one exceedence of the WWH minimum D.O. criterion at RM 11.6. The Buckeye Lake WWTP discharges into a highly channel modified, low gradient segment of the South Fork. The assimilation of nutrient loads (particularly nitrate-N) from the Buckeye Lake WWTP may have been limited by the low gradient, highly modified character of this reach. The discharge of oxygen demanding wastes from Buckeye Lake WWTP coupled with the reduced assimilative capacity of the modified segment resulted in the lower mean D.O. values, and the single exceedence observed. Though WQ criteria exceedences of common chemical parameters were observed within the South Fork during the summer of 1993, the frequency and magnitude were modest, and did not appear to indicate a significant impact to the chemical integrity of the water column.

Sediment samples were collected at four stations on the South Fork Licking River, located between RM 31.5 (Cable Rd.) and RM 4.7 (Irving Wick Rd.). Analysis included selected heavy metal and organic chemical parameters. Nearly all metal parameters were ranked as either non or slightly elevated. Only zinc and iron were found at elevated concentrations. The elevated concentration of iron occurred at RM 31.5, and most likely was reflective of natural background levels. The elevated concentration of zinc occurred at RM 12.9 (downstream Buckeye Lake WWTP). The source of the zinc contamination is unclear at this time. The concentration observed may have been related to the low gradient character of the South Fork Licking River between RM 18.9 and RM 11.7. Due to low gradient and a highly modified channel, portions of this reach contained considerable deposits of clayey silts. Contaminants bound to the exchange complex of colloidal clays would likely accumulate through increased deposition of bedload and suspended sediments.

As a result, sediment samples collected within depositional areas would contain a high percentage of clayey silts (a greater potential to bind cations), and thus may contain concentrations of cation in excess of background levels. Regardless, the concentration of zinc was well below the ER-M values, and no impact associated with sediment metal contamination was evident. Results from the sediment organic analysis indicated that the majority of the organic chemical parameters occurred at concentrations at or near laboratory detection limits. One PAH (Benzo (A) Pyrene) and several organochlorine pesticide residues were found at levels above the detection limits. The level of contamination appeared modest (only slightly above the detection limit) and localized, occurring at RM 5.7 only (upstream Ramp Creek). Given the prevailing agricultural land use within the South Fork Licking River basin, the occurrence of chlorinated pesticide residues was not unexpected, and was most likely related to past agricultural application of these environmentally persistent compounds. The concentrations observed were ranked as non-elevated and were well below ER-M values.

Historical ambient chemical data were employed to analyze changes in environmental conditions through time within the South Fork Licking River. The most comprehensive historical chemical data set was collected in 1984 and included the upper and middle segments (RM 30.75 to RM 12.7). In comparison with the results from the 1984 survey (within a similar reach) the 1993 data indicatedlittle change in water quality. Only the segment under the influence of the Pataskala WWTP demonstrated notable improvements. In 1984, ambient nutrient levels were clearly elevated, and D.O. concentrations were markedly reduced downstream of the Pataskala WWTP. After extensive treatment upgrades in 1992, nutrient concentrations were reduced to background levels and D.O. levels were considerably improved. Within the remaining portions of the upper and middle portions of the South Fork, concentrations of conventional chemical parameters appeared comparable and fairly stable, both longitudinally as well as through time.

Ambient biological data were available from 1981 and 1984. The 1981 sampling effort included the stream reach between RM 7.2 and RM 0.9, while the 1984 effort included the reach between RM 31.5 and RM 12.7. For the purpose of trends analysis, the coverage provided by the combined 1981 and 1984 study areas was similar in size to that of the entire 1993 study area; allowing an evaluation of longitudinal biological performance (through time) within the majority of the South Fork Licking River. Between 1981-84, 15 river miles (47.3 %) were considered to be in FULL attainment, 10.4 mile (32.7%) were in PARTIAL attainment, and 6.3 miles (20.0%) were in **NON** attainment of the designated WWH aquatic life use. Results from the 1993 survey indicated considerable biological improvement throughout the entire South Fork study area, with 100% (31.7 miles) of the miles evaluated in FULL attainment of the WWH use designation (Table 1). The most significant area of biological recovery was observed within the reach extending downstream from the Hebron WWTP to the mouth. In 1981, the biological condition of the fish and benthic macroinvertebrate communities within this segment were generally characterized as fair. In 1993, environmental conditions improved to such an extent, that the lower reach of the South Fork supported fish and benthic invertebrate assemblages performing at an exceptional (EWH) level. The improved environmental conditions observed within this segment, as well as the remaining portions of the South Fork Licking River were commensurate with the general trend of reduced pollutant loadings (*i.e.* improved treatment) within the subbasin.

*Entity Specific Summaries for the South Fork Licking River*

Pataskala WWTP

The Pataskala WWTP was constructed to replace the previous facultative lagoon based waste treatment, and became fully operational in May, 1992. The current facility has a designed flow capacity of 0.80 MGD (million gallons per day). Prior to the treatment improvements, the contribution of conventional pollutant loads from the Pataskala WWTP appeared erratic, despite fairly stable conduit flow. The variability was reflective of the simple (lagoon based) treatment process. After 1992, loading of BOD, ammonia-N, and TSS were reduced. Ambient chemical and biological data gathered during the 1993 sampling effort indicated no discernible impact from the Pataskala WWTP. Within the reach under the influence of the Pataskala WWTP, conventional nutrient levels were near background levels, dissolved oxygen concentration were well above WQ standards, and the condition of the fish and benthic macroinvertebrate assemblages indicated full attainment of the designated WWH use (Table 1).

Buckeye Lake

The Buckeye Lake WWTP currently discharges directly to the South Fork Licking River at RM 14.2. Formerly, this facility discharged to Waste Weir Run which confluenced with the South Fork at RM 12.8. Monthly operating reports revealed no significant history of permit violations, though recent problems have been identified with the seepage receiving station and the sludge digesters, which are currently under investigation. Since 1979, third quarter 50th percentile loadings of BOD and TSS have significantly decreased. Given fairly stable conduit flows, recent elevated 95th percentile values suggested possible treatment irregularities. Ammonia-N and nitrate-N were not monitored until 1987, and since that time third quarter ammonia-N loadings appeared modest and stable. Nitrate-N loads however, demonstrated a recent increase with more effective nitrification within the treatment process. A bioassay screening performed on the Buckeye Lake WWTP in May, 1993 revealed acute toxicity. A follow-up test performed in September, 1993 indicated no acute toxicity from the effluent sample. These results appeared consistent with the recent variable pollutant loads, and suggested variable effluent quality.

Ambient nutrient levels in 1993 downstream of the Buckeye Lake WWTP appeared reflective of the relative contribution of conventional pollutants from this facility within the South Fork Licking River. The Buckeye Lake WWTP discharges approximately 39.1% of the TSS and 86.9% of the nitrate-N loads within this subbasin, and a distinct input of these parameters, as well as total phosphorus and BOD were evident downstream of this facility in 1993. An extremely elevated concentration of ammonia-N (19.5 mg/l) was detected from an effluent sample collected during mid-August. On the same date ambient water samples revealed exceedences of the chronic criterion for ammonia-N, and fecal coliform PCR standard downstream of the facility at RM 12.96. Mean dissolved oxygen concentrations downstream of the Buckeye Lake WWTP demonstrated a marked decline. Despite diminished concentrations, adequate dissolved oxygen levels were generally maintained, though one value below the minimum WWH criterion was recorded at RM 11.63 during mid-August. An additional fecal coliform exceedence was recorded within the reach under the influence of Buckeye Lake WWTP, however, the sample was collected during a period of elevated stream flow and was likely reflective of diffuse nonpoint sources and/or treatment disruption associated with increased influent resulting from elevated surface runoff.

The effect of nutrient inputs from the Buckeye Lake WWTP may have been exacerbated by the low gradient, highly modified character of the South Fork Licking River surrounding the discharge point. Typically the South Fork contained numerous riffle/run/pool complexes and an abundance of coarse substrate. Swift stream flow (higher gradient), frequent agitation and ample substrates would maintain an assimilative capacity much greater than that of the highly modified and silted reach found between RM 18.9 and RM 11.7. Though adequate D.O. was generally maintained, a fairly distinct D.O. *sag* was evident within and downstream of the channelized reach. The discharge of oxygen demanding wastes from the Buckeye Lake WWTP coupled with the reduced assimilative capacity of the modified segment likely resulted in the lower mean D.O. values observed.

Ambient biological performance (fish and benthic macroinvertebrate communities) downstream of Buckeye Lake WWTP demonstrated a marked decline. The condition of the fish and benthic invertebrate assemblages were characterized as near exceptional upstream of the treatment facility, and declined to a marginally good/good level downstream at RM 13.1/13.0. Despite the diminished conditions recorded downstream of the Buckeye Lake WWTP, biological performance met the minimum WWH criteria, and FULL attainment of the WWH use designation was observed (Table 1). The performance of the fish and invertebrate communities appeared to integrate both the simple and highly modified condition of the physical habitat at RM 13.1/13.0, as well as the chemical impact to the water column associated with Buckeye Lake WWTP.

Hebron WWTP

The Hebron WWTP discharges to the South Fork Licking River via Beaver Run, which confluences with the South Fork at RM 9.0. The WWTP process was upgraded in the summer of 1990, with a designed flow capacity of 0.675 MGD. Despite a 1993 average third quarter conduit flow of 0.43 MGD (approximately 60% of current capacity) treatment irregularities were evidenced in the compliance records. Violations of the zinc, cadmium, and mercury limits have been recorded, as well as recent erratic (highly elevated 95th percentile) third quarter loadings of ammonia-N, and TSS. In addition, septic conditions were observed by Ohio EPA staff during the summer of 1993 in Beaver Run as a result of the discharge of untreated sewage. A review of chronic and acute bioassays generated by the Hebron WWTP between September, 1991 and August 1992 indicated acute toxicity in only one of six tests. Chronic toxicity was observed in three of the four tests. The recent treatment irregularities appeared related to industrial entities serviced by the Hebron WWTP. Forty percent of the Hebron WWTP influent are from industrial sources. It is likely that poorly treated or erratic industrial loadings to this facility periodically limited the ability of the Hebron WWTP to provide consistent and effective waste treatment.

Ambient nutrient levels in 1993 downstream of the Hebron WWTP appeared reflective of the relative contribution of conventional pollutants from this facility within the South Fork Licking River. The Hebron WWTP discharges approximately 39.8% of the TSS and 46.2% of the ammonia-N (the majority of these parameters) total loads within this subbasin, and a distinct input of these parameters was evident downstream of this facility in 1993. Within the reach under the influence of the Hebron WWTP, one exceedence of the criterion for the prevention of chronic toxicity for ammonia-N, and two exceedences of the PCR fecal coliform criterion were recorded. The fecal bacteria exceedences were recorded at two stations downstream of the Hebron WWTP on the same date in mid-July. Stream flows during this time were elevated within the South Fork and the fecal coliform levels observed were likely reflective of diffuse nonpoint sources and/or treatment disruption associated with increased surface runoff. The ammonia-N exceedence was recorded during normal stream flows and apparently reflected inadequate treatment.

Despite the recent history of compliance problems (*e.g.* chronic toxicity, industrial pretreatment issues, and WQ exceedences) the results from the 1993 field efforts indicated no *significant* ambient chemical or biological impact to the South Fork Licking River from the Hebron WWTP. Though nutrient inputs were evident from this facility, wastes appeared to be assimilated and or diluted downstream. Adequate dissolved oxygen levels were maintained downstream from the Hebron WWTP, and were comparable with upstream values. The ambient biological performance (fish and benthic macroinvertebrate communities) both up and downstream of the Hebron WWTP was characterized as near exceptional (EWH), with community and habitat indices from each station achieving nearly identical values (Table 1). The condition of the fish and benthic invertebrate assemblages downstream of the Hebron WWTP were reflective of macrohabitat and ecoregional expectations, indicating FULL attainment of the WWH aquatic life use designation. No adverse effect associated with the Hebron WWTP was evident within the resident biological assemblages.

<u>Heath WWTP</u>
The Heath WWTP discharges directly to the South Fork Licking River at RM 2.2. The facility was constructed in 1961 and expanded to its present size in 1971. As a result of numerous permit violations during the mid-1980s, the Heath WWTP process was upgraded in 1990 and 1993. Effluent quality has fluctuated considerably since 1979. After the recent treatment ugrades, loadings of $BOD_,$ nitrate-N, and TSS decreased, but ammonia-N loads have increased. The shift in ammonia-N loadings likely indicated problems with the nitrification process, given a fairly stable third quarter conduit flow. The Heath WWTP effluent failed two of three acute toxicity tests conducted in 1986. After significant treatment ugrades, the entity conducted two chronic bioassays during November, 1991 and March, 1992, and six acute bioassays between October, 1991 and May, 1992. The results indicated that an acceptable level of chronic toxicity was observed for all tests (*i.e*. $TU_C$ values were less than the 1.0 trigger). Acute bioassays conducted in April and September 1993 by Ohio EPA generated mixed results, and suggested variable effluent quality. One hundred percent mortality to *Ceriodaphnia* was observed in the one of the tests, while the other effluent and composite samples did not cause any adverse effects to either test organism.

Ambient nutrient levels in 1993 downstream of the Heath WWTP appeared reflective of the relative contribution of conventional pollutants from this facility within the South Fork Licking River. The Heath WWTP discharges approximately 41.7% of the total ammonia-N load within this subbasin. A distinct increase in the concentration of ammonia-N was evident downstream of this facility in 1993, and included two exceedences of the criterion for the prevention of chronic toxicity at two sampling stations. Additionally, three exceedences of the fecal coliform primary contact criterion were recorded at two stations downstream of the Heath WWTP. Both of the ammonia-N and one of the fecal coliform exceedences occurred during periods of elevated stream flow and were likely reflective of diffuse nonpoint sources and/or treatment disruption associated with increased influent resulting from elevated surface runoff. Though nutrient inputs were evident from this facility, wastes appeared to be assimilated and or diluted downstream, and adequate dissolved oxygen levels were maintained.

Ambient biological performance (fish and benthic macroinvertebrate communities) downstream of The Heath WWTP was characterized as near exceptional (EWH), within both the mixing zone and further downstream (Table 1). The condition of the fish and benthic invertebrate assemblages were reflective of available macrohabitats and ecoregional expectations, indicating FULL attainment of the WWH use designation. No adverse effect associated with the Hebron WWTP was evident within the resident biological assemblages.

***Ramp Creek***

Ambient biological, water column chemical, and sediment sampling was conducted at four stations between RM 2.0 (Heath Boundary Rd.) and RM 0.1 (near mouth) within Ramp Creek. The primary objective was to evaluate the influence of Koppers Co., the Newark Air Force Base, Kaiser Aluminum Co., and the Union Oil/Ashland Petroleum.

Results from the water chemistry analysis indicated no exceedences of water standards within Ramp Creek study area. Sediment analysis indicated that nearly all metal parameters were ranked as non or slightly elevated. Only arsenic was found to occur at a concentration ranked as elevated at RM 1.32 (downstream Kopper Co.). The arsenic contamination observed (as with other areas within the Licking River study area) was likely an artifact of past agricultural use of arsenic based pesticides, herbicides, and defoliants.

Organic chemical contamination appeared modest, with most parameters occurring near or below laboratory detection limits. Four PAH compounds were detected at RM 0.7 (downstream Kaiser Aluminum Co.). Petroleum laden seepage from the north stream bank of Ramp Creek and oil contaminated sediments were observed at RM 0.7 by Ohio EPA field staff during the 1993 summer sampling effort. This station was located within the ground water plume (near the western margin) emanating from the Union Oil/Ashland Petroleum facility. Though Kaiser Aluminum did contribute oil and grease loads to Ramp Creek during the third quarter, 1993; oil contamination was not apparent within the Kaiser Aluminum mixing zone or from the Kaiser landfill (south stream bank). Consequently, Kaiser Aluminum did not appear to be the source of the petroleum-PAH contamination, rather contaminated seepage from the Union Oil/Ashland Petroleum complexe appeared a more probable source. Additional contaminants detected at RM 0.7 included several organochlorine pesticide residues. As with pesticide residues encountered at other locations within the Licking River study area, the contamination observed within Ramp Creek were most likely related to past application of these environmentally persistent compounds.

The performance of the fish and benthic macroinvertebrate assemblages indicated FULL attainment of the designated WWH aquatic life use for 85% (1.7 miles) of the Ramp Creek study area, while PARTIAL attainment was observed for 15% (0.3 miles) of the two mile reach evaluated. The condition of the fish community at all four sampling stations was characterized as exceptional. The fish assemblages were diverse and well organized, fully reflective of available macrohabitats and ecoregional expectations. The area of PARTIAL attainment was limited to RM 0.7 (downstream Kaiser Aluminum), and was a result of failure of the benthic invertebrate community to perform at a level consistent with WWH biological criteria. The degraded condition of the benthic invertebrate assemblage encountered at RM 0.7 appeared reflective of the impact of petroleum contaminated seepage from the Union Oil/Ashland Petroleum facility. As noted above, during the collection of biological samples Ohio EPA field staff observed that the sediments at RM 0.7 were contaminated with petroleum. The impact observed at RM 0.7 was highly localized, with rapid biological recovery further downstream, where the benthic invertebrate community again performed at a level consistent with WWH biological criteria.

***Selected Tributaries***

Ambient biological sampling was conducted in four headwater streams within the Licking River basin: Big Run (tributary of the Licking River mainstem), Lobdell Creek (tributary of Raccoon Creek), Vance Creek and Sycamore Creek (tributaries of the North Fork Licking River).

The 1993 sampling effort on Big Run included one station, located at RM 5.0/5.1 (Prior Rd.). Based on the performance of the resident biological assemblages, **NON** attainment of the designated WWH use designation was observed (Table 1). The diminished condition of the fish and benthic invertebrate communities was a result of depauperate stream habitat. FULL attainment of the WWH use designation was observed in Vance Creek (RM 0.7), Sycamore Creek (RM 0.1), and Lobdell Creek (RM 1.6 and RM 0.2).

## Conclusions

*Licking River (mainstem)*

- As a result of treatment process upgrades to the Newark WWTP and an aggressive implementation of pretreatment requirements for entities contributing influent loads, significant improvements in the environmental conditions of the Licking River mainstem were documented in 1993. Discharge constituents as well as ambient nutrient concentrations have been reduced substantially since the mid-1980s, with meaningful water quality improvements evident. Additionally, a basin wide trend of reduced pollutant loadings undoubtedly contributed to improved water quality within the Licking River mainstem.

- The resident biological assemblages demonstrated complete recovery from the degraded conditions observed in 1981, achieving a near exceptional level of performance at the majority of the sampling stations in 1993. The fish and benthic macroinvertebrate communities appeared fully reflective of available macrohabitats and ecoregional expectations.

- Only modest impairment of the WWH aquatic life use designation was observed immediately downstream of the Dillon reservoir spillway. The benthic invertebrate community appeared adversely affected by hypolimnetic withdrawal from the Dillon dam pool. The impact was modest and highly localized, evidenced by rapid biological recovery further downstream.

*North Fork Licking River*

- No chemical, physical or ambient biological impact to the North Fork Licking River was evident from Owens Corning/City of Newark Landfills. Water column and sediment analysis did not indicate off-site contamination from the landfill complex. The fish assemblage maintained a comparable level of performance both up and downstream of the landfills, however, the benthic invertebrate community demonstrated a marked decline downstream. The condition of the invertebrate community appeared reflective of a modest CSO influence, and did not suggest an impact from the landfills situated upstream.

*South Fork Licking River*

- No *significant* impact was evident downstream of the Pataskala, Buckeye Lake, Hebron, or Heath WWTPs in 1993. The chemical integrity of the water column appeared intact, and ambient biological conditions indicated FULL attainment of the designated WWH aquatic life use throughout the entire South Fork Licking River study area.

- Comparisons of the 1993 biological results with those from previous surveys in 1981, 1984, and 1988 revealed substantial improvement of environmental conditions within the lower 7-8 miles of the South Fork. This improvement appeared commensurate with the aggregate reductions in mass loadings from WWTPs discharging within the South Fork subbbasin, and represented complete recovery from the degraded conditions documented in previous studies.

- Though FULL attainment of the aquatic life use designation was observed downstream of the Buckeye Lake WWTP a conspicuous decline in community performance was evident. The condition of the fish and benthic invertebrate assemblages appeared to integrate both the influence of immoderate nutrient loadings (particularly nitrate-N) as well as the physically depauperate, highly modified character of the South Fork surrounding the Buckeye Lake WWTP discharge. As a result of treatment improvements, it was apparent that Buckeye Lake WWTP has achieved highly effective nitrification, with less than 0.05% ammonia-N loads to the South Fork originating from this facility. However, nitrate-N loads have significantly increased and the WWTP now contributes 86.9% of total nitrate-N loads to the South Fork Licking River. The assimilation and/or dilution of oxygen demanding wastes appeared greatly limited by the low gradient, physically simplified stream conditions observed between RM 18.9 and RM 11.7. Consequently, dissolved oxygen concentrations were reduced, and ambient biological conditions were diminished.

- These results clearly demonstrated the importance of natural riverine conditions (*e.g.* a sinuous, naturally developed channel and mature wooded riparian corridor) in providing *both* the complement of macrohabitats required to support and maintain aquatic communities, as well as maintaining the natural ability of stream systems to assimilate nutrient inputs with minimal environmental disturbance. If the physical conditions of the the South Fork within this modified reach were comparable to the general high quality conditions observed within the majority of the subbasin, the effects of immoderate nutrient loads would have likely been lessened.

- Despite the recent history of compliance problems the results from the 1993 sampling efforts indicated no *significant* ambient chemical or biological impact to the South Fork Licking River from the Hebron or Heath WWTPs. However, treatment upsets as evidenced by variable effluent performance from both the Hebron and Heath WWTPs may pose a risk to the maintenance of the high quality environmental conditions now present within the lower 7-8 miles of the South Fork Licking River.

*Ramp Creek*

- No chemical or biological impact downstream from the Newark Air Force Base landfill, Kopper Co., or Kaiser Aluminum Co. was evident in 1993. Three of the four biological sampling sampling stations supported fish and benthic macroinvertebrate communities fully consistent with the WWH aquatic life use designation. Impairment of the aquatic life use was observed at RM 0.7 only. The impact appeared related to petroleum contaminated seepage from the Union Oil/Ashland Petroleum facility. The impact was modest and localized, evidence by rapid biological recovery downstream.

*Raccoon Creek*

- No significant impact to the lower portion of Raccoon Creek was evident from the Newark WWTP CSOs. The fish and benthic macroinvertebrate communities upstream and within the area influenced by CSOs, fully attained the WWH designated aquatic life use. Based on historical ambient biological sampling, conditions have improved within the lower reach of Raccoon Creek. The improvements appeared commensurate with improved operations at the Newark WWTP (*i.e.* reduced CSO bypassing), as well as a general trend of reduced pollutant loadings from permitted dischargers within the Raccoon Creek subbasin.

## 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. This study represents a first use of this type of biological data to evaluate and establish aquatic life use designations. 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.

- All of the rivers and streams evaluated within the 1993 Licking River study area are recommended to retain the current WWH aquatic life use designation.

*Status of Non-Aquatic Life Uses*

- Currently, the Licking River mainstem, the North Fork Licking River, Raccoon Creek, the South Fork Licking River, and other selected tributaries evaluated as part of this study are designated for Primary Contact Recreational (PCR), Agricultural and Industrial Water Supplies. Based upon the findings of this investigation, these use designations appeared appropriate and should be retained.

*Future Monitoring Needs*

- A complete reevaluation of the Licking River study area should be conducted in 1998 or 2003 as provided in the Five Year Monitoring Basin Approach to monitoring and NPDES permit reissuance.

- Given limited sampling resources, the influence of the Hebron WWTP was only assessed on the South Fork Licking River. The ambient biological and chemical conditions of Beaver Run (the receiving water body for Hebron WWTP effluent) were not investigated in 1993. No impact was discernible downstream of the confluence of Beaver Run within the South Fork Licking River, though septic conditions were observed within Beaver Run as a result of the discharge of untreated sewage. The environmental conditions of Beaver Run should be investigated as soon as resources are available, to identify and characterize the influence of the Hebron WWTP on this water body.

*Other Recommendations*

- The ability of the channel modified segment downstream of the Buckeye Lake WWTP to assimilate nutrient loads, with minimal environmental disturbance, appeared in jeopardy. The information gathered in 1993 suggested that additional nutrient loads would likely exceed the assimilative capacity of this reach, resulting in localized impairment of the WWH use designation within the South Fork Licking River. Careful consideration must be given to any expansion of the Buckeye Lake WWTP waste load allocation.

- Treatment irregularities and variable effluent quality from the Hebron WWTP appeared related to poorly managed industrial influent loadings. The city of Hebron should develop and aggressively implement an industrial pretreatment program for entities serviced by the Hebron WWTP.

**Study Area**

- The Licking River watershed includes 779 miles$^2$, and is the fourth largest direct tributary to the Muskingum River. The Licking River basin drains the majority of Licking county and portions of Knox, Fairfield, Perry, and Muskingum counties, Ohio. The mainstem of the Licking River is 30.2 miles in length (48.6 Km) and formed by the confluence of the North and South Forks of the Licking River. Four major subbasin comprise the majority of the Licking River watershed and include the North Fork Licking River, Rocky Fork Licking River, South Fork Licking River, and Raccoon Creek (Figure 1). Additional stream characteristics and identified pollution sources evaluated within the 1993 Licking River study area listed in Table 2. The location of all chemical, physical, and biological sampling stations within the study area may be found in Table 3.

- The Licking River basin drains portions of three Ohio Ecoregions (Omernick and Gallant 1988); the Eastern Corn Belt Plain (ECBP), the Erie Ontario Lake Plain (EOLP), and the Western Allegheny Plateau (WAP). The ECBP and the EOLP ecoregions represent the glaciated portion of the watershed, characterized by gently rolling till plains with modest relief. Agriculture is the predominant land use within these regions. The WAP represents the unglaciated portion of the watershed. The physiography of this region consists of a dissected plateau comprised of horizontally bedded sandstone, siltstone, shale, and limestone, and is characterized by steeper, more rugged terrain than other ecoregions within the Ohio (Whittier *et al.* 1987). Given the generally poor condition of the soils and the highly dissected relief, agriculture is not as prevalent within the WAP as other ecoregions within the Ohio (Whittier *et al.* 1987).

- The segment of the Licking River mainstem impounded by Dillon Reservoir (RM 12.7-RM 6.2), and the stream reach that flows through Blackhand Gorge State Nature Preserve (RM 23.9-RM 19.0) are currently designated State Resource Waters (SRW). The remaining segments of the Licking River mainstem and all other water bodies within the 1993 study area are currently classified as WWH. Water supply use designations of agricultural and industrial, and the recreation use designation of primary contact apply to all water bodies within the study area.

- Dillon Lake Reservoir is located in the eastern portion of Muskingum county and was constructed on the Licking River mainstem in 1962, to accommodate and manage flood flows. The spillway is located six miles upstream from the confluence with the Muskingum River and impounds approximately ten river miles. Results from both an Ohio EPA and U.S. Army Corps of Engineers study indicated modest PCB (total) contamination of the sediments within Dillon Lake. Polychlorinated biphenol concentrations within the sediments ranged between 0.185 and 2.01 ppm, and were determined to pose a minimum human health risk. The most significant impact to the Dillon Lake resource is the physical degradation associated with the accumulation of sediment. The Ohio EPA and SCS reported sedimentation rates of 300,000 to 500,000 tons per year. It is estimated that up to 18% of the reservoir capacity has been has been lost due to sediment accretion. Efforts to remediate the sediment problems include; plans to dredge up to 3 million cubic yards of sediment to improve navigation within the upper portions of the dam pool, as well as initiating erosion controls measures within the watershed upstream of the reservoir.

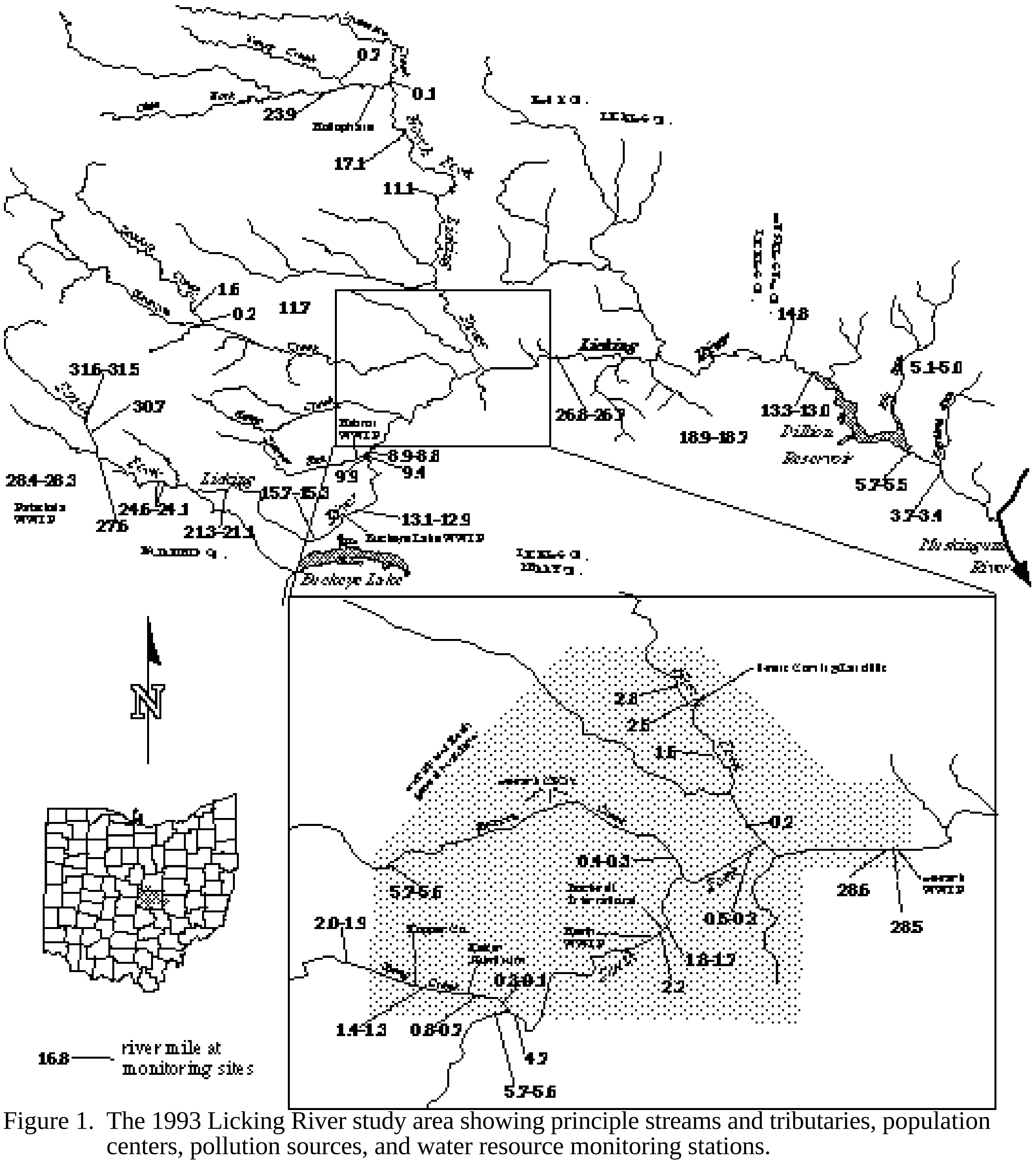


Figure 1. The 1993 Licking River study area showing principle streams and tributaries, population centers, pollution sources, and water resource monitoring stations.

Table 2. Stream characteristic and significant identified pollution sources within the 1993 Licking River study area (Ohio DNR 1960 and Ohio EPA 1992).

| Stream | Length (Miles) | Average Fall (Feet/Mile) | Drainage Area (Square Miles) | Nonpoint Sources Pollution Categories | Point Sources Evaluated |
|---|---|---|---|---|---|
| Licking River (mainstem) | | | | | |
| | 30.2 | 9.1 | 779.0 | Agriculture<br>Storm & Sanitary Sewers<br>Construction Sites<br>Oil & Gas Production<br>In Place Pollutants | Newark WWTP |
| Big Run | | | | | |
| | 9.7 | 18.6 | 24.0 | Agricultural<br>Urban Runoff<br>Channelization<br>Oil & Gas Production | N/A |
| North Fork Licking River | | | | | |
| | 38.4 | 12.7 | 239.0 | Agriculture<br>Sanitary Sewers<br>Coal Mining<br>Oil & Gas Production<br>On-site Septic System | Utica WWTP<br>Centerburg WWTP<br>OC/Newark Landfills<br>Newark CSOs |
| Vance Creek | | | | | |
| | 6.2 | 23.5 | 10.8 | Agriculture | N/A |
| Sycamore Creek | | | | | |
| | 14.1 | 19.9 | 28.9 | Agriculture<br>On-site Septic Systems | N/A |
| South Fork Licking River | | | | | |
| | 33.9 | 3.5 | 288.0 | Agriculture<br>Storm & Sanitary Sewers<br>Urban Runoff<br>Channelization<br>Stream Bank Modification<br>Bridge Construction<br>On-site Septic System | Pataskala WWTP<br>Buckeye Lake WWTP<br>Hebron WWTP<br>Heath WWTP<br>Newark CSOs |
| Ramp Creek | | | | | |
| | 8.4 | 28.7 | 17.4 | Urban Runoff<br>Oil & Gas Production<br>Landfill(s) | Kooper Co.<br>Kaiser Aluminum<br>Union/Ashland Oil<br>Newark Air Force Base |
| Raccoon Creek | | | | | |
| | 27.5 | 11.8 | 103.8 | Livestock<br>On-site Septic Systems | Newark CSOs<br>Granville WWTP<br>Johnstown WWTP<br>Owens Corning |
| Lobdell Creek | | | | | |
| | 12.1 | 20.2 | 18.4 | Livestock<br>Channelization | N/A |

Table 3. Sampling locations (water chemistry-C, sediment metal-SM, sediment organic-SO, macroinvertebrate sample-B, fish community-F, continuous monitors-D, effluent-E) within the 1993 Licking River study area.

| ***River/Stream*** River Mile | Sample Type | Latitude/Longitude | Landmark | USGS 7.5' Quad. |
|---|---|---|---|---|
| ***Licking River*** | | | | |
| 28.6 | (F,B,C,SM,SO, D) | 40˚03'08"/82˚22'52" | Ust. Newark WWTP | Hanover |
| 28.5 | (F,B,C) | 40˚03'09"/82˚21'42" | Newark WWTP (Mix Zone) | Hanover |
| 26.8 | (B,D) | 40˚03'33"/82˚20'16" | Stadden Rd. | Hanover |
| 26.7 | (C,SM) | 40˚03'33"/82˚20'23" | Stadden Rd. | Hanover |
| 26.6 | (F) | 40˚03'39"/82˚20'08" | Stadden Rd. | Hanover |
| 18.9 | (B,D) | 40˚03'27"/82˚13'12" | Toboso Rd. | Toboso |
| 18.7 | (F,C) | 40˚03'30"/82˚13'11" | Toboso Rd. | Toboso |
| 14.8 | (B) | 40˚03'44"/82˚10'34" | Dst. Hanby trib. | Toboso |
| 13.3 | (F) | 40˚03'30"/82˚09'20" | Adj. Hill Rd. | Toboso |
| 13.0 | (C) | 40˚02'52"/82˚09'20" | Adj. Hill Rd. | Toboso |
| 5.7 | (B) | 39˚59'22"/82˚04'30" | Dst. Dillon Reservoir | Zanesville West |
| 5.5 | (F,C,D) | 40˚59'20"/82˚04'14" | Dst. Dillon Reservoir | Zanesville West |
| 3.7 | (C) | 39˚58'14"/82˚05'24" | Dillon Falls Rd. | Zanesville West |
| 3.6 | (B) | 39˚58'14"/82˚03'24" | Dillon Falls Rd. | Zanesville West |
| 3.4 | (F) | 40˚58'08"/82˚03'22" | Dillon Falls Rd. | Zanesville West |
| ***Big Run*** | | | | |
| 5.1 | (B) | 40˚03'40"/82˚04'42" | Prior Rd. | Dresden |
| 5.0 | (F) | 40˚03'35"/82˚04'47" | Prior Rd. | Dresden |
| ***North Fork Licking River*** | | | | |
| 23.9 | (C) | 40˚15'14"/82˚30'29" | TR 70 | Homer |
| 17.1 | (C) | 40˚13'38"/82˚26'45" | Dst. Utica WWTP | Utica |
| 11.1 | (C) | 40˚10'44"/82˚25'14" | SR 13 | Utica |
| 2.8 | (B,C,SM,SO) | 40˚05'13"/82˚24'38" | Ust. OC/Newark Landfills | Newark |
| 2.5 | (F) | 40˚05'00"/82˚24'23" | Ust. OC/Newark Landfills | Newark |
| 1.6 | (C,SM,SO) | 40˚04'22"/82˚24'06" | Manning St. | Newark |
| 0.2 | (F,B,C,SO) | 40˚15'58"/82˚29'57" | Adj. Fleek Ave. | Newark |
| ***Vance Creek*** | | | | |
| 0.7 | (F,B) | 40˚15'58"/82˚29'57" | Beger Rd. | Hunt |
| ***Sycamore Creek*** | | | | |
| 0.1 | (F,B) | 40˚15'46"/82˚27'27" | near mouth | Hunt |

Table 3. continued.

| ***River/Stream*** River Mile | Sample Type | Latitude/Longitude | Landmark | USGS 7.5' Quad. |
|---|---|---|---|---|
| ***South Fork Licking River*** | | | | |
| 31.6 | (B) | 40˚01'28"/82˚41'20" | Cable Rd. | Jersey |
| 31.5 | (F,C,SM,SO) | 40˚01'26"/82˚41'19" | Cable Rd. | Jersey |
| 28.4 | (B) | 39˚59'21"/82˚40'17" | Ust. Pataskala WWTP. | Pataskala |
| 28.3 | (F) | 39˚59'20"/82˚40'15" | Ust. Pataskala WWTP | Pataskala |
| 27.6 | (F,B,C) | 39˚39'40"/82˚39'40" | Dst. Pataskala WWTP | Pataskala |
| 24.6 | (F,C) | 39˚58'04"/82˚37'34" | York Rd. | Pataskala |
| 24.1 | (B) | 39˚58'08"/82˚37'19" | York Rd. | Pataskala |
| 21.3 | (F) | 39˚57'45"/82˚34'53" | Gale Rd. | Millersport |
| 21.2 | (C) | 39˚57'45"/82˚34'48" | Gale Rd. | Millersport |
| 21.1 | (B) | 39˚57'45"/82˚34'43" | Gale Rd. | Millersport |
| 15.7 | (C) | 39˚55'38"/82˚31'19" | SR 79 | Millersport |
| 15.4 | (B) | 39˚55'33"/82˚30'44" | SR 79 | Millersport |
| 15.3 | (F) | 39˚55'34"/82˚30'35" | SR 79 | Millersport |
| 14.2 | (E) | 39˚56'11"/82˚29'40" | Buckeye Lake WWTP Effluent | Millersport |
| 13.1 | (F) | 39˚56'54"/82˚28'48" | SR 79 | Thornville |
| 13.0 | (B) | 39˚56'52"/82˚28'55" | SR 79 | Thornville |
| 12.9 | (C,SM,SO) | 39˚56'24"/82˚28'51" | SR 79 | Thornville |
| 11.6 | (C) | 39˚57'40"/82˚28'09" | US 40 | Thornville |
| 9.9 | (B) | 39˚59'18"/82˚28'31" | Ust. Beaver Run (Hebron) | Thornville |
| 9.4 | (F) | 39˚59'11"/82˚08'25" | Ust. Beaver Run (Hebron) | Thornville |
| 8.9 | (B) | 39˚58'46"/82˚28'46" | Dst. Beaver Run (Hebron) | Thornville |
| 8.8. | (F) | 39˚59'24"/82˚28'27" | Dst. Beaver Run (Hebron) | Thornville |
| 5.7 | (SM,SO) | 40˚04'01"/82˚26'59" | Ust. Ramp Creek | Newark |
| 5.6 | (C) | 40˚00'58"/82˚26'58" | Ust. Ramp Creek | Newark |
| 4.7 | (C,SM,SO) | 40˚00'57"/82˚26'20" | Irving Wick Rd. | Newark |
| 2.2 | (F,B,C) | 40˚02'05"/82˚24'45" | Heath WWTP (Mix Zone) | Newark |
| 1.8 | (C) | 40˚02'15"/82˚24'43" | Dst. Heath WWTP | Newark |
| 1.7 | (F,B) | 40˚02'23"/82˚24'51" | Dst. Heath WWTP | Newark |
| 1.4 | (C) | 40˚02'34"/82˚24'43" | Orchard St. | Newark |
| 0.5 | (F) | 40˚03'01"/82˚23'25" | Second St. | Newark |
| 0.4 | (B) | 40˚03'03"/82˚23'47" | Second St. | Newark |
| 0.3 | (C) | 40˚02'33"/82˚23'49" | Second St. | Newark |
| ***Ramp Creek*** | | | | |
| 2.0 | (F,B,SM,SO) | 40˚01'35"/82˚28'51" | Thornwood Rd. | Newark |
| 1.9 | (C) | 40˚01'34"/82˚28'49" | Thornwood Rd. | Newark |
| 1.4 | (F,B,C) | 40˚01'23"/82˚28'20" | Dst. Kopper Co. | Newark |
| 1.3 | (SM,SO) | 40˚01'18"/82˚28'11" | Dst. Kopper Co. | Newark |
| 0.8 | (C,SM,SO) | 40˚01'11"/82˚27'37" | Dst. Kaiser Aluminum | Newark |
| 0.7 | (F,B) | 40˚01'10"/82˚27'36" | Dst. Kaiser Aluminum | Newark |

Table 3. continued.

| ***River/Stream*** River Mile | Sample Type | Latitude/Longitude | Landmark | USGS 7.5' Quad. |
|---|---|---|---|---|
| ***Ramp Creek*** | | | | |
| 0.3 | (C) | 40˚01'08"/82˚27'05" | SR 79 | Newark |
| 0.1 | (F,B,SM,SO) | 40˚01'01"/82˚26'53" | Liberty St. | Newark |
| ***Raccoon Creek*** | | | | |
| 11.7 | (C) | 40˚04'08"/82˚33'07" | SR 161 | |
| 5.7 | (C,SM, SO) | 40˚02'52"/82˚28'30" | Cherry Valley Rd. | Newark |
| 5.6 | (F) | 40˚02'57"/82˚28'27" | Cherry Valley Rd. | Newark |
| 0.4 | (C,SM,SO) | 40˚03'02"/82˚24'41" | Adj. Raccoon Drive | Newark |
| 0.3 | (F,SM) | 40˚03'02"/82˚23'11" | Adj. Raccoon Drive | Newark |
| ***Lobdell Creek*** | | | | |
| 1.6 | (F) | 40˚06'10"/82˚35'53" | Upstream Landfill | Granville |
| 0.2 | (F) | 40˚05'13"/82˚35'32" | Raccoon Valley Rd. | Granville |

## METHODS

All chemical, physical, and biological field, laboratory, data processing, and data analysis methodologies 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 I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment. Chemical, physical and biological sampling locations are listed in Table 4.

### Determining Use Attainment Status

The attainment status of aquatic life uses (*i.e.*, FULL, PARTIAL, and **NON**) is determined by using the biological criteria codified in the Ohio Water Quality Standards (WQS; Ohio Administrative Code [OAC] 3745-1-07, Table 7-17). The biological community performance measures which are used include the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. The IBI and ICI are multimetric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984). The ICI was developed by Ohio EPA (1987b) and further described by DeShon (1994). The MIwb is a measure of fish community abundance and diversity using numbers and weight information and is a modification of the original Index of Well-Being originally applied to fish community information from the Wabash River (Gammon 1976; Gammon *et al.* 1981).

Performance expectations for the principal aquatic life uses in the Ohio WQS (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 the aquatic life use is FULL if all three indices (or those available) meet the applicable biocriteria, PARTIAL if at least one of the indices does not attain and performance at least fair, and **NON**-attainment if all indices fail to attain or any index indicates poor or very poor performance. Partial and non-attainment indicate that the receiving water is impaired and does not meet the designated use criteria specified by the Ohio WQS.

### Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1994). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of 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, as opposed to the characteristics of a single sampling site. As such, individual sites may have 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 greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

### Macroinvertebrate Community Assessment

Macroinvertebrates were sampled quantitatively using multiple-plate, artificial substrate samplers (modified Hester/Dendy) in conjunction with a qualitative assessment of the available natural substrates. During the present study, macroinvertebrates collected from the natural substrates were also evaluated using an assessment tool currently in the developmental phase. This method relies on tolerance values derived for each taxon, based upon the abundance data for that taxon from artificial substrate (quantitative) samples collected throughout Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected are weighted by its abundance on the artificial substrates. The mean of the weighted ICI scores for the taxon results in a value which represents its relative level of tolerance on the ICI's 0 to 60 scale. For the qualitative collections the median tolerance value of all organisms from a site resulted in a score termed the Qualitative Community Tolerance Value (QCTV). The QCTV shows potential as a method to supplement existing assessment methods using the natural substrate collections.

### Fish Community Assessment

Fish were sampled using wading or boat method pulsed DC electrofishing gear. The wading method was used at a frequency of one or two samples at each site. The boat method was used at a frequency of two or three samples at each site.

## Area of Degradation Value (ADV)

An Area Of Degradation Value (ADV; Rankin and Yoder 1991; Yoder and Rankin 1994) was calculated for the study area based on the longitudinal performance of the biological community indices. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, or ICI) departs from the applicable biocriterion or the upstream level of performance (Figure 2). The "magnitude" of impact refers to the vertical departure of each index below the biocriterion or the upstream level of performance. The total ADV is represented by the area beneath the biocriterion (or upstream level) when the results for each index are plotted against river mile. The results are also expressed as ADV/mile to normalize comparisons between segments and other streams and rivers.

## Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are the principal arbiter of aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria in the role of principal arbiter within a weight of evidence framework has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991a; Yoder 1994). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and the biological response signatures (Yoder and Rankin 1994) within the biological data itself. Thus the assignment of principal causes and sources of impairment in this report do not represent a true "cause and effect" analysis, but rather represent the association of impairments (based on response indicators) with stressor and exposure indicators whose links with the biosurvey data are based on previous research or experience with analogous situations and impacts. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified. The process is similar to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning patient health. Such diagnoses are based on previous research which experimentally or statistically linked symptoms and test results to specific diseases or pathologies. Thus a doctor relies on previous experience in interpreting symptoms (*i.e.*, multiple lines from test results) to establish a diagnosis, potential causes and/or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. As in medical science, where the ultimate arbiter of success is the eventual recovery and the well-being of the patient, the ultimate measure of success in water resource management is restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993) here we are referring to the process for identifying biological integrity and causes/sources associated with observed impairment, not whether human health and ecosystem health are analogous concepts.

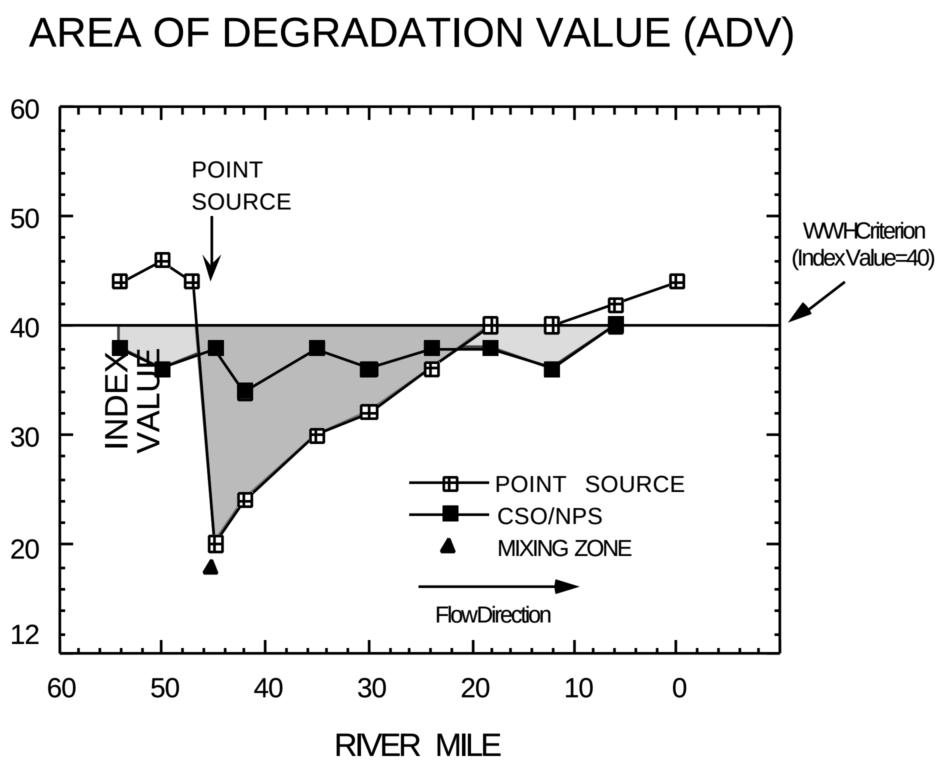


Figure 2. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and the solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears as a solid triangle); the filled boxes and dashed shading (area of departure) represents a typical response to a nonpoint source or combined sewer overflow impact. The blended shading represents the overlapping impact of the point and nonpoint sources.

## Results and Discussion

## Licking River (mainstem)

### *Pollutant Loadings*

- Monthly effluent loadings are reported to the Ohio EPA by all NPDES (National Pollution Discharge Elimination System) permitted discharging entities. Third quarter (July - September) Monthly Operating Report (MOR) data provided the quantity and character of pollutant loadings from 1976 through 1993 for each WWTP evaluated within the 1993 Licking River study area. Pollutant loading trends analysis included the 95th and 50th percentiles of five parameters where available: Ammonia-nitrogen ($NH_3$-N), Nitrate-nitrogen ($NO_3$-N), Five-day Biological Oxygen Demand ($BOD_5$), Total Suspended Solids (TSS), and Annual discharge (MGD).

**Newark WWTP**

- The Newark WWTP is an advanced secondary wastewater treatment facility with a design flow of 8.0 MGD (Million Gallons per Day). The effluent discharges to the Licking River at RM 28.55. The facility's basic processes includes screening, grit removal, primary treatment, advanced secondary treatment, and disinfection/dechlorination. The sewer system is authorized to discharge from 30 overflows and bypasses during extreme storm events when the flow exceeds system capacity. Overflow bypasses are located on the Licking River mainstem, North Fork Licking River, South Fork Licking, and Raccoon Creek in and around the city of Newark.

- The Newark WWTP is the only significant permitted point source discharger contributing conventional pollutant loads to the Licking River mainstem. The Newark WWTP has shown substantial decreases in pollutant loadings as a result of both improved pretreatment requirements and improvements to the waste treatment process. These actions were initiated to comply with the more stringent water quality standards defined by the Clean Water Act (CWA) amendments of 1984, and as a result of pervasive and severe pretreatment problems. The compliance history of the Newark WWTP revealed numerous permit violations between 1979 and 1983. The contribution of toxic materials (including phenols and formaldehyde) and shock loadings of BOD and ammonia to the waste stream periodically inhibited and/or eliminated effective waste treatment by the Newark WWTP during this time (Ohio EPA 1986). Due to excessive and poorly treated influent loadings during 1983, the Newark WWTP was out of compliance for nearly a year. The direct impact to the Licking River was evidenced by numerous documented fish kills between August and October, 1983.

- The Newark WWTP effluent quality has improved significantly based on loading trends over the past 18 years. Third quarter 95th and 50th percentile loading data exhibited noticeable decreases in mean $BOD_5$, TSS, and $NH_3$-N (Figure 3). Total Suspended Solids (TSS) and $BOD_5$ displayed a general increasing trend until the mid-1980s, after which a marked decrease was observed. Ammonia-nitrogen loadings displayed a general decreasing trend, and by 1989 were virtually eliminated through improved treatment. As expected, $NO_3$-N loadings increased commensurate with improved nitrification (Figure 3).

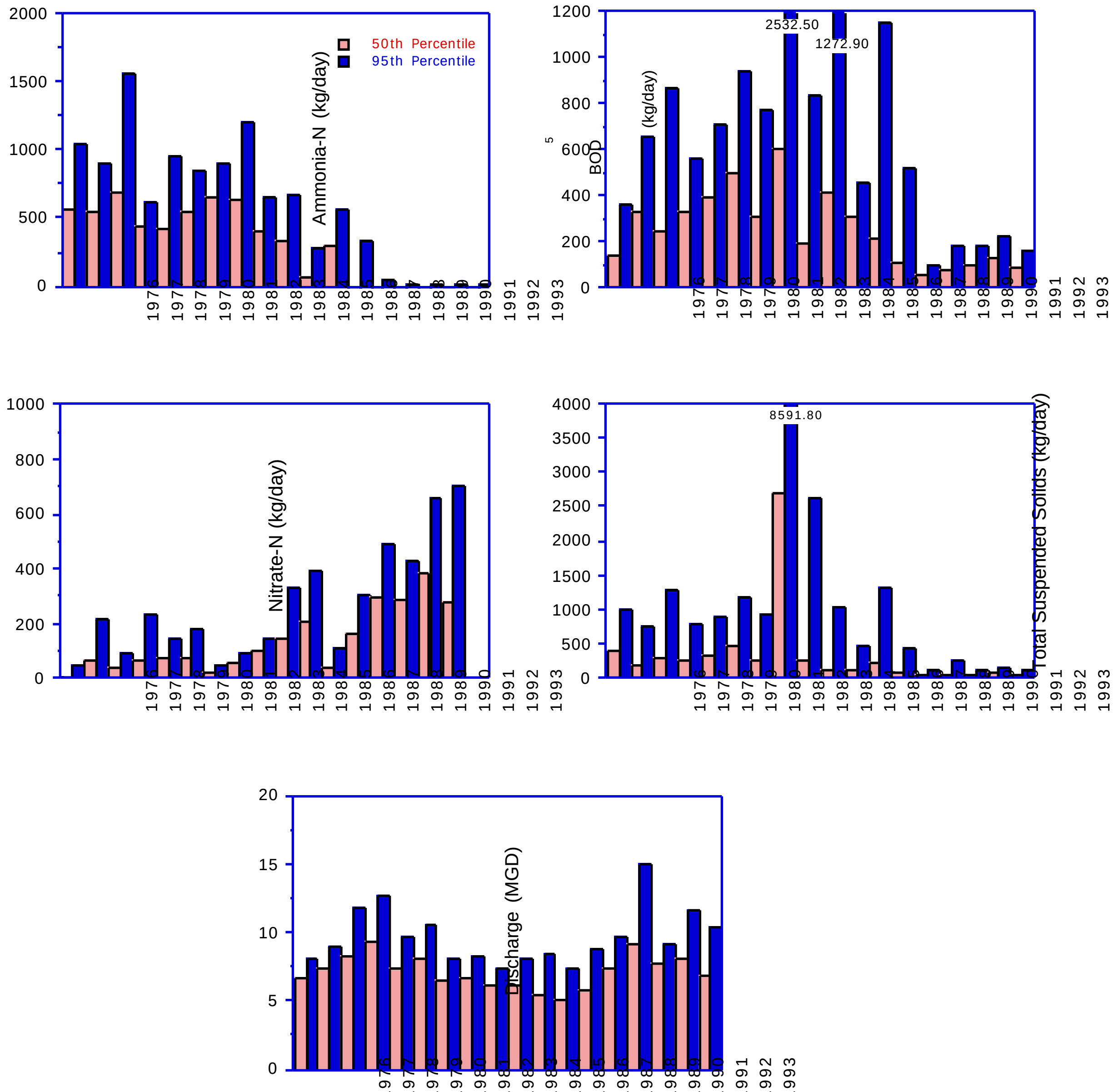


Figure 3. Annual third quarter 50th and 95th percentile of discharge (MGD) and pollutant loadings (kg/day) of ammonia-N, nitrate-N, $BOD_5$, and TSS from the Newark WWTP, 1976-1993.

- Based on flow data from a May 1992 Wasteload Allocation (WLA), toxic units of 1.1 TUa (acute toxic units) and 2.8 TUc (chronic toxic units) were calculated for the Newark WWTP. The entity conducted six chronic tests from August 1989 to November 1993 (Table 4). Results showed values of 1.4 TUc during three of these bioassays and <1.0 TUc for the other three. Additionally, Ohio EPA conducted two acute bioassays in April and September 1993. Both tests did not indicate significant mortality or adverse effects to either test organism in any of the effluent or instream samples.

Table 4. Chronic (TUc) toxicity data collected by the Newark WWTP.

| | *Ceriodapnia* | | | Fathead Minnow | | |
|---|---|---|---|---|---|---|
| | **Percent % Affected** | | TUc | **Percent % Affected** | | TUc |
| Date | Upst. | Far Field | Effluent | Upst. | Far field | Effluent |
| August 89 | 0 | - | <1.0 | 45 | - | <1.0 |
| September 92 | 0 | Reduct. | 1.4 | 32 | 23 | <1.0 |
| January 93 | 0 | 10 | 1.4 | 28 | 27 | 1.4 |
| April 93 | 10 | 0 | <1.0 | 22 | 12 | <1.0 |
| August 93 | 20 | 0 | 1.4 | 8 | 17 | <1.0 |
| November 93 | 10 | 0 | <1.0 | 10 | 24 | <1.0 |

***Chemical Water Quality***

- Replicate water column chemical grab samples were collected at eight stations within the Licking River mainstem during the 1993 sampling effort. Chemical sampling included six ambient, one mixing zone and one effluent sample. River flow data from the USGS gauge station located at RM 26.75 on the Licking River indicated elevated stream flows throughout most of the 1993 sampling effort (Figure 4). The mean daily flows were generally above the estimated 80% flow duration.

- Fecal coliform counts in excess of the PCR criterion were the only water quality exceedences encountered within the Licking River mainstem during the 1993 sampling effort (Table 5). Four exceedences of the fecal coliform criterion were encountered at four stations between RM 28.6 (upstream of Newark WWTP) and RM 13.0 (Hill Rd.). The majority of the fecal coliform exceedences appeared to be associated with elevated stream flow, and likely reflected inputs from CSOs, WWTP by-passes, flushed septic ditches, as well as agricultural or other diffuse sources.

- Water column chemical samples revealed nutrient inputs from the Newark WWTP. Total phosphorous, $NH_3$-N, and $NO_3$-N were elevated downstream of this facility (Figure 5). Nevertheless, adequate D.O. levels were maintained throughout the Licking River mainstem, and it appeared as though the nutrient inputs were rapidly assimilated. Downstream of Dillon Reservoir $NH_3$-N concentrations were again elevated in comparison with other stations within the Licking River mainstem. The increase in unionized ammonia was likely a result of

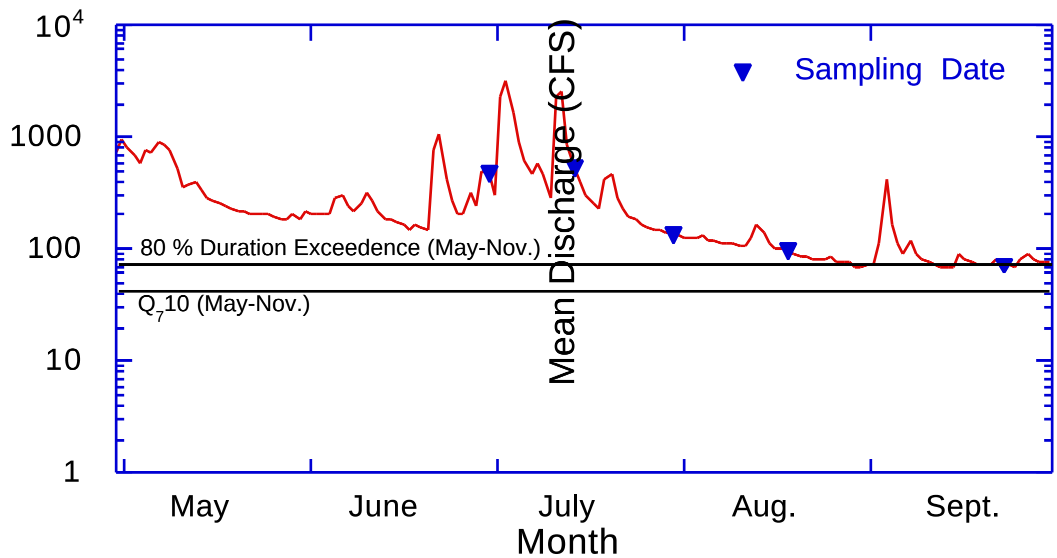


Figure 4. Flow hydrograph for the Licking River at Stadden Rd (RM 26.8), May through September 1993. May through November low flow conditions ($Q_7 10$ [42 cfs] and 80% duration flow [74 cfs] for the period of record are indicated on the hydrograph (USGS 1993 and USGS 1981).

hypolimnetic discharge from Dillon Reservoir. Thermal stratification of the water column during the summer months likely induced anoxia within the hypolimnion. In the absence of D.O., nitrogenous compounds would undergo ammonification. As a result, subsequent discharge of water from the hypolimnion contained elevated concentrations of $NH_3$-N.

- Diurnal dissolved oxygen, temperature, pH, and conductivity data were collected with Datasonde continuous sampling units during August, 1993, at four stations located at RM 28.65, RM 26.75, RM 18.87, and RM 3.9. The three stations between RM 28.65 (upstream Newark WWTP) and RM 18.87 (Toboso Rd.) displayed the typical D.O. and temperature fluctuations associated with diurnal photosynthetic and respiration rates (Figure 6). In contrast, the station located at RM 3.9 (downstream of Dillon Reservoir) did not display the expected oscillating patterns encountered at other stations within the Licking River mainstem. The diurnal D.O. and temperature values appeared inversely related (Figure 6). Dissolved oxygen concentrations collected between August 24-27 were low, with a mean value of 3.26 mg/l and a maximum of 4.02 mg/l. At RM 3.9 all datasonde D.O values were below the minimum average D.O. criterion of 5.0 mg/l, set forth in Ohio WQS. The inverse D.O. and temperature pattern and the low D.O. concentrations recorded at this station appeared related to hypolimnetic withdrawal (discharge) from Dillon Reservoir.

Table 5. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in the Licking River study area, 1993.

| Stream Name | River Mile | Date | Exceedence: Parameter (value) |
|---|---|---|---|
| ***Licking River (mainstem)*** | | | |
| | 28.65 | 9/21/93 | Fecal Coliform (52000[◊]) |
| | 26.75 | 6/29/93 | Fecal Coliform (9000[◊]) |
| | 18.87 | 6/29/93 | Fecal Coliform (5200[◊]) |
| | 13.00 | 7/12/93 | Fecal Coliform (4400[◊]) |
| | 47% (22 of 47) samples exceeded the iron criteria of 1.0 mg/l | | |
| ***North Fork Licking River*** | | | |
| | 17.10 | 7/13/93 | Fecal Coliform (4300[◊]) |
| | 11.13 | 7/13/93 | Fecal Coliform (3300[◊]) |
| | 2.82 | 7/13/93 | Fecal Coliform (3200[◊]) |
| | 1.64 | 7/13/93 | Fecal Coliform (2500[◊]) |
| | 0.20 | 9/21/93 | Fecal Coliform (2700[◊]) |
| | 39% (14 of 36) samples exceeded the iron criteria of 1.0 mg/l | | |
| ***South Fork Licking River*** | | | |
| | 24.60 | 7/13/93 | Fecal Coliform (2500[◊]) |
| | 21.24 | 7/13/93 | Fecal Coliform (3300[◊]) |
| | 15.75 | 7/13/93 | Fecal Coliform (3900[◊]) |
| | 14.20 (Effluent Sample) | 8/76/93 | Total Ammonia-N (19.50[‡‡]) |
| | 12.96 | 7/13/93 | Fecal Coliform (2300[◊]) |
| | | 8/17/93 | Fecal Coliform (25000[◊]) |
| | | | Total Ammonia-N (2.15[‡]) |
| | 11.63 | 8/18/93 | D.O. (3.65[†]) |
| | 8.88 | 7/13/93 | Fecal Coliform (2700[◊]) |
| | | 8/18/93 | Total Ammonia-N (2.28[‡]) |
| | 5.68 | 7/13/93 | Fecal Coliform (2800[◊]) |
| | 1.86 | 7/28/93 | Total Ammonia-N (0.65[‡]) |
| | | 9/22/93 | Fecal Coliform (42000[◊]) |
| | | 10/8/93 | Fecal Coliform (4700[◊]) |

Table 5. continued.

| Stream Name | River Mile | Date | Exceedence: Parameter (value) |
|---|---|---|---|
| ***South Fork Licking River*** | | | |
| | 1.45 | 7/28/93 | Total Ammonia-N (0.56‡) |
| | | | Fecal Coliform (8370◊) |
| | 0.35 | 9/22/93 | Fecal Coliform (4100◊) |
| | 42% (33 of 79) samples exceeded the iron criteria of 1.0 mg/l. | | |
| ***Raccoon Creek*** | | | |
| | 11.70 | 6/29/93 | Fecal Coliform (2400◊) |
| | 5.70 | 6/29/93 | Fecal Coliform (3800◊) |
| | 0.35 | 6/29/93 | Fecal Coliform (2200◊) |
| | 36% (5 of 14) samples exceeded the iron criteria of 1.0 mg/l. | | |

◊ -Exceeds numerical bacteriological criterion for primary contact waters (OAC chapter 3745-1, page 07-36).
† -Exceeds minimum outside mixing zone criterion for WWH (OAC chapter 3745-1 table 7-1, page 8).
‡ -Exceeds outside mixing zone total ammonia-N criterion based on temperature and pH (OAC chapter 3745-1 table 7-7, page 07-39).
‡‡ -Violates Buckeye Lake WWTP permit limitation (30 day and 7 day) for total ammonia-N during summer (OEPA NPDES Permit 4PJ00000*ED)

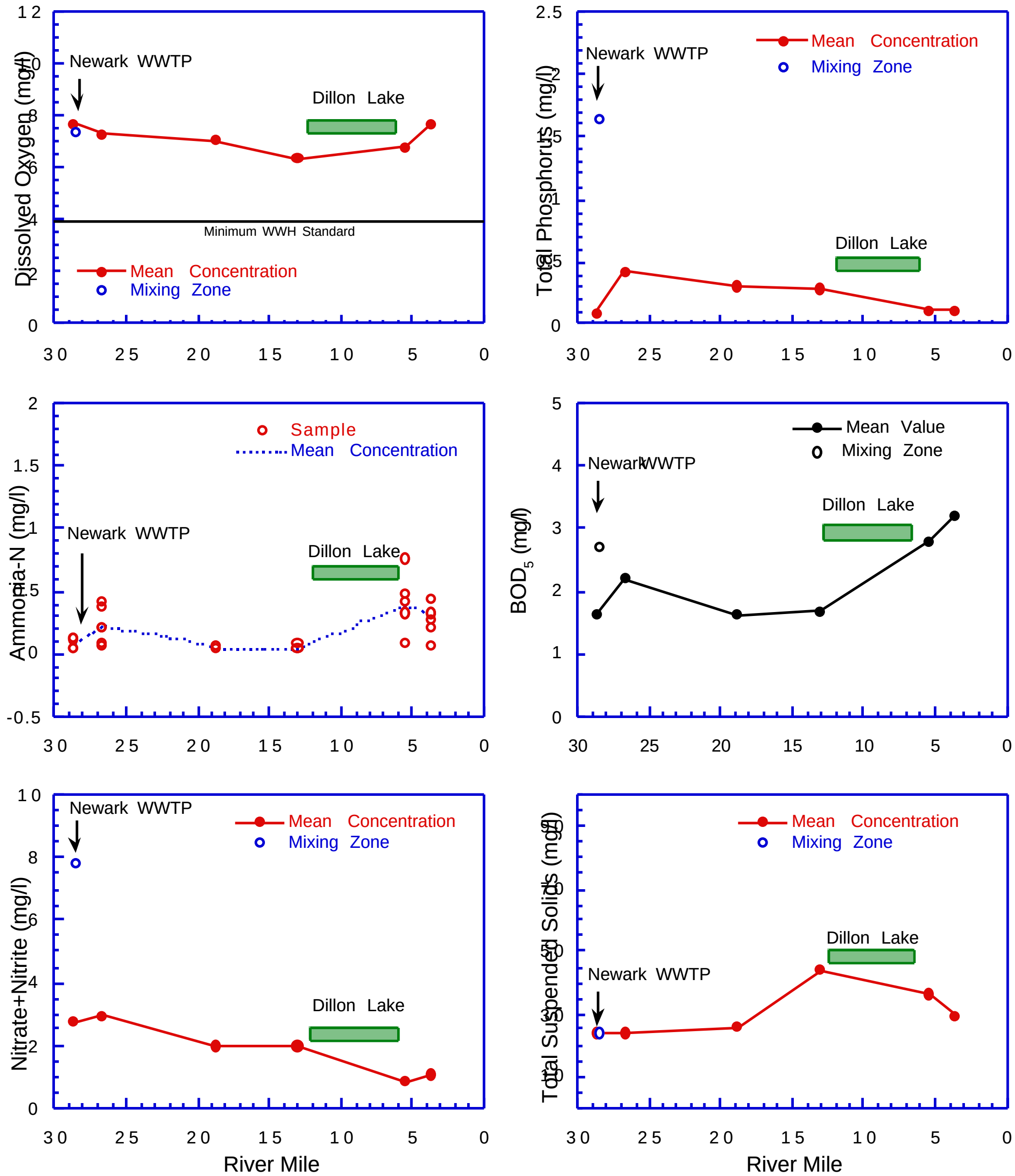


Figure 5. Longitudinal mean concentrations of dissolved oxygen, ammonia-N, nitrate-N, total phosphorus, five-day biochemical oxygen demand, and TSS in the Licking River mainstem, 1993.

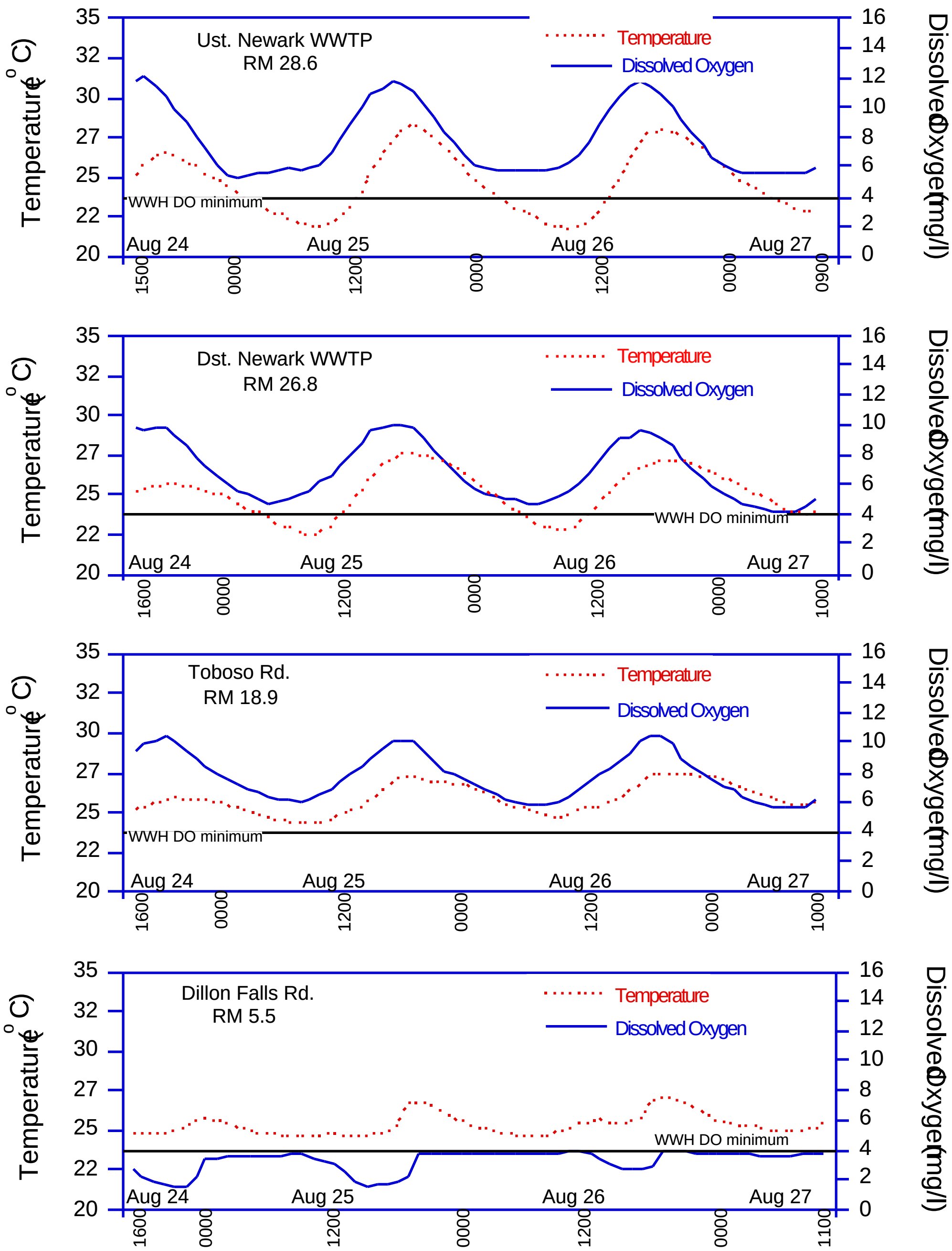


Figure 6. Diurnal Temperature and Dissolved Oxygen (D.O.) from Datsonde™ continuous monitoring units placed at four stations on the Licking River mainstem between August 24-27, 1993.

***Sediment Chemistry***

- Contaminants present in sediments create the potential for continued environmental impact, even where water column pollutant levels are below established criteria, and may have a negative impact on water quality even if pollutant loadings have been eliminated. Certain pollutants have toxic impacts on aquatic life and may pose a threat to human health. To evaluate the extent of sediment contamination within the Licking River mainstem sediment samples were collected at two locations, RM 28.65 (upstream Newark WWTP) and RM 26.75 (downstream Newark WWTP). Chemical analysis included heavy metals and semi-volatile organic compounds. Selected parameters were ranked based on a sediment classification system described by Kelly and Hite (1984) and toxicity based guidelines described by Long and Morgan (1991). The Kelly and Hite classification system ranks pollutant concentrations from non-elevated to extremely elevated. Long and Morgan (1991) determined an effects range-low (ER-L) value which indicates the low end of the range of concentrations in which toxic effects were observed or predicted and effects range-median (ER-M) value which indicated the concentration above which toxic effects were frequently or always observed, or predicted among most test organisms.

- Sediment metals scan revealed zinc and arsenic at elevated concentrations within the Licking River mainstem (Table 6). Elevated concentrations of arsenic were detected both upstream and downstream of Newark WWTP, and were likely reflective of background levels associated with past agricultural use of arsenic based pesticides, herbicides, and defoliants. Though concentrations were ranked as elevated (Kelly and Hite 1984) the ambient levels observed were below the ER-M value reported by Long and Morgan (1991). Zinc was found at an elevated concentration at RM 28.65. The source of zinc contamination is unknown at this time, but may have resulted from urban nonpoint sources from the city of Newark. Though concentration of zinc at RM 28.65 was ranked as elevated (Kelly and Hite 1984) the ambient level observed was below the ER-M value reported by Long and Morgan (1991).

- A sediment organic scan for priority pollutants was conducted at one station on the Licking River mainstem at RM 28.65. The results from the analysis indicated that concentrations of most organic contaminants were near or below detection limits. Only Bis (2-Ethylhexyl) phthalate was found to occur at concentration above detection limits (Table 7). Bis (2-Ethylhexyl) phthalate is used as a plasticizer for polyvinyl chloride and other polymers in large quantities and is likely to be released to the air and water during the production and disposal of these plastic products (Howard 1990). Data reported by Myer and Sanders (1973) have shown that certain phthalates may be detrimental to the reproduction of aquatic organisms at low concentration, and Bis (2-Ethlyhexyl) phthalate has been demonstrated to bioconcentrate in aquatic organisms (Howard 1990). However, the phthalate contamination within the Licking River mainstem was very modest and no discernible impact to the Licking River was evident.

Table 6. Dry weight concentrations of heavy metals (mg/kg) in sediments of the 1993 Licking River study area. All parameter concentrations (excluding Nickel) were ranked based on the stream classification system described by Kelly and Hite (1984). Concentrations preceded by an (*) exceeded the ER-M value described by Morgan and Long (1991).

| River Mile | As | Cd | Cr | Cu | Fe | Pb | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| ***Licking River*** | | | | | | | | |
| 28.65 | 14.8[c] | 0.49[a] | 12.9[a] | 26.3[a] | 19600[b] | 22.6[a] | 13.2 | 112.0[c] |
| 26.75 | 11.8[c] | 0.44[a] | 11.9[a] | 22.7[a] | 16800[a] | 18.8[a] | 11.3 | 95.2[b] |

[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.

Table 7. Dry weight concentrations of semi-volatile organic pollutants detected in the sediments of the Licking River mainstem, 1993.

| Parameter | RM 28.65* |
|---|---|
| ***Licking River*** | |
| **PAHs** (mg/kg or ppm) | |
| Phenanthrene | ND (0.6) |
| Anthracene | ND (0.6) |
| Flouranthene | ND (0.6) |
| Pyrene | ND (0.6) |
| Benzo (A) Anthracene | ND (0.6) |
| Chrysene | ND (0.6) |
| Benzo (K) Flouranthene | ND (0.6) |
| Benzo (A) Pyrene | ND (0.6) |
| Indeno (1, 2, 3, - CD) Pyrene | ND (0.6) |
| Benzo (G, H, I) Perylene | ND (0.6) |
| **PHTHALATES** (mg/kg or ppm) | |
| Bis (2 - Ethylhexyl) Phthalate | 16.1 |

* Corrected method detection limits based on weight and dilutions of sample, non-detected (ND) are presented in parenthesis.

***Physical Habitat for Aquatic Life***

- During the 1993 field sampling efforts the macrohabitats of the Licking River mainstem were evaluated at six fish sampling stations. Qualitative Habitat Evaluation Index values ranged between 50.0 at RM 13.3 (upstream Dillon Lake) and 79.5 at RM 28.6 (upstream of Newark WWTP), with a mean reach QHEI score of 71.7. A Mean QHEI value greater than 60.0 suggested that the near and instream macrohabitats of the Licking River mainstem were of a sufficient quality to support and maintain a community of aquatic organisms consistent with the WWH use designation (Rankin 1989).

- The quality of physical habitats within the Licking River was fairly consistent throughout the study area. Warmwater habitats attribute were generally predominant, reflective of the overall physical integrity and heterogeneity of this system. Positive aspects of near and instream habitats included: abundant native and glacial coarse substrates, good/excellent channel development, abundant instream cover, limited and/or recovery from channelization, and an abundance of well developed pooled areas (Table 8). Only one station achieved a QHEI score less than the mean reach value of 71.7. This station was located within the uppermost reach of the backwaters of Dillon Reservoir at RM 13.3. The diminished habitat quality at this station was a result of the lentic characteristics associated with on-stream impoundments. All other station within the study area contained a diverse array of macrohabitat types commonly associated with natural, free flowing riverine systems. The general high quality of the physical habitats, excluding Dillon Reservoir, appeared fully capable of supporting WWH aquatic communities.

Table 8. Qualitative Habitat Evaluation Index (QHEI) matrix showing warmwater and modified habitat attributes for the Licking River study area, 1993.

Key QHEI Components

| | | | WWH Attributes | | | | | | | | | | | MWH Attributes: High Influence | | | | | | MWH Attributes: Moderate Influence | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| River Mile | QHEI | Gradient (ft/mile) | No Channelization or Recovered | Boulder/Cobble/Gravel Substrates | Silt Free Substrates | Good/Excellent Development | Moderate/High Sinuousity | 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 Sinuousity | Sparse/No Cover | Max Depth < 40 cm (WD,HW) | Total H.I. MWH Attributes | Recovering Channel | Heavy/Moderate Silt Cover | Sand Substrates (Boat) | Hardpan Substrate Origin | Fair/Poor Development | Low/No Sinuosity | Only 1-2 Cover Types | Intermittent & Poor Pools | No Fast Current | High/Moderate Embeddedness | Ext./Moderate Riffle Embed. | No Riffle | Total M.I. MWH Attributes | MWH H.I./WWH Ratio | MWH M.I./WWH Ratio |
| 7-200) – Licking River | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28.6 | 79.5 | 5.7 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | | 9 | | | | | | 0 | | | | | | | | | | | ▲ | | 1 | .10 | .20 |
| 26.6 | 76.0 | 3.6 | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | | 7 | | | | | | 0 | | | | | | ▲ | | | | ▲ | ▲ | | 3 | .13 | .50 |
| 18.7 | 75.5 | 3.7 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | | 9 | | | | | | 0 | | ▲ | | | | ▲ | | | | ▲ | ▲ | | 4 | .10 | .50 |
| 13.3 | 50.0 | .1 | ■ | | | ■ | ■ | ■ | | | ■ | | 5 | | ● | | | | 1 | | ▲ | | | ▲ | | | | ▲ | ▲ | | ▲ | 5 | .33 | 1.17 |
| 5.5 | 72.5 | 9.4 | ■ | ■ | | ■ | | ■ | | | ■ | | 5 | | | | | | 0 | | ▲ | | | ▲ | ▲ | | | ▲ | ▲ | | ▲ | 6 | .17 | 1.17 |
| 3.4 | 76.5 | 6.8 | ■ | ■ | | ■ | | ■ | ■ | | ■ | | 6 | | | | | | 0 | | ▲ | | | | ▲ | | | | ▲ | ▲ | | 4 | .14 | .71 |

Table 8. continued.

Key QHEI Components: ■ = WWH Attributes; ● = MWH Attributes, High Influence; ▲ = MWH Attributes, Moderate Influence

| River Mile | QHEI | Gradient (ft/mile) | WWH: No Channelization or Recovered | WWH: Boulder/Cobble/Gravel Substrates | WWH: Silt Free Substrates | WWH: Good/Excellent Development | WWH: Moderate/High Sinuosity | WWH: Extensive/Moderate Cover | WWH: Fast Current/ Eddies | WWH: Low/Normal Embeddedness | WWH: Max Depth > 40 cm | WWH: Low/No Riffle Embeddedness | Total WWH Attributes | MWH High Influence: Channelized or No Recovery | MWH High Influence: Silt/Muck Substrates | MWH High Influence: Low Sinuosity | MWH High Influence: Sparse/No Cover | MWH High Influence: Max Depth < 40 cm (WD,HW) | Total H.I. MWH Attributes | MWH Moderate Influence: Recovering Channel | MWH Moderate Influence: Heavy/Moderate Silt Cover | MWH Moderate Influence: Sand Substrates (Boat) | MWH Moderate Influence: Hardpan Substrate Origin | MWH Moderate Influence: Fair/Poor Development | MWH Moderate Influence: Low/No Sinuosity | MWH Moderate Influence: Only 1-2 Cover Types | MWH Moderate Influence: Intermittent & Poor Pools | MWH Moderate Influence: No Fast Current | MWH Moderate Influence: High/Moderate Embeddedness | MWH Moderate Influence: Ext./Moderate Riffle Embed. | MWH Moderate Influence: No Riffle | Total M.I. MWH Attributes | MWH H.I./WWH Ratio | MWH M.I./WWH Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (17-204) – Big Run | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.0 | 40.5 | 9.0 | | ■ | | | | | | | ■ | | 2 | ● | ● | ● | ● | | 4 | | ▲ | | | ▲ | ▲ | | | ▲ | ▲ | | ▲ | 6 | 1.67 | 3.67 |
| (17-250) – North Fork Licking River | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.5 | 82.5 | 11.4 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | 9 | | | | | | 0 | | | | | | | | | | ▲ | | | 1 | .10 | .20 |
| .2 | 60.0 | 5.7 | | ■ | | | | | ■ | ■ | ■ | | 4 | ● | | | ● | | 2 | ▲ | | | | ▲ | ▲ | | | | | ▲ | | 4 | .60 | 1.40 |
| (17-262) – Sycamore Creek | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .1 | 80.0 | 12.8 | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | | 7 | | | | | | 0 | | | | | | | | | | ▲ | ▲ | | 2 | .13 | .38 |
| (17-264) – Vance Creek | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .7 | 59.5 | 15.1 | | ■ | | | | | | ■ | ■ | ■ | 4 | | | ● | | | 1 | ▲ | | | | ▲ | ▲ | | | ▲ | | | | 4 | .40 | 1.20 |
| (17-220) – South Fork Licking River | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31.5 | 60.0 | 19.6 | ■ | | | ■ | ■ | ■ | | ■ | ■ | | 6 | | | | | | 0 | | | | | ▲ | | | | ▲ | ▲ | ▲ | | 4 | .14 | .71 |
| 28.3 | 64.5 | 16.3 | ■ | ■ | | | | ■ | | | ■ | | 4 | | | ● | ● | | 2 | | | | | ▲ | ▲ | | | ▲ | ▲ | ▲ | | 5 | .60 | 1.60 |
| 27.6 | 83.0 | 11.2 | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | | 8 | | | | | | 0 | | | | | | | | | | ▲ | ▲ | | 2 | .11 | .33 |
| 24.6 | 83.0 | 10.6 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | 9 | | | | | | 0 | | | | | | | | | ▲ | | | | 1 | .10 | .20 |
| 21.3 | 67.0 | 9.6 | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | | 7 | | | | | | 0 | | ▲ | | | | | | | | ▲ | ▲ | | 3 | .13 | .50 |
| 15.3 | 59.5 | 2.5 | | ■ | | | | | | ■ | ■ | | 4 | | | | ● | | 1 | ▲ | ▲ | | | ▲ | ▲ | | | ▲ | ▲ | ▲ | | 7 | .40 | 1.80 |
| 13.1 | 39.0 | 2.5 | | | | | | | | | ■ | | 1 | ● | ● | | ● | | 3 | ▲ | ▲ | | | ▲ | ▲ | | | ▲ | ▲ | ▲ | | 7 | 2.00 | 5.50 |
| 9.4 | 76.5 | 3.5 | ■ | ■ | | | ■ | ■ | | | ■ | | 5 | | | | | | 0 | | ▲ | | | ▲ | | | | ▲ | ▲ | ▲ | | 5 | .17 | 1.00 |
| 8.8 | 75.0 | 3.5 | ■ | ■ | | ■ | ■ | ■ | | | ■ | | 6 | | | | | | 0 | | ▲ | | | ▲ | | | | ▲ | ▲ | ▲ | | 5 | .14 | .86 |
| 4.3 | 85.5 | 7.2 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | 9 | | | | | | 0 | | ▲ | | | | | | | | | | | 1 | .10 | .20 |
| 1.7 | 82.5 | 9.5 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | | 8 | | | | | | 0 | | | | | | | | | | ▲ | ▲ | | 2 | .11 | .33 |
| .5 | 60.5 | 4.7 | | ■ | | | | | | ■ | ■ | | 3 | | | | ● | | 1 | ▲ | | | | ▲ | ▲ | | | ▲ | | ▲ | | 5 | .50 | 1.75 |

Table 8. continued.

Key QHEI Components

| River Mile | QHEI | Gradient (ft/mile) | WWH Attributes: No Channelization or Recovered | Boulder/Cobble/Gravel Substrates | Silt Free Substrates | Good/Excellent Development | Moderate/High Sinuousity | Extensive/Moderate Cover | Fast Current/ Eddies | Low/Normal Embeddedness | Max Depth > 40 cm | Low/No Riffle Embeddedness | **Total WWH Attributes** | MWH Attributes, High Influence: Channelized or No Recovery | Silt/Muck Substrates | Low Sinuousity | Sparse/No Cover | Max Depth < 40 cm (WD,HW) | **Total H.I. MWH Attributes** | MWH Attributes, Moderate Influence: Recovering Channel | Heavy/Moderate Silt Cover | Sand Substrates (Boat) | Hardpan Substrate Origin | Fair/Poor Development | Low/No Sinuosity | Only 1-2 Cover Types | Intermittent & Poor Pools | No Fast Current | High/Moderate Embeddedness | Ext./Moderate Riffle Embed. | No Riffle | **Total M.I. MWH Attributes** | **MWH H.I./WWH Ratio** | **MWH M.I./WWH Ratio** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17-221) – Raccoon Creek | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.6 | 77.5 | 7.5 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | | 9 | | | | | | 0 | | | | | | | | | ▲ | | ▲ | | 2 | .10 | .30 |
| .3 | 65.0 | 7.3 | | ■ | | ■ | | | ■ | ■ | ■ | | 5 | | | | ● | | 1 | ▲ | | | | ▲ | ▲ | | | | | ▲ | | 4 | .33 | 1.00 |
| 17-223) – Lobdell Creek | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.6 | 51.5 | 21.2 | ■ | | | | ■ | | | ■ | | ■ | 4 | | | | ● | ● | 2 | | | | | ▲ | | | | ▲ | | | | 2 | .60 | 1.00 |
| .2 | 70.5 | 11.7 | ■ | ■ | | | ■ | ■ | ■ | ■ | ■ | ■ | 8 | | | | | | 0 | | | | | ▲ | | | | ▲ | | | | 2 | .11 | .33 |
| 17-232) – Ramp Creek | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Year: 93 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.0 | 80.5 | 18.8 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | 10 | | | | | | 0 | | | | ▲ | | | | | | | | | 1 | .09 | .18 |
| 1.4 | 76.5 | 21.2 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | 9 | | | | | | 0 | | | | | | | | | | | | | 0 | .10 | .10 |
| .7 | 66.5 | 16.9 | ■ | ■ | | ■ | ■ | | ■ | | ■ | ■ | 7 | | | | ● | | 1 | ▲ | | | | | | | | | ▲ | | | 2 | .25 | .50 |
| .1 | 75.5 | 22.7 | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | 9 | | | | | | 0 | | | | ▲ | | | | | | | | | 1 | .10 | .20 |

***Biological Assessment: Benthic Invertebrate Community***

- In 1993, macroinvertebrate samples from the Licking River were collected at seven stations between RM 28.6 (upstream Newark WWTP) and RM 3.6 (Dillon Falls Rd.). The ICI and narrative evaluations ranged between 52 (exceptional) at RM 18.9 and 18 (fair) at RM 5.5. With the exception of RM 5.5, the benthic macroinvertebrate community performed at a level consistent with the WWH use designation throughout the Licking River mainstem.

- The Newark WWTP did not have a discernible effect on the macroinvertebrate community at RM 28.5. In comparison with the upstream station (RM 28.6) community indices (ICI, QCTV, and Qualitative EPT) indicated performance consistent with the WWH biocriteria (Table 9 and Figure 7).

- Performance consistent with the WWH biological criteria was observed at all stations located between RM 26.8 (upstream Newark WWTP) and RM 14.0 (upstream Dillon reservoir). There was no apparent effect on the macroinvertebrate community from the Hanby tributary (nonpoint source issue) which enters the Licking River upstream of RM 14.8.

- Downstream from the Dillon Reservoir at RM 5.5 the macroinvertebrate community was reflective of fair water quality conditions. This station was situated several hundred meters downstream from the reservoir spillway. The quantitative artificial substrate samplers were set in a flow of 0.75 cfs, but during retrieval flow over the plates was reduced to 0.20 cfs. The benthic invertebrate community at this station achieved an ICI of 18, the lowest value recorded in the 1993 Licking River study area. Qualitative sampling yielded a QCTV score of 25.2 with only four EPT taxa. The fair condition of the invertebrate community and the flow discrepancies were likely a result of both variable and hypolimnetic discharge from Dillon Reservoir.

- Macroinvertebrate community samples collected at RM 3.6 (Dillon Falls Rd.) were indicative of good water quality, and community performance consistent with the WWH biological criteria was observed (ICI=38). The natural substrates yielded a median QCTV score of 38.1 and 13 EPT taxa.

Table 9. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Licking River basin, July - August, 1993.

| Stream River Mile | Relative Density | Quant. Taxa | Qual. Taxa | Qual. EPT[b] | QCTV[c] | ICI | Narrative Evaluation |
|---|---|---|---|---|---|---|---|
| | | | *Quantitative Evaluation* | | | | |
| ***Licking River*** | | | | | | | |
| *Erie-Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | |
| 28.6 | 2,926 | 47 | 65 | 14 | 38.7 | 40 | Good |
| 28.5[mz] | 1,172 | 40 | 24 | 6 | 38.6 | 34 | Good |
| 26.8 | 2,240 | 43 | 57 | 15 | 37.0 | 46 | Exceptional |
| *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | | | |
| 18.9 | 729 | 43 | 53 | 16 | 38.9 | 52 | Exceptional |
| 14.8 | 2,884 | 37 | 52 | 21 | 39.7 | 43 | Exceptional |
| 5.5 | 1,993 | 17 | 30 | 4 | 25.2 | 18* | Fair |
| 3.6 | 3,540 | 31 | 40 | 13 | 38.1 | 38 | Good |
| ***North Fork Licking River*** | | | | | | | |
| *Erie-Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | |
| 2.8 | 3,504 | 34 | 39 | 11 | 38.6 | 44 | Very Good |
| 0.2 | - | Qual Only | 41 | 7 | 32.4 | - | Fair |
| ***Raccoon Creek*** | | | | | | | |
| *Erie-Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | |
| 5.8 | 586 | 46 | 49 | 12 | 38.7 | 46 | Exceptional |
| 0.2 | - | Qual. Only | 49 | 9 | 38.0 | - | Marginally Good |
| ***South Fork Licking River*** | | | | | | | |
| *Eastern Corn Belt Plains WWH Use Designation (Existing)* | | | | | | | |
| 31.6 | - | Qual. only | 40 | 10 | 38.7 | - | Good |
| 28.4 | 344 | 34 | 37 | 10 | 38.7 | 32[ns] | Marginally Good |
| 27.6 | 766 | 28 | 53 | 10 | 35.7 | 36 | Good |
| *Erie-Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | |
| 24.1 | 512 | 54 | 62 | 15 | 35.7 | 40 | Good |
| 21.1 | - | Qual Only | 56 | 11 | 37.1 | - | Good |
| 15.4 | 2,565 | 54 | 77 | 16 | 35.7 | 50 | Exceptional |
| 13.0 | 1,220 | 40 | 50 | 13 | 33.1 | 34 | Good |
| 9.9 | 2,199 | 34 | 41 | 13 | 38.9 | 42 | Very Good |
| 8.9 | 2,607 | 35 | 47 | 12 | 38.6 | 42 | Very Good |
| 4.7 | 2,308 | 43 | 44 | 10 | 38.6 | 44 | Very Good |
| 2.2[mz] | 1,2440 | 37 | 53 | 13 | 38.9 | 46 | Exceptional |
| 0.4 | 1,784 | 45 | 55 | 0 | 34.3 | 36 | Good |

Table 9. continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | ***Quantitative Evaluation*** | | | | |
| **Stream River Mile** | **Relative Density** | **Quant. Taxa** | **Qual. Taxa** | **Qual. EPT**[b] | **QCTV**[c] | **ICI** | **Narrative Evaluation** |
| **Ramp Creek** | | | | | | | |
| *Erie-Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | |
| 2.0 | 460 | 51 | 30 | 8 | 37.5 | 42 | Very Good |
| 1.4 | 401 | 35 | 31 | 6 | 36.4 | 42 | Very Good |
| 0.7 | - | Qual. Only | 24 | 2 | 33.2 | - | Poor |
| 0.1 | 435 | 32 | 31 | 9 | 36.2 | 52 | Exceptional |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | ***Qualitative Evaluation*** | | | |
| **Stream River Mile** | **No.Qual. Taxa** | **QCTV**[c] | **Qual. EPT**[b] | **Relative Density** | **Predominant Organisms** | **Narrative Evaluation**[a] |
| | | *Erie-Ontario Lake Plain WWH Use Designation (Existing)* | | | | |
| **Big Run** | | | | | | |
| 5.1 | 40 | 34.0 | 6 | Mod | caddisflies, corixids midges | Fair |
| **North Fork Licking River** | | | | | | |
| 0.2 | 41 | 32.4 | 7 | Low | midges, heptagenid.mayflies | Fair |
| **Vance Creek** | | | | | | |
| 0.7 | 52 | 38.6 | 12 | Mod | caddisflies, water penny heptagenid mayflies | Good |
| **Sycamore Creek** | | | | | | |
| 0.1 | 62 | 38.9 | 19 | Mod | caddisflies, *Isonychia* and heptagenid mayflies, midges | Very Good |
| **Raccoon Creek** | | | | | | |
| 0.2 | 49 | 38.0 | 9 | Low-Mod | caddisflies, midges,Snails | Marginally Good |
| **South Fork Licking River** | | | | | | |
| 21.1 | 56 | 37.1 | 11 | Mod | baetid mayflies caddisflies, red midges | Good |
| | | *Eastern Corn Belt Plains WWH Use Designation (Existing)* | | | | |
| **South Fork Licking River** | | | | | | |
| 31.6 | 40 | 38.7 | 10 | Low-Mod | caddisflies, midges heptagenid mayflies dryopoid beetles | Good |
| **Ramp Creek** | | | | | | |
| 0.7 | 24 | - | 2 | Low | midges | Poor |

Table 9. continued.

**Ecoregional Biocriteria:**
Erie-Ontario Lake Plain (EOLP)

| INDEX | WWH | EWH | MWH[d] |
| --- | --- | --- | --- |
| ICI | 34 | 46 | 22 |

a - A qualitative narrative evaluation is used when quantitative data is not available to calculate the Invertebrate Community Index (ICI) scores and where flow over artificial substrates was less than 0.3 ft/sec.
b - EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).
c - Qualitative Community Tolerance Value (QCTV) calculated as the average of the weighted ICI for each taxa.
d - Modified Warmwater Habitat for channel modified areas.
* - Significant departure from ecoregional biocriterion (>4 ICI units); poor and very poor results are underlined.
ns - Nonsignificant departure from ecoregional biocriterion (≤4 ICI units).

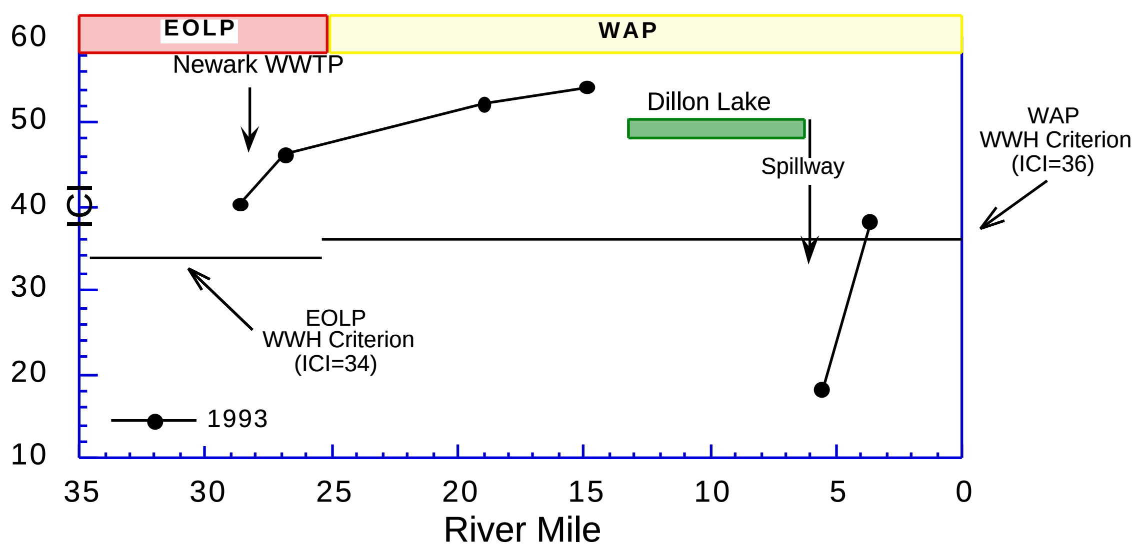


Figure 7. Longitudinal performance of the Invertebrate Community Index (ICI) from the Licking River mainstem, 1993.

### *Biological Assessment: Fish Community*

- A total of 4,470 fish comprised of 54 species and nine hybrids was collected from the Licking River mainstem between July 7 and August 15, 1993. The sampling effort included seven stations located between RM 28.6 (upstream Newark WWTP) and RM 3.4 (Dillon Fall Rd.).

- The numerically predominant fish species were: northern hog sucker (9.71%), golden redhorse (9.40%), spotfin shiner (8.97%), gizzard shad (6.92%), bluegill (6.25%), and silver shiner (5.03%). Species that predominated in terms of biomass were: common carp (32.8%), golden redhorse (17.3%), channel catfish (7.33%), northern hog sucker (6.52%), black redhorse (5.88%), and silver redhorse (4.45%).

- In terms of relative abundance, the majority of the predominant species were classified as either moderately intolerant (northern hog sucker and golden redhorse) or highly intolerant (silver shiner) of habitat and water quality degradation (Ohio EPA 1987b). In terms of biomass, the predominance of common carp within community samples collected appeared fairly typical of medium to large river systems within the state of Ohio. This highly adaptable and tolerant species is well distributed (Trautman 1981) and its predominance , viewed in context with the abundance of sensitive sucker species (northern hog sucker, golden redhorse, silver redhorse, and black redhorse), *did not* appear indicative of environmental degradation. Both in terms of relative abundance and biomass, moderate and highly intolerant fishes were well represented within the assemblage. The abundance of these sensitive sucker and minnow species was reflective of the good water quality and intact macrohabitats generally found within the Licking River mainstem.

- All fish community samples from the Licking River mainstem were collected with the standard boat sampling methodology, where both the MIwb and the IBI community indices were employed to evaluate ambient biological condition (Ohio EPA 1989b). Community indices and narrative evaluation ranged between very good/marginally good (MIwb=9.4; IBI=39) at RM 13.3 and Exceptional (MIwb=9.9; IBI=50) at RM 28.6. Viewed in the aggregate (all stations) the fish assemblage was characterized as exceptional/very good. Community performance as measured by the MIwb and IBI meet or exceeded the ecoregional WWH biological criteria at all stations within the Licking River mainstem (Table 10).

- The structural and functional organization of the fish community was indicative of a high quality water resource (*i.e.* where both the chemical and physical integrity of the water body has been maintained). Species richness was high and intolerant species were represented within the fish assemblage, while mean percent occurrence of tolerant species was low (10.4%). Insectivory was the predominant feeding guild (63.4%), carnivory occurred at levels comparable to ecoregional expectations, and the mean percent occurrence of omnivorous species was low (18.7%). Typically, omnivorous and generalized feeding species predominate in areas where environmental degradation (chemical and/or physical) have disrupted or simplified the food base. The abundance of specialized insectivorous and carnivorous species coupled with and the low occurrence of omnivorous and generalist feeders indicated a high level of trophic integrity within the fish community.

- The quality and extent of riffle/run/pool macrohabitats were indicated by the abundance, both in terms of species richness and density (No./km), of sucker species, particularly the redhorse suckers (*Moxostoma sp.*). This component of the fish assemblage is lithophilic and insectivorous, requiring coarse substrates relatively free of silts, and the swift well oxygenated habitats associated with developed riffle/run/pool complexes to fulfill spawning and feeding requirements (Trautman 1981 and Smith 1979). The quality and structural heterogeneity of "quiet" pool habitats was indicated by the diverse assemblage of sunfish (Centrarchidae) species generally found within the Licking river mainstem (Ohio EPA 1987b). Other components of the fish assemblage that were indicative of high quality macrohabitats included sensitive minnows and darters.

- No impact was evident within the fish community downstream of the Newark WWTP. Community performance as measured by the MIwb and IBI was characterized as exceptional, both upstream and downstream of the treatment facility (Figure 8). Performance within the fish community at or near an exceptional level was maintained throughout the study area, except at the sampling station located at RM 13.3. This station was situated within the uppermost reach of the backwaters of Dillon Reservoir. The fish assemblage clearly integrated the transition from the lotic macrohabitats associated with free flowing riverine systems, to the more lentic macrohabitats associated with on-stream impoundments. Though performance was markedly reduced in response to the change in habitat quality at this station, minimal functional organization was maintained and was consistent WWH biological criteria (Figure 8).

Table 10. Fish community indices based on pulse D.C. electrofishing samples collected by Ohio EPA within the Licking River study area, 1981-1993.

| Stream River Mile | Mean Number Species | Cumulative Species | Mean Rel.No. (No./Km) | Mean Rel.Wt. (Wt./Km) | QHEI | Mean Index of Well-Being | Mean Biotic Integrity | Narrative Evaluation |
|---|---|---|---|---|---|---|---|---|
| ***Licking River (1993)*** | | | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | | |
| 28.6[B] | 24.0 | 28 | 667.0 | 156.7 | 79.5 | 9.9 | 50 | Exceptional |
| 28.5[mz,B] | 17.0 | 22 | 1,455.0 | 110.0 | - | 9.4 | 45 | V.Good |
| 26.6[B] | 23.5 | 29 | 704.9 | 199.1 | 76.0 | 10.0 | 49 | Exceptional |
| *Western Alleghney Plateau WWH Used Designation (Existing)* | | | | | | | | |
| 18.7[B] | 21.5 | 28 | 787.0 | 155.5 | 75.5 | 9.8 | 46 | Except./V.Good |
| 13.3[B] | 20.0 | 25 | 656.4 | 164.9 | 50.0 | 9.4 | 39[ns] | V.Good/M.Good |
| 5.5[B] | 27.0 | 32 | 798.0 | 150.8 | 72.5 | 9.7 | 46 | Except./V.Good |
| 3.4[B] | 24.5 | 31 | 592.9 | 161.9 | 76.5 | 9.9 | 48 | Exceptional |

Table 10. continued.

| Stream River Mile | Mean Number Species | Cumulative Species | Mean Rel.No. (No./Km) | Mean Rel.Wt. (Wt./Km) | QHEI | Mean Index of Well-Being | Mean Biotic Integrity | Narrative Evaluation |
|---|---|---|---|---|---|---|---|---|
| ***Licking River (1988)*** | | | | | | | | |
| *Western Alleghney Plateau WWH Use Designation (Existing)* | | | | | | | | |
| 3.6[B] | 25.0 | 35 | 615.4 | 151.0 | 83.0 | 9.1 | 40 | V.Good/Good |
| ***(1985)*** | | | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | | |
| 28.1[B] | 26.0 | 26 | 1,351.4 | 358.2 | 58.0 | 10.0 | 38[ns] | Except./M.Good |
| 26.4[B] | 25.0 | 25 | 1,038.0 | 151.6 | - | 9.4 | 40 | Except./Good |
| *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | | | | |
| 13.4[B] | 17.0 | 17 | 328.0 | 162.9 | - | 8.3[ns] | 32* | Good/Fair |
| ***(1981)*** | | | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | | |
| 30.1[B] | 15.0 | 23 | 370.7 | 273.3 | - | 7.1* | 33* | Fair |
| 27.5[B] | 15.3 | 23 | 285.4 | 63.1 | - | 7.0* | 29* | Fair |
| 24.8[B] | 16.7 | 27 | 319.4 | 99.4 | - | 7.2* | 29* | Fair |
| *Western Allegheny Plateau WWH Use Designation (Existing)* | | | | | | | | |
| 20.0[B] | 8.7 | 14 | 252.7 | 44.6 | - | 6.4* | 24* | Fair/Poor |
| 16.1[B] | 13.0 | 21 | 294.0 | 36.3 | - | 6.4* | 27* | Fair/Poor |
| 11.0[B] | 10.3 | 16 | 202.0 | 14.5 | - | 5.4* | 25* | Poor |
| ***Big Run (1993)*** | | | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | | |
| 5.0[H] | 18.0 | 18 | 622.5 | 9.7 | 40.5 | N/A | 30* | Fair |
| ***North Fork Licking River (1993)*** | | | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | | |
| 2.5[B] | 31 | 34 | 1,375.0 | 123.8 | 82.5 | 10.9 | 51 | Exceptional |
| 0.2[B] | 20 | 27 | 815.9 | 80.1 | 60.0 | 9.4 | 46 | V.Good |
| ***(1985)*** | | | | | | | | |
| *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | | | |
| 0.9[B] | 28.0 | 28 | 898.5 | 33.3 | - | 9.5 | 52 | Exceptional |

Table 10. continued.

| Stream River Mile | Mean Number Species | Cumulative Species | Mean Rel.No. (No./Km) | Mean Rel.Wt. (Wt./Km) | QHEI | Mean Index of Well-Being | Mean Biotic Integrity | Narrative Evaluation |
|---|---|---|---|---|---|---|---|---|
| ***North Fork Licking River (1982)*** | | | | | | | | |
| | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 2.4[B] | 25.5 | 32 | 676.0 | 92.6 | 77.0 | 9.3 | 41 | V.Good/Good |
| ***(1981)*** | | | | | | | | |
| | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 2.0[B] | 23.7 | 33 | 502.0 | 144.2 | - | 8.6[ns] | 39[ns] | M.Good |
| 0.7[B] | 15.7 | 23 | 342.7 | 27.5 | - | 7.7* | 31* | Fair |
| ***Vance Creek (1993)*** | | | | | | | | |
| | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 0.7[H] | 25.0 | 25 | 1,047.0 | 47.5 | 59.5 | N/A | 48 | V.Good |
| ***Sycamore Creek (1993)*** | | | | | | | | |
| | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 0.1[W] | 25.0 | 25 | 1,324.5 | 13.5 | 80.0 | 8.9 | 48 | Good/V.Good |
| ***South Fork Licking River (1993)*** | | | | | | | | |
| | | *Eastern Corn Belt Plains WWH Use Designation (Existing)* | | | | | | |
| 31.5[H] | 19.5 | 20 | 1,803.8 | 37.2 | 60.0 | N/A | 47 | V.Good |
| 28.3[W] | 20.0 | 22 | 2,064.0 | 21.4 | 64.5 | 9.4 | 47 | Except./V.Good |
| 27.6[W] | 24.0 | 27 | 1,666.5 | 50.5 | 83.0 | 9.6 | 49 | Except./V.Good |
| 24.6[W] | 21.0 | 23 | 2,268.0 | 25.5 | 83.0 | 9.1 | 46 | V.Good |
| 21.3[W] | 25.5 | 28 | 2,067.4 | 43.7 | 67.0 | 9.6 | 52 | Exceptional |
| 15.3[W] | 31.5 | 35 | 1,188.0 | 28.7 | 59.5 | 8.6 | 49 | Good/V.Good |
| 13.1[B] | 20.5 | 26 | 395.0 | 176.9 | 39.0 | 8.9 | 37[ns] | Good/M.Good |
| 9.4[B] | 24.5 | 29 | 469.0 | 135.3 | 76.5 | 9.9 | 51 | Exceptional |
| 8.8[B] | 24.5 | 27 | 533.0 | 145.8 | 75.0 | 9.8 | 51 | Exceptional |
| 4.3[B] | 22.0 | 26 | 526.0 | 80.9 | 85.5 | 9.6 | 49 | Exceptional |
| 2.2[mz,B] | 16.0 | 20 | 1,115.0 | 190.1 | - | 9.6 | 48 | Exceptional |
| 1.7[B] | 26.5 | 30 | 1,037.0 | 104.5 | 82.5 | 10.2 | 52 | Exceptional |
| 0.5[B] | 21.5 | 24 | 901.2 | 163.0 | 60.5 | 10.2 | 53 | Exceptional |

Table 10. continued.

| Stream River Mile | Mean Number Species | Cumulative Species | Mean Rel.No. (No./Km) | Mean Rel.Wt. (Wt./Km) | QHEI | Mean Index of Well-Being | Mean Biotic Integrity | Narrative Evaluation |
|---|---|---|---|---|---|---|---|---|
| ***South Fork Licking River (1988)*** | | | | | | | | |
| | | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 19.1[B] | 31.0 | 31 | 1,795.5 | 25.6 | 75.0 | 10.1 | 54 | Exceptional |
| 15.3[B] | 33.0 | 33 | 396.0 | 19.7 | - | 8.4 | 48 | Good/V.Good |
| ***(1984)*** | | | | | | | | |
| | | | *Eastern Corn Belt Plains WWH Use Designation (Existing)* | | | | | |
| 31.5[H] | 14.0 | 17 | 717.7 | 12.9 | 64.0 | N/A | $36^{ns}$ | M.Good |
| 28.5[H] | 16.5 | 18 | 1,100.6 | 18.6 | 70.0 | N/A | 42 | Good |
| 27.6[W] | 23.0 | 27 | 6,387.8 | 192.3 | 69.0 | 9.9 | $37^{ns}$ | Except./M.Good |
| 26.2[W] | 22.0 | 25 | 1,920.5 | 26.4 | 68.0 | 8.2 | $36^{ns}$ | Good/M.Good |
| | | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 21.5[B] | 31.5 | 33 | 1,876.5 | 50.9 | - | 10.1 | 47 | Except./V.Good |
| 21.3[B] | 34.0 | 34 | 1,650.5 | 44.5 | - | 10.2 | 44 | Except./Good |
| 13.1[B] | 13.7 | 19 | 415.5 | 154.1 | 42.0 | 9.0 | $39^{ns}$ | Good/M.Good |
| 12.7[B] | 17.0 | 25 | 449.2 | 350.8 | - | 8.9 | 34* | Good/Fair |
| ***(1981)*** | | | | | | | | |
| | | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | |
| 7.2[B] | 15.7 | 24 | 227.4 | 36.4 | - | 7.4* | 31* | Fair |
| 2.1[B] | 18.0 | 29 | 366.7 | 49.7 | - | 7.3* | 33* | Fair |
| 0.9[B] | 18.5 | 33 | 447.4 | 92.5 | - | 7.9* | 35* | Fair |
| ***Ramp Creek (1993)*** | | | | | | | | |
| | | | *Eastern Ontario Lake Plains- WWH Use designation (Existing)* | | | | | |
| 2.0[H] | 18.0 | 19 | 2,369 | NA | 80.5 | NA | 53 | Exceptional |
| 1.4[H] | 20.0 | 23 | 1,678 | NA | 76.5 | NA | 53 | Exceptional |
| 0.7[H] | 19.0 | 22 | 3,045 | NA | 66.5 | NA | 51 | Exceptional |
| 0.1[H] | 20.0 | 21 | 1,509 | NA | 75.5 | NA | 55 | Exceptional |

Table 10. continued.

| Stream River Mile | Mean Number Species | Cumulative Species | Mean Rel.No. (No./Km) | Mean Rel.Wt. (Wt./Km) | QHEI | Mean Index of Well-Being | Mean Biotic Integrity | Narrative Evaluation |
|---|---|---|---|---|---|---|---|---|
| ***Raccoon Creek (1993)*** | | | | | | | | |
| | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 5.6[B] | 22.5 | 25 | 2640.4 | 148.0 | 77.5 | 10.0 | 43 | Except./Good |
| 0.3[B] | 25.5 | 26 | 1,315.1 | 112.1 | 65.0 | 10.2 | 50 | Exceptional |
| ***Raccoon Creek (1981)*** | | | | | | | | |
| | | *Erie Ontario Lake Plain WWH Use Designation (Existing)* | | | | | | |
| 0.6[B] | 20.0 | 26 | 500.0 | 41.7 | - | 7.6* | 31* | Fair |
| ***Lobdell Creek (1993)*** | | | | | | | | |
| | | *Eastern Corn Belt Plain WWH Use Designation (Existing)* | | | | | | |
| 1.6[H] | 13 | 13 | 1,280.0 | - | 51.5 | N/A | 40 | Good |
| 0.2[H] | 17 | 17 | 1,429.0 | - | 70.5 | N/A | 48 | Good |

* - Significant departure from applicable biological criteria (≥4 IBI and ≥0.5 MIwb units), poor and very poor results are underlined.
ns - Nonsignificant departure from biocriteria (≤4 IBI and ≤0.5 MIwb units).
N/A - Headwater station (MIwb not applicable).
*mz* - Mixing zone sample.
H - Headwater station.
W - Wading station.
B - Boat station.

## Ecoregional Biological Criteria:

*Eastern Corn Belt Plains (ECBP)*

| Index - Site Type | WWH | EWH | MWH[c] |
|---|---|---|---|
| IBI - Headwater/Wading | 40 | 50 | 24 |
| MIwb - Wading | 8.3 | 9.4 | 6.2 |

*Erie Ontario Lake Plain (EOLP)*

| Index - Site Type | WWH | EWH | MWH[c] |
|---|---|---|---|
| IBI - Headwater | 40 | 50 | 24 |
| IBI - Wading | 38 | 50 | 24 |
| IBI - Boat | 40 | 48 | 24 |
| MIwb - Wading | 7.9 | 9.4 | 6.2 |
| MIwb - Boat | 8.7 | 9.6 | 5.8 |

*Western Allegheny Plateau (WAP)*

| Index - Site Type | WWH | EWH | MWH[c] |
|---|---|---|---|
| IBI- Boat | 40 | 48 | 24 |
| MIwb - Boat | 8.6 | 9.6 | 5.8 |

c - Modified Warmwater Habitat for channel Modified areas.

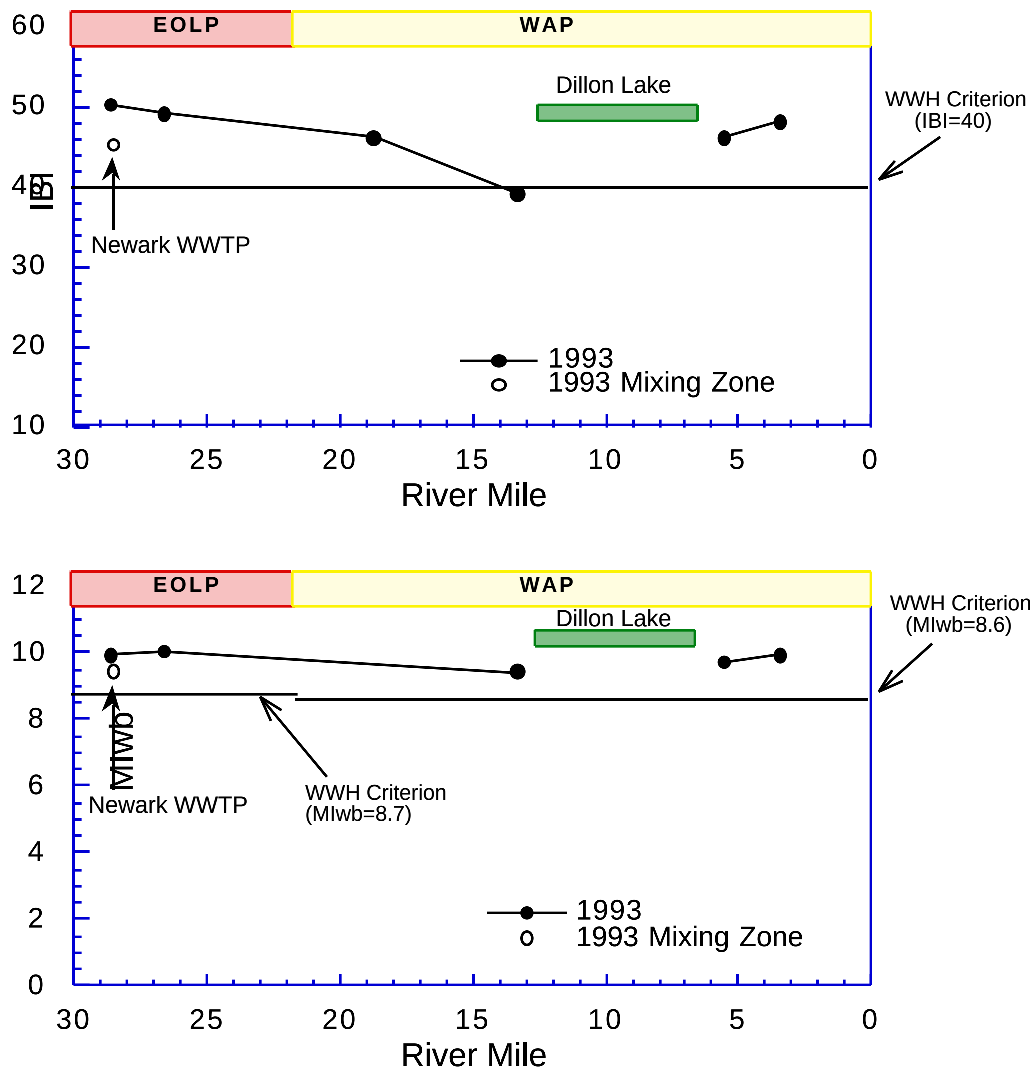


Figure 8. Longitudinal performance of the Index of Biotic Integrity (IBI, upper plot) and the Modified Index of Well-being (MIwb, lower plot) within the Licking River mainstem, 1993.

# Big Run

### *Physical Habitat for Aquatic Life*

- During the 1993 field sampling efforts the macrohabitats of Big Run were evaluated at one sampling station located at RM 5.0 (Prior Rd.). Nearly every aspect of the physical habitat of Big Run appeared diminished, and was reflected in a QHEI value of 40.5. High and moderate influence modified habitat attributes were predominant, primarily influenced by past channelization and land use within the subbasin (Table 8). The substrates were primarily silts, sand, and pea gravel and channel development was limited. The poor condition of the macrohabitats within Big Run would likely exert a negative influence on the ambient biological performance.

### *Biological Assessment: Benthic Invertebrate Community*

- The benthic invertebrate assemblage of Big Run was evaluated at RM 5.1 (Prior Rd.). Predominant organisms from the natural substrates were corixids, midges, and two moderately tolerant taxa of hydropsychid caddisflies (*Cheummatopsyche sp.* and *Hydropsyche depruata* group) The QCTV value of 34.0 was consistent with ecoregional expectation. However, only six EPT taxa were collected which is below ecoregional expectation. As a consequence, the benthic invertebrate community received a narrative evaluation of fair. Deviation from ecoregional expectation appeared related to modified habitat and moderate nonpoint source enrichment.

### *Biological Assessment: Fish Community*

- A total of 415 fish comprised of 18 species was collected from Big Run at RM 5.0 (Prior Rd.) on August 8, 1993. The station was located within the headwaters of Big Run (*i.e.* drainage areas $\leq$20 miles$^2$), where only the IBI community index was employed to evaluate ambient biological condition (Ohio EPA 1989b).

- The numerically predominant fish species were: white sucker (29.6%), creek chub (22.4%), bluntnose minnow (15.9%), spotfin shiner (0.1%), and green sunfish (7.47%). Species that predominated in terms of biomass were: white sucker (49.3%), creek chub (30.1%), green sunfish (6.91%), bluntnose minnow (3.75%), and spotfin shiner (2.16%). Both in terms of relative abundance and biomass the fish community within Big Run was predominated by highly tolerant, omnivorous and generalized feeding species.

- Community performance as measured by the IBI was characterized as fair (IBI=30), and failed to achieve WWH biological criteria (Table 10). This reach appeared channel modified and the substrates where primarily shifting and unstable sand, pea gravel, and clayey silts. The predominant fish species encountered at this station have all demonstrated (due to their particular life history) the ability to thrive in silted and otherwise physically disturbed waters (Trautman 1981 and Smith 1979). The predominance of these and other species appeared related to degraded (simplified) macrohabitats.

# North Fork Licking River

## *Pollutant Loadings*

### Utica WWTP

- Utica WWTP utilizes a conventional activated sludge process to treat a design flow of 0.16 MGD. This process involves primary settling, aeration, secondary settling, chlorine contact, and $SO_2$ dechlorination before discharging to the North Fork Licking River at RM 17.0.

- Monthly Operating Report data since 1979, indicated elevated $BOD_5$ and TSS loads to the North Fork Licking River prior to the treatment improvements in 1984. After the plant upgrades were operational, $BOD_5$ and TSS loads were significantly reduced. Ammonia-N loads were not monitored until 1988, and have remained minimal since that time (Figure 9). Given fairly stable conduit flow through the treatment facility, the recent increase $NO_3$-N loadings is likely a result of improved nitrification. In comparison with all sources analyzed, the Utica WWTP contributed 73% (147 kg) of TSS, 54% (340 kg) of $BOD_5$, <1.0 % (4.5 kg) of $NH_3$-N and 100% (30.0 kg) of $NO_3$-N of the total third quarter loadings to North Fork Licking River.

### Centerburg WWTP

- Centerburg WWTP was designed to treat 0.2 MGD of influent wastewater. The plant treatment process consists of a trickling filter, solids reaeration, and a final clarifier prior to rapid sand filtration. The most recent upgrade at this facility occurred in May, 1989. The effluent is discharged to an unnamed tributary southeast of Centerburg which confluences with the North Fork Licking River at RM 38.08. The Ohio EPA has recently issued notices of violation to the city of Centerburg. The permit violations were due to hydraulic washouts caused by heavy rainfalls and problems with the sand filtration system.

- Data from MORs provided by the Centerburg WWTP since 1976 indicated low $BOD_5$ and TSS loads. Ammonia-N was not monitored until 1986, and since that time $NH_3$-N increased slightly the first two years followed by a downward trend after 1988. From 1991 through 1993, $NH_3$-N loads were minimal. Although water quality problems do exist during storm events, evidenced by periodic septic conditions within the receiving tributary, loadings from the Centerburg WWTP have recently been reduced (Figure 10). Third quarter 1993 total loadings revealed results very similar to those from Utica WWTP. Twenty-seven percent (54 kg) of TSS, 44% (280 kg) of $BOD_5$, and 2.4% (15 kg) of $NH_3$-N were released into North Fork from Centerburg WWTP.

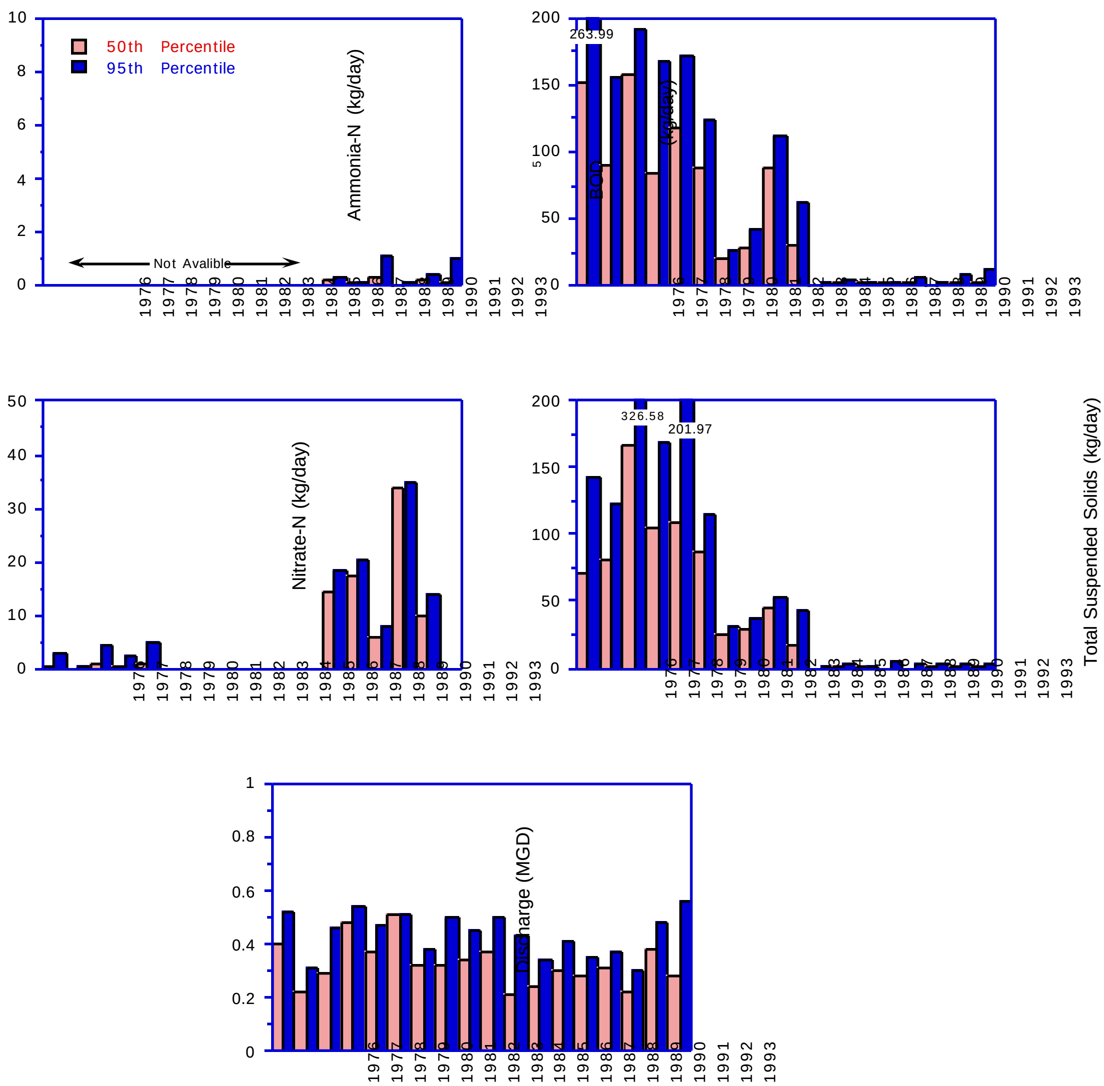


Figure 9. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, nitrate-N, $BOD_5$, and TSS from the Utica WWTP, 1978-1993, North Fork Licking River.

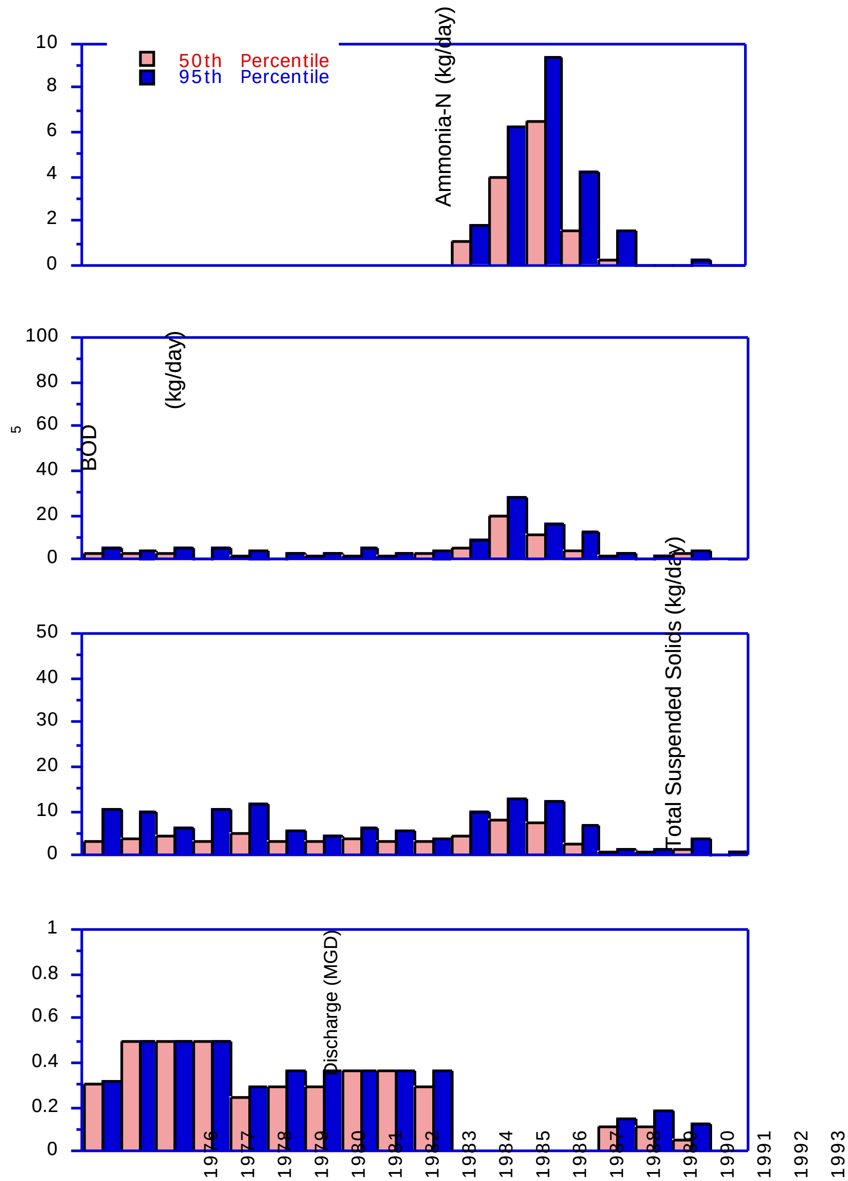


Figure 10. Annual third quarter 50th and 95th percentile discharge and pollutant loading of ammonia-N, $BOD_5$, TSS from the Centerburg WWTP, 1978-1993, North Fork Licking River.

### *Chemical Water Quality*

- The 1993 North Fork Licking River chemical sampling effort included replicate samples collected at six stations between RM 23.9 (Dunlop Road) and RM 0.2 (near mouth). Fecal coliform counts in excess of PCR criterion were the only water quality exceedences encountered during the 1993 sampling effort (Table 5). Five exceedences were encountered at five stations between RM 17.1 (downstream Utica WWTP) and RM 0.20 (Fleek Ave.). All but one of the fecal coliform exceedences were recorded on July 12, and appeared related to elevated stream flow, and likely reflected inputs from CSOs, WWTP by-passes, or other diffuse sources. All other water column parameters analyzed were well within Ohio WQS. No significant impact to the chemical integrity of the water column was apparent from Utica WWTP, Centerburg WWTP, and Owens Corning/City of Newark Landfills.

### *Sediment Chemistry*

- To evaluate the extent of sediment contamination within the North Fork Licking River, and to characterize the influence from the Owens Corning/City of Newark landfill complex, sediment samples were collected from three locations, RM 2.28 (upstream Owens Corning/Newark landfills), RM 1.64 (downstream Owens Corning/Newark landfills), and RM 0.2 (adjacent Fleek Ave.) Chemical analysis included selected heavy metals and semi-volatile organic compounds.

- Sediment metals scans at RM 2.28 and RM 1.64 found arsenic at elevated levels within the North Fork Licking River (Table 11). Elevated concentrations of arsenic were detected both upstream and downstream of the Owens Corning/Newark landfills, and were likely reflective of background levels associated with past agricultural use of arsenic based pesticides herbicides, and defoliants. Though concentrations were ranked as elevated (Kelly and Hite 1984) the ambient levels observed were below the ER-M reported by Long and Morgan (1991). A sediment organic scan for priority pollutants was conducted at three stations on the North Fork Licking River. The results from the analysis indicated that all organic parameters analyzed occurred at concentrations below laboratory detection limits (Table 12). Sediment analysis demonstrated that the Owens Corning/Newark landfills did not contribute heavy metal and/or organic contaminants to the North Fork Licking River.

Table 11. Dry weight concentrations of heavy metals (mg/kg) in sediments of the 1993 North Fork Licking River. All parameter concentrations (excluding Nickel) were ranked based on the stream classification system described by Kelly and Hite (1984). Concentrations preceded by an (*) exceeded the ER-M value described by Morgan and Long (1991).

| River Mile | As | Cd | Cr | Cu | Fe | Pb | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| ***North Fork Licking River*** | | | | | | | | |
| 2.28 | 13.0[c] | 0.40[a] | 11.2[a] | 17.8[a] | 17800[a] | 17.5[a] | 10.8 | 86.6[b] |
| 1.64 | 15.4[c] | 0.56[b] | 11.2[a] | 16.3[a] | 16600[a] | 16.2[a] | 13.4 | 82.5[b] |

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

Table 12. Dry weight concentrations of semi-volatile organic pollutants analysed in the sediments of the North Fork Licking River, 1993.

| Parameter | RM 2.28* | RM 1.64* | RM 0.20* |
|---|---|---|---|
| ***North Fork Licking River*** | | | |
| **PAH's** (mg/kg or ppm) | | | |
| Phenanthrene | ND (0.5) | ND (0.5) | ND (0.6) |
| Anthracene | ND (0.5) | ND (0.5) | ND (0.6) |
| Flouranthene | ND (0.5) | ND (0.5) | ND (0.6) |
| Pyrene | ND (0.5) | ND (0.5) | ND (0.6) |
| Benzo (A) Anthracene | ND (0.5) | ND (0.5) | ND (0.6) |
| Chrysene | ND (0.5) | ND (0.5) | ND (0.6) |
| Benzo (K) Flouranthene | ND (0.5) | ND (0.5) | ND (0.6) |
| Benzo (A) Pyrene | ND (0.5) | ND (0.5) | ND (0.6) |
| Indeno (1, 2, 3, - CD) Pyrene | ND (0.5) | ND (0.5) | ND (0.6) |
| Benzo (G, H, I) Perylene | ND (0.5) | ND (0.5) | ND (0.6) |
| **PHTHALATES** (mg/kg or ppm) | | | |
| Bis (2 - Ethylhexyl) Phthalate | ND (0.5) | ND (0.5) | ND (0.6) |

* Corrected method detection limits based on weight and dilutions of sample, non-detected (ND) are presented in parenthesis.

### *Physical Habitat for Aquatic Life*

- During the 1993 field sampling efforts the macrohabitats of the North Fork Licking River were evaluated at two sampling stations located at RM 2.5 (upstream Owens Corning Landfill) and RM 0.2 (Fleek Ave.). Both station achieved QHEI values at or above 60.0, which suggested that the macrohabitats of the North fork Licking River were of a sufficient quality to support and maintain a community of aquatic organisms consistent with WWH use designation (Rankin 1989).

- The upper most sampling station at RM 2.5 achieved a QHEI score of 82.5, where warmwater habitat attributes were overwhelmingly predominant (Table 8). The macrohabitats encountered at RM 2.5 were diverse and characterized as being of high quality. This reach contained abundant coarse substrates, numerous riffle/run/pool complexes, excellent channel development, and a persistent wooded riparian corridor.

- The condition of the physical habitats encountered at RM 0.2 were diminished in comparison to the upstream station. The lower reach of North Fork Licking River has been subject to channelization and associated maintenance activities through the city of Newark. The impact of these activities were reflected in a reduced QHEI value of 60.0. Despite the abundance of high and moderate influence modified habitat characteristics, minimum habitat integrity was maintained.

### *Biological Assessment: Benthic Invertebrate Community*

- Benthic macroinvertebrate community samples were collected at RM 2.8 (Upstream Owens Corning /Newark Landfills) and RM 0.2 (Fleek Ave.) from the North Fork Licking River. The quantitative artificial substrate sampling at RM 2.8 yielded an ICI score of 44. The station was located downstream from the dam at Hornsmill/Waterworks Rd. Physical recovery from past channelization was evident, with good riffle development and fair margin quality. The natural substrates yielded a QCTV score of 38.6 with eleven EPT taxa. Community performance at this station was characterized as good, consistent with the WWH biological criteria.

- The station at RM 0.2 was located downstream from numerous CSOs from the city of Newark and Owens Corning/Newark Landfills. This station was highly channel modified, and maintained through the city of Newark. The river channel was generally shallow, wide, and of a fairly uniform cross-section. The quantitative artificial substrate samplers were lost at this station, thus ambient biological evaluation was based upon qualitative sampling from the natural substrates. The qualitative sampling yielded a QCTV score of 32.4 with seven EPT taxa. Midges and *Stenacron sp.*(a moderately tolerant mayfly) were predominant taxa collected from the natural substrates. Qualitative indices from this station were not consistent the WWH biological criteria (based upon ecoregional expectations) and received a narrative evaluation of fair. The benthic macroinvertebrate community appeared to integrate modest nutrient inputs from Newark's CSOs

### *Biological Assessment: Fish Community*

- A total of 2,173 fish comprised of 36 species and three hybrids was collected from North Fork Licking River, between July 27 and September 16, 1993. The sampling effort included two stations located at RM 0.2 (Fleek Ave.) and RM 2.5 (upstream of Owens Corning and Newark landfills).

- The numerically predominant fish species were: northern hog sucker (13.2%), central stoneroller (10.2%), black redhorse (9.28%), sand shiner (7.85%), and gizzard shad (5.86%). Species that predominated in terms of biomass were: black redhorse (25.0%), common carp (17.0%), northern hog sucker (11.4%), gizzard shad (10.0%), and white sucker (11.4%).

- In terms of relative abundance moderately intolerant (northern hog sucker and sand shiner) and highly intolerant (black redhorse) species were well represented within the fish assemblage. The abundance of the central stoneroller, a herbivorous species, was likely an indication of modest nutrient enrichment, particularly within the lower reach of the North Fork Licking River. In terms of biomass, the predominance of the black redhorse was highly significant. The black redhorse is a *signature species* of diverse and well organized (high quality) fish communities within Ohio. Typically, the common carp is the predominate component of the biomass within the fish assemblage of Ohio’s medium to large river systems; including many of the state’s *best* streams. However, within the North Fork Licking River the highly intolerant black redhorse was predominant (in terms of biomass), an uncommon phenomenon, and its abundance was indicative of a high quality water resource. Both in terms of relative abundance and biomass the fish community within the areas investigated was predominated by sensitive sucker and minnow species.

- Fish community samples from the North Fork Licking River were collected with the standard boat sampling methodology, where both the MIwb and the IBI community indices were employed to evaluate ambient biological condition (Ohio EPA 1989b). Fish community indices and narrative evaluations ranged between exceptional (MIwb=10.9; IBI=51) at RM 2.5 and very good (MIwb=9.4; IBI=46) at RM 0.2 (Table 10). Community performance as measured by the MIwb and IBI exceeded the WWH biological criteria at both sampling stations.

- Longitudinal performance of the fish community portrayed a modest decline near the confluence at RM 0.2 (Fleek Ave.), though performance consistent with WWH biological criteria was maintained. The observed decline appeared related to the diminished habitats encountered at this station. The lower reach of the North Fork Licking River appeared highly channel modified through the city of Newark. This segment has been dredged and the channel width has been significantly increased to accommodate high river flows. The modified character and associated maintenance activities resulted in reduced habitat quality in comparison to the sampling station upstream. The fish community appeared to integrate the change in condition of physical habitat. However, given the high level integrity of the macrohabitats generally encountered upstream within the North Fork Licking River subbasin, the influence of this relatively small highly modified reach appeared insignificant. Typically, streams with relatively intact stream habitat have demonstrated the ability to support good fish communities in short stretches of degraded habitat (Rankin 1989 and Rankin 1995); the areas being populated and utilized by emigrants from more the productive, high quality areas.

## Vance Creek

### *Physical Habitat for Aquatic Life*

- During the 1993 field sampling efforts the macrohabitats of Vance Creek were evaluated at one station located at RM 0.7 (Beger Rd.), and achieved a QHEI score 59.5. Both warmwater and modified habitat attributes occurred, though neither were predominant (Table 8). The sampling reach was channel modified in the past, however, physical recovery appeared underway. Positive aspects of stream habitat included modest development of riffle/run/pool complexes and low embeddedness of coarse substrates. Several components of diminished macrohabitats were evident, related to past channelization and adjacent land use, and included: greatly limited channel heterogeneity, lack of mixed current velocities, and low/no functional sinuosity. Generally, the macrohabitats encountered at this station were of a diminished quality, however, minimum integrity appeared to be maintained.

### *Biological Assessment: Benthic Macroinvertebrate Community*

- The qualitative sample collected from Vance Creek RM 0.7 yielded a median QCTV score of 38.6 with 12 EPT taxa. Qualitative community indices from this station were consistent the WWH biological criteria, based upon ecoregional expectation. The natural substrates at this site were predominated by caddisflies, water pennies, and heptagenid mayflies. The benthic macroinvertebrate community was characterized as good.

### *Biological Assessment: Fish Community*

- Fish community data were collected from Vance Creek at RM 0.7. Vance Creek possesses a drainage are less than 20 miles$^2$ and is classified as a headwater stream, where only the IBI community index is employed to evaluate ambient biological condition. Community performance as measured by the IBI was characterized as very good (IBI=48) (Table 10). The fish assemblage demonstrated structural and functional organization consistent with the WWH biological criteria.

## Sycamore Creek

### *Physical Habitat for Aquatic Life*

- During the 1993 sampling effort the macrohabitats of Sycamore Creek were evaluated at one sampling station located at RM 0.1 (Vance Rd.), and achieved a QHEI value of 80.0. Warmwater habitat attributes were predominant and included: abundant coarse substrates, well developed channel, high/moderate functional sinuosity, and abundant pooled areas (Table 8). The only limiting aspect of instream habitat was a moderate embedding of coarse substrates. The macrohabitats encountered at RM 0.1 appeared fully capable of supporting a community of aquatic organisms consistent with the WWH use designation.

### *Biological Assessment: Benthic Macroinvertebrate Community*

- Qualitative benthic macroinvertebrate community samples were collected from Sycamore Creek at RM 0.1. This station achieved the highest QCTV score (38.9) and highest number of EPT taxa (19) of the three smaller tributaries sampled in the Licking River study area. Caddisflies and *Isonychia sp.* (mayfly) were the predominant organisms on the natural substrates. This site was evaluated as very good.

### *Biological Assessment: Fish Community*

- Fish community data were collected from one station on Sycamore Creek at RM 0.1 (Vance Rd.). Community indices and narrative evaluations were good/very good (MIwb=8.9; IBI=48) (Table 10). The fish assemblage demonstrated structural and functional organization consistent with the WWH biological criteria.

## South Fork Licking River

### *Pollutant Loadings*

**Pataskala WWTP**

- The Pataskala WWTP was constructed to replace the previous facultative lagoon based waste treatment facility. The upgraded treatment facility commenced operation in May, 1992, with a design capacity of 0.80 MGD. The treatment process involves screening, oxidation ditch/extended aeration, clarifiers, ultraviolet disinfection, cascade aeration, aerobic digestion, and sludge drying beds. In addition, two lagoons were constructed for emergency use.

- The facility has only recently been operational, and thus a meaningful pollutant loadings trends assessment was not possible. Third quarter $BOD_5$ and TSS loadings from the old facility (lagoon based) were irregular, and ammonia-N was not monitored until 1987. The upgraded facility did not achieve effective waste treatment until the second year of operation (Figure 11). The Pataskala WWTP contributed 2.55% (74 kg) $NH_3$-N, 7.79% (480 kg) TSS, 5.87% (206 kg) $BOD_5$, and less than 0.08% (2.01 kg) of $NO_3$-N loadings to South Fork Licking River during third quarter 1993.

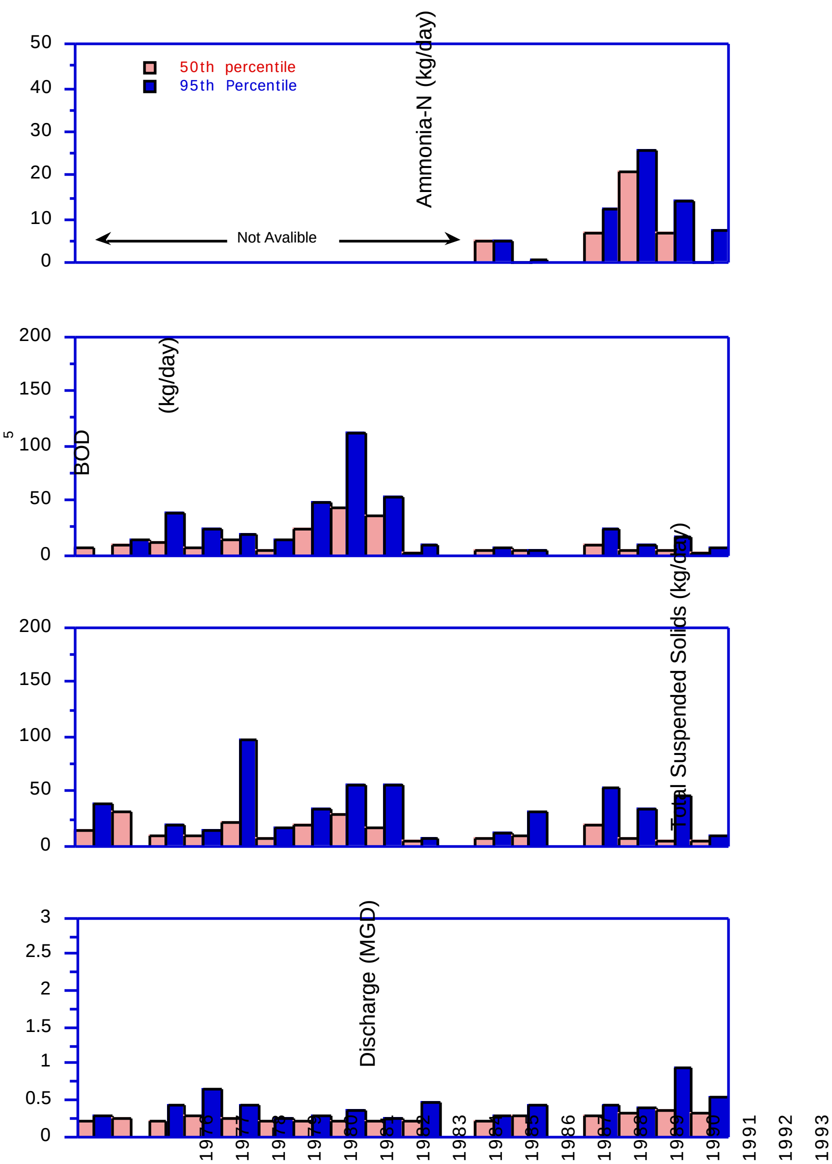


Figure 11. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, nitrate-N, TSS, and $BOD_5$ from the Pataskala WWTP, 1976-1993, South Fork Licking River.

**Buckeye Lake WWTP**

- Buckeye Lake WWTP is a secondary treatment facility with a design flow of 1.1 MGD. The treatment process involves primary and secondary treatment, screening, primary settling, trickle filtration, solids contact channels, final clarification, chlorination/dechlorination, and post aeration before discharging to South Fork Licking River at RM 14.20. A 3.5 million gallon stormwater retention basin serves as a flow equalization basin during periods when flows exceed peak capacity.

- Monthly Operating Reports revealed no major permit violations. Problems have been found to exist with the septage receiving station and the sludge digesters, and are currently being investigated. Additionally, violations of chlorine were recorded in May, June, and July, 1993 and fecal coliform exceedences occurred in June and July, 1993. Nevertheless, these violations did not constitute a significant impact to the South Fork Licking River.

- Third quarter MOR data indicated that the loadings of both $BOD_5$ and TSS displayed similar trends. Loadings of these parameters were at the highest levels during the late-1970s, but a fairly steady decline was apparent through 1987. Between 1988 and 1993, TSS and $BOD_5$ appeared fairly stable. Possible treatment irregularities were evidenced by the recent erratic 95th percentile for TSS (Figure 12). Ammonia-N and $NO_3$-N were not monitored until 1987. Ammonia-N loads appeared fairly stable through the period of record. Nitrate-N loads appeared erratic and displayed a steady increase since 1990, likely reflecting improved nitrification. The Buckeye Lake WWTP contributed 39.1% (2408 kg) of the TSS, 64.5% (272 kg) of the $BOD_5$, 86.7% (2092 kg) of the $NO_3$-N, and <0.05% (1.4 kg) of $NH_3$-N loadings during the third quarter of 1993.

- A bioassay screening performed in May, 1993 revealed acute toxicity to *Ceriodaphnia dubia*. A follow-up test performed in September, 1993 indicated no acute toxicity from the 001 effluent. These results are consistent with the variable pollutant loadings within the period of record and were likely reflective of variable treatment efficiencies.

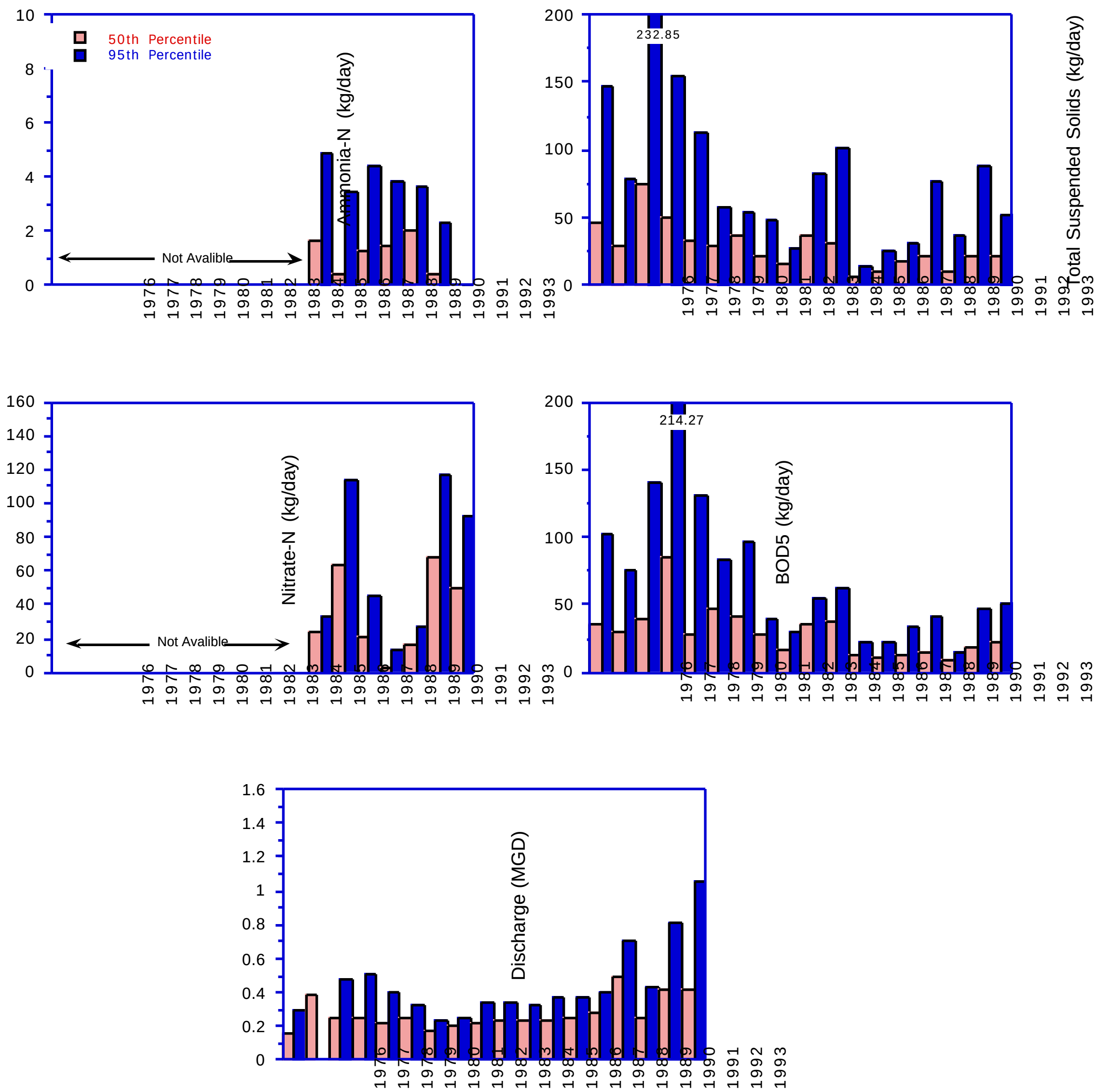


Figure 12. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, nitrate-N, TSS, and $BOD_5$ from the Buckeye Lake WWTP, 1976-1993, South Fork Licking River.

**Hebron WWTP**

- The Hebron WWTP was constructed in 1964 and upgraded in 1990, with a design flow of 0.675 MGD. The treatment process involves grit removal, extended aeration, clarification, tertiary filtration, anaerobic sludge digestion, chlorination/de-chlorination, and post aeration. The facility receives 0.238 MGD pretreated influent from industrial sources. In 1993, the average flow through the plant was 0.43 MGD. The treated wastewater is discharged to Beaver Run which confluences with South Fork Licking River at RM 9.03.

- Third quarter median loads of $NH_3$-N, TSS, and $BOD_5$ displayed similar, decreasing trends (Figure 13). However, variable effluent quality was evidenced by recent erratic and elevated 95th percentile (maximum) loadings of TSS and $NH_3$-N, likely reflective of treatment disruptions. Compliance records indicated that heavy metal violations of mercury, cadmium, and zinc occurred in 1991. In addition, Ohio EPA field staff recently documented the discharge of untreated sewage to Beaver Run on September 20, 1993. The pretreatment industrial entities serviced by Hebron WWTP contribute 40% of the influent, and are likely the cause of the recent treatment irregularities.

- The Hebron WWTP contributed 46.2% (1334 kg) $NH_3$-N, 1.1% (26.4 kg) of $NO_3$-N, 39.8% (2451 kg) TSS, and 18.9% (2272 kg) of the $BOD_5$ loadings to South Fork Licking River during third quarter 1993.

- The Hebron WWTP was required to perform monthly acute bioassays on *Ceriodaphnia* and quarterly chronic bioassays on *Ceriodaphnia* and fathead minnows, with Allowable Effluent Toxicity (AET) values of 0.3 $TU_a$ (30% adverse effects) and 1.1 $TU_c$. A review of biomonitoring data collected by the entity from September 1991 to August 1992 (Table 13) showed only one of the acute tests exceeding 0.3 $TU_a$, while three of the four chronic tests exceeded the 1.1 $TU_c$. Based on qualitative benthic invertebrate samples collected in 1988, impairment of the WWH aquatic life was observed downstream of Hebron WWTP. Also, residual chlorine may have been a causal agent for some of the observed toxicity, since a dechlorinated sample produced a significantly reduced toxic response compared to a chlorinated sample in the bioassay screening tests. As a consequence, the Ohio EPA proposed that the Hebron WWTP take remedial steps and examine at treatment plant performance, general housekeeping practices, the plants pretreatment program, treatment chemicals, and a number of other potential causes of effluent toxicity. Currently the entity is reviewing its pretreatment program. Once the remedial program is complete, compliance monitoring for chronic tests will be enforced.

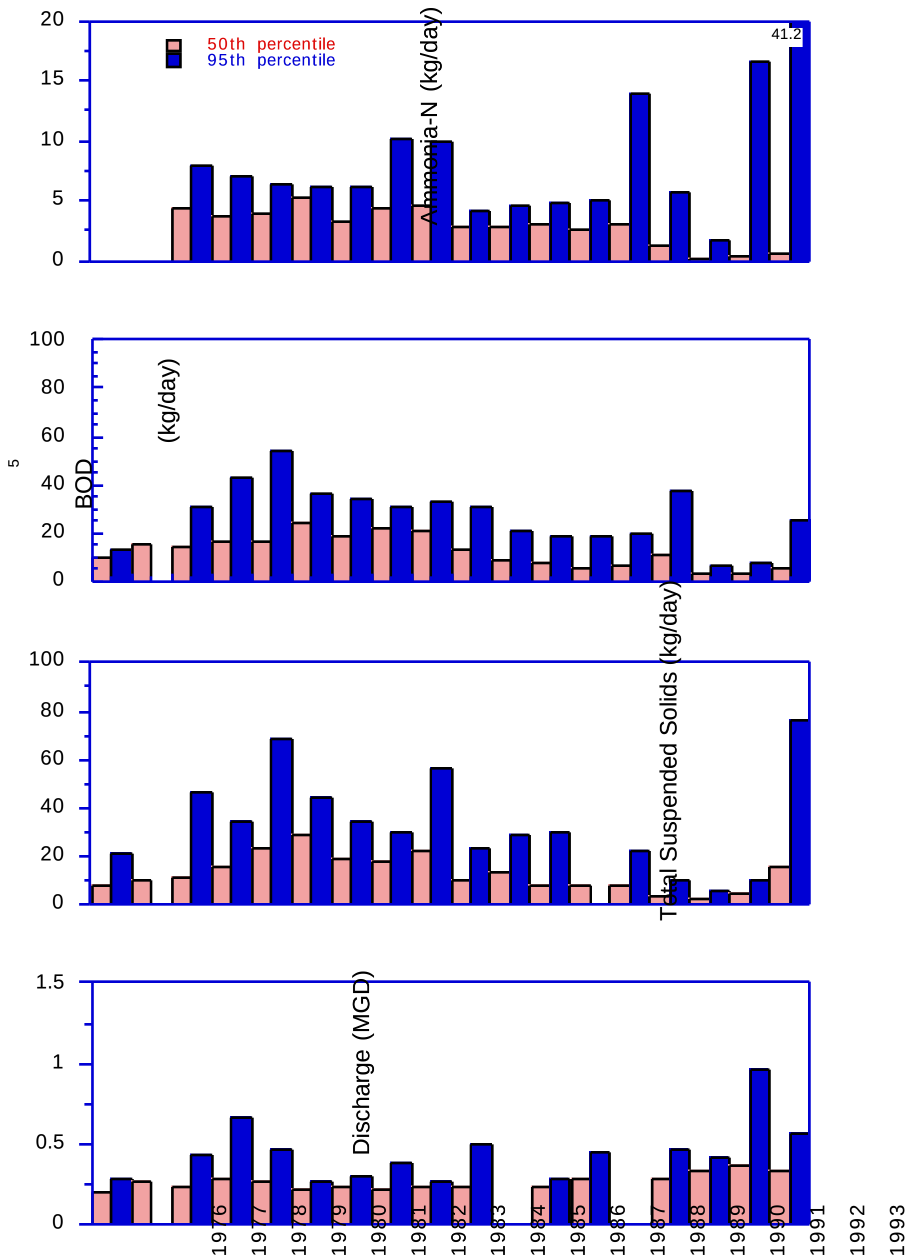


Figure 13. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, TSS, and $BOD_5$ from the Hebron WWTP, 1976-1993, South Fork Licking River.

Table 13. Bioassay derived chronic ($TU_c$) and acute ($TU_a$) toxicity data from Hebron WWTP.

| | *Ceriodapnia* | | | Fathead Minnow | | |
|---|---|---|---|---|---|---|
| | **Percent % Affected** | | $TU_c$ | **Percent % Affected** | | $TU_c$ |
| Date | Upst. | Farfield | Effluent | Upst. | Farfield | Effluent |
| December 91 | 0 | 0 | 1.1 | 2 | 8 | <1.0 |
| February 92 | 0 | Reduct.* | >5.0 | 0 | 2 | <1.0 |
| May 92 | 0 | Reduct.* | >5.0 | 23 | 13 | 1.1 |
| May 92(dechlor.) | - | - | 1.1 | - | - | <1.0 |
| August 92 | 0 | 0 | 3.5 | 3 | 0 | <1.0 |

*-reduction in the mean number of young.

| | *Ceriodaphnia* | | | |
|---|---|---|---|---|
| | **Percent % Affected** | | | $TU_a$ |
| Date | Upst. | Nearfield | Effluent | Effluent |
| September 91 | 0 | 100 | 100 | 7.7 |
| October 91 | 0 | 0 | 0 | <1.0 |
| December 91 | 0 | 0 | 0 | <1.0 |
| January 92 | 0 | 0 | 0 | <1.0 |
| March 92 | 0 | 0 | 0 | <1.0 |
| April 92 | 0 | 0 | 0 | <1.0 |
| June 92 | 0 | 0 | 0 | <1.0 |
| July 92 | 0 | 0 | 0 | <1.0 |

**Heath Wastewater Treatment Plant**

- The Heath WWTP is an advanced secondary wastewater treatment facility with a design flow of 1.75 MGD. The treatment process involves screening, grit removal, primary treatment, secondary treatment, rapid sand filtration and chlorination/dechlorination. The final effluent is discharged to the South Fork Licking River at RM 2.20. The current treatment plant was constructed in 1961 and was expanded to its present size in 1971. In 1985, final effluent limits were issued for Heath WWTP requiring nitrification and advanced secondary level $BOD_5$ removal for the summer months. Unable to meet these limits, the city of Heath received Findings and Orders from the Ohio EPA on March 6, 1986. Following numerous permit violations, Heath entered into a Consent Order requiring them to follow an agreed upon construction schedule. Detailed plans and specifications were submitted, and Heath was granted a permit to install in order to improve the facility in April, 1990. Treatment improvements were initiated in 1991 and 1993.

- Mean and maximum third quarter pollutant loadings revealed no distinct trend for the discharge constituents from Heath WWTP, despite a modest decline in conduit flow (Figure 14) . Peak loads appeared to coincide with violations occurring throughout the period of record. Median loads did not appear particularly elevated, however, recent extreme 95th percentile loadings of $NH_3$-N, $BOD_5$, and TSS evidenced variable treatment efficacy. Maximum loads of $NH_3$-N occurred after treatment upgrades, and suggested problems with the nitrification process. The Heath treatment facility contributed 41.7% (1205 kg) of the $NH_3$-N, 12% (288 kg) of $NO_3$-N, 13.4% (825 kg) of the TSS, and 5.09% (178 kg) of the $BOD_5$ loadings to South Fork Licking River during the third quarter, 1993.

- The Heath WWTP effluent failed two of three acute toxicity tests (2.2 $TU_a$ and 3.1 $TU_a$) conducted in 1986. The treatment plant upgraded in July 1988. Monthly acute and quarterly chronic toxicity tests for one year with a trigger based on 1.0 $TU_a$ and 2.7 $TU_c$ were recommended. The entity conducted two chronic bioassays (November 1991 and March 1992) and six acute bioassays (from October 1991 to May 1992) and reported results < 1.0 $TU_c$ and < 1.0 $TU_c$ for all tests (Table 14). Two acute bioassays conducted in April and September 1993 by Ohio EPA personnel reported one effluent grab sample which resulted in 100% mortality to *Ceriodaphnia*. The other effluent grab and composite samples did not cause any adverse effects to either test organism.

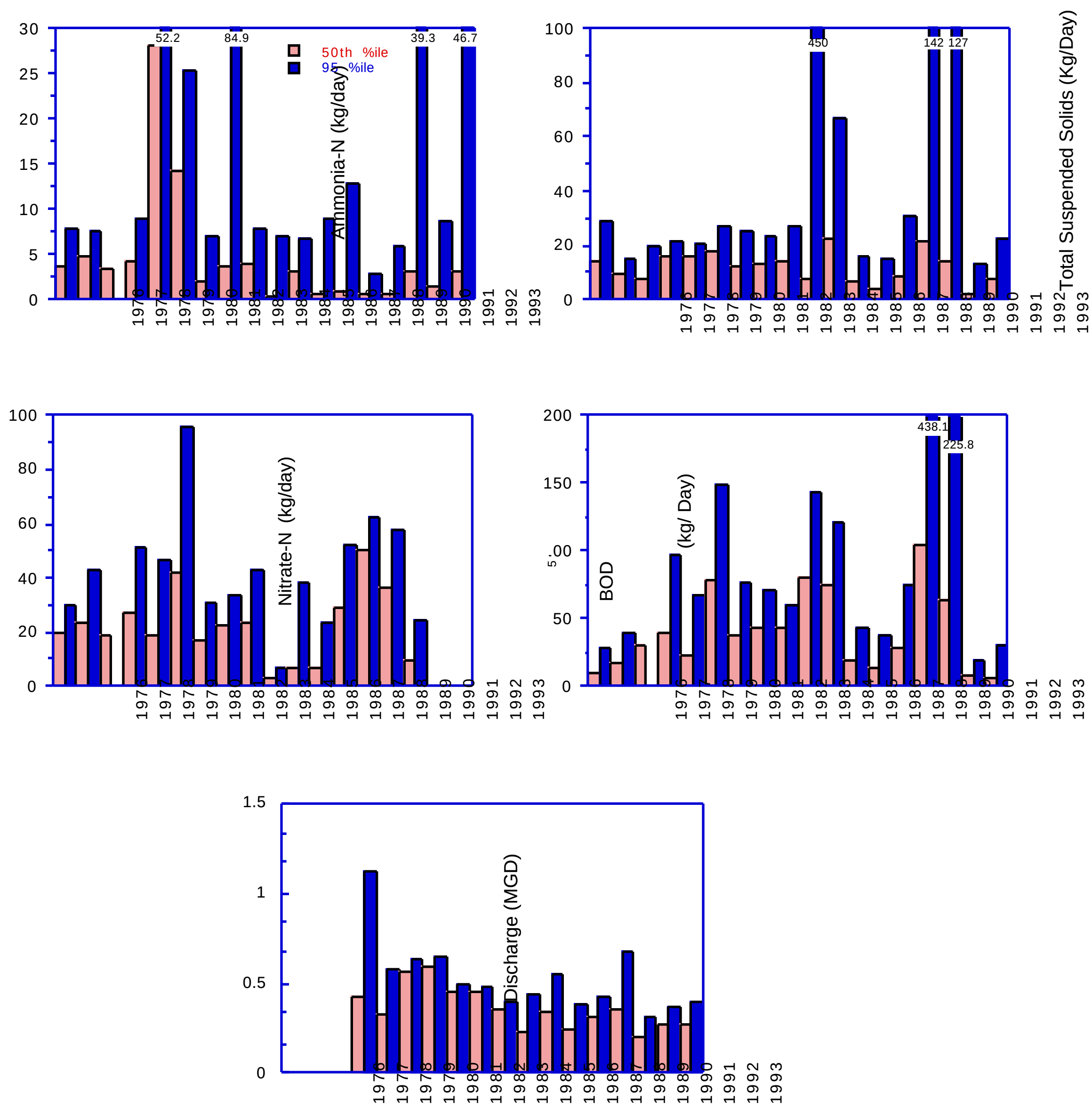


Figure 14. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, nitrate-N, TSS, and $BOD_5$ from the Heath WWTP, 1976-1993, South Fork Licking River.

Table 14. Chronic (TUc) and acute (TUa) toxicity data collected by the Heath WWTP.

| | *Ceriodaphnia* | | | | Fathead Minnow | | | |
|---|---|---|---|---|---|---|---|---|
| | **Percent % Affected** | | | TUc | **Percent % Affected** | | | TUc |
| Date | Upst. | Near Field | Far Field | Effluent | Upst. | Near Field | Far Field | Effluent |
| November 91 | 0 | 0 | 0 | <1.0 | 8 | 0 | 5 | <1.0 |
| March 92 | 0 | 0 | 10 | <1.0 | 13 | 5 | 13 | <1.0 |

| | *Ceriodaphnia* | | |
|---|---|---|---|
| | **Percent % Affected** | | TUa |
| Date | Upst. | Near | Effluent |
| October 91 | 0 | 0 | <1.0 |
| December 91 | 5 | 0 | <1.0 |
| January 92 | 0 | 0 | <1.0 |
| February 92 | 0 | 0 | <1.0 |
| April 92 | 0 | 0 | <1.0 |
| May 92 | 0 | 5 | <1.0 |

***Chemical Water Quality***

- Replicate water column chemical grab samples were collected from 14 stations within the South Fork Licking River. The chemical sampling effort included 12 ambient, one mixing zone, and one effluent sample. River flow data from USGS gage stations located at RM 8.88 on South Fork Licking River indicated elevated stream flows throughout most of the 1993 sampling effort. The mean daily flows were generally above the estimated 80% duration (Figure 15).

- Four WWTP facilities (Pataskala, Buckeye Lake, Hebron, and Heath) discharge treated wastewater, either directly or indirectly, to the South Fork Licking River. The subbasin is also subject to nutrient and sediment inputs from agricultural and other diffuse pollutant sources. Additionally, observations from Ohio EPA field staff documented minor sources of nutrient and septic inputs from several failing home septic systems.

- Eleven exceedences of the primary contact fecal coliform criterion were recorded within the 1993 South Fork Licking River study area. Fecal coliform exceedences were encountered at nine sampling stations between RM 24.6 and RM 0.35 (Table 5). Eight of the fecal coliform exceedences were associated with elevated stream flow, encountered between July 12-29, 1993. These exceedences likely reflected inputs from CSOs, WWTP by-passes, flushed septic ditches, as well as other diffuse sources. Three of the fecal coliform exceedences did not appear associated with elevated stream flow and occurred on August 18, September 22, and October 8, 1993, downstream of both the Buckeye Lake WWTP (RM 12.96) and Heath WWTP (RM 1.9), and near the mouth (RM 0.35). The exceedences associated with wastewater treatment facilities likely reflected variable treatment efficacy. Given the numerous stormwater bypasses and overflows within the lower reach of the South Fork Licking River through the city of Newark, the exceedence encountered at RM 0.35 appeared related to modest dry flow CSO and/or bypass discharge from Newark WWTP.

- Concentrations of $NH_3$-N within the the upper portion of the South Fork River study area (upstream of Buckeye Lake WWTP) were at or near detection limits, well below WQ standards. All $NH_3$-N exceedences were limited to the lower portion of the South Fork study area (Buckeye Lake WWTP to the mouth), and included four $NH_3$-N exceedences of the 30 day average chronic criterion (Figure 16 and Table 5). Two of the $NH_3$-N exceedences occurred downstream of Heath WWTP at RM 1.86 and RM 1.45. The elevated concentrations of unionized ammonia at these stations occurred on July 28, 1993 (a high river flow date) and appeared related to treatment to disruptions associated with surface runoff. The remaining $NH_3$-N exceedences occurred downstream of Buckeye Lake WWTP (RM 12.96) and downstream of Beaver Run/Hebron WWTP (RM 8.88). These exceedences were recorded on August 17-18, 1993 at which time the stream flow of the South Fork Licking River was not elevated, and can only be attributed to marginal waste treatment at these entities. Replicate effluent samples from Buckeye Lake WWTP indicated one permit violation of $NH_3$-N (19.5 mg/l) on August 17.

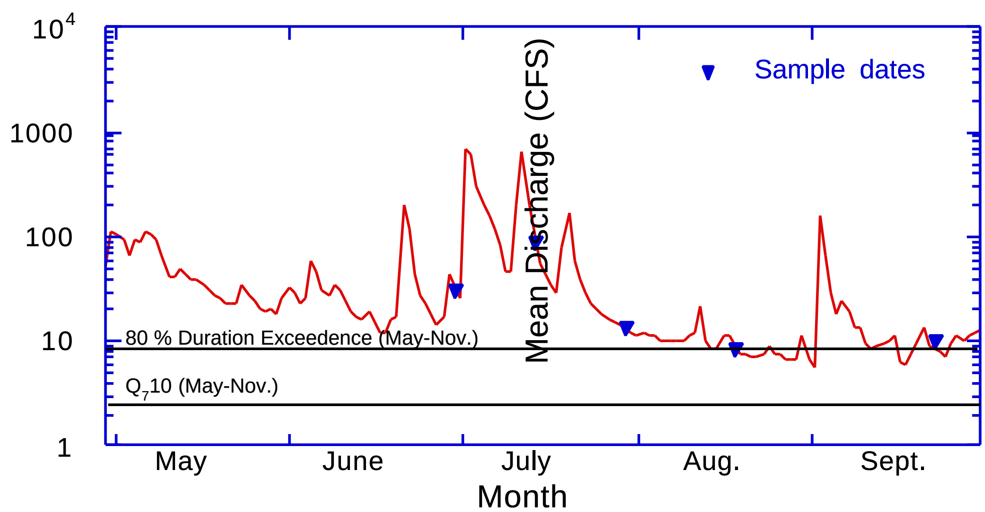


Figure 15 Flow hydrograph for the South Fork Licking River at Hebron, May through September 1993. May through November low-flow conditions ($Q_7 10$ [1.4 cfs] and 80% duration flow [13 cfs] for the period of record are indicated on the hydrograph (USGS 1993 and USGS 1981).

- Nitrate-N, total phosphorus, and $BOD_5$ increased longitudinally, with a marked increase downstream of Buckeye Lake WWTP (Figure 16). Total Suspended Solids (TSS) concentrations were low and longitudinally stable the within the upper portion of the South Fork Licking River study area. Downstream of both the Buckeye Lake WWTP and Beaver Run (Hebron WWTP) TSS demonstrated a marked increase, but ambient levels were rapidly reduced further downstream.

- Despite fairly distinct nutrient inputs downstream of the Hebron WWTP, Heath WWTP, and most significantly Buckeye Lake WWTP, adequate D.O. levels were generally maintained throughout the study area. Only one exceedence of the minimum D.O. standard was recorded within the South Fork Licking River study area at RM 11.63 (downstream Buckeye Lake WWTP) (Table 5). The effect of nutrient inputs from Buckeye Lake WWTP may have been exacerbated by the low gradient, highly modified character of the South Fork Licking River surrounding the discharge point. Typically the South Fork contained numerous riffle/run/pool complexes and abundance of coarse substrates. Swift stream flow (higher gradient), frequent agitation and ample substrates would likely maintain an assimilative capacity much greater than that of the highly modified and silted reach between RM 18.9 and RM 11.7. Though adequate D.O. was generally maintained, a fairly distinct D.O. sag was evident within and downstream of the channelized reach (Figure 16). The discharge of oxygen demanding wastes from Buckeye Lake WWTP and Hebron WWTP coupled with the reduced assimilative capacity of the modified reach likely resulted in the lower mean D.O. values observed.

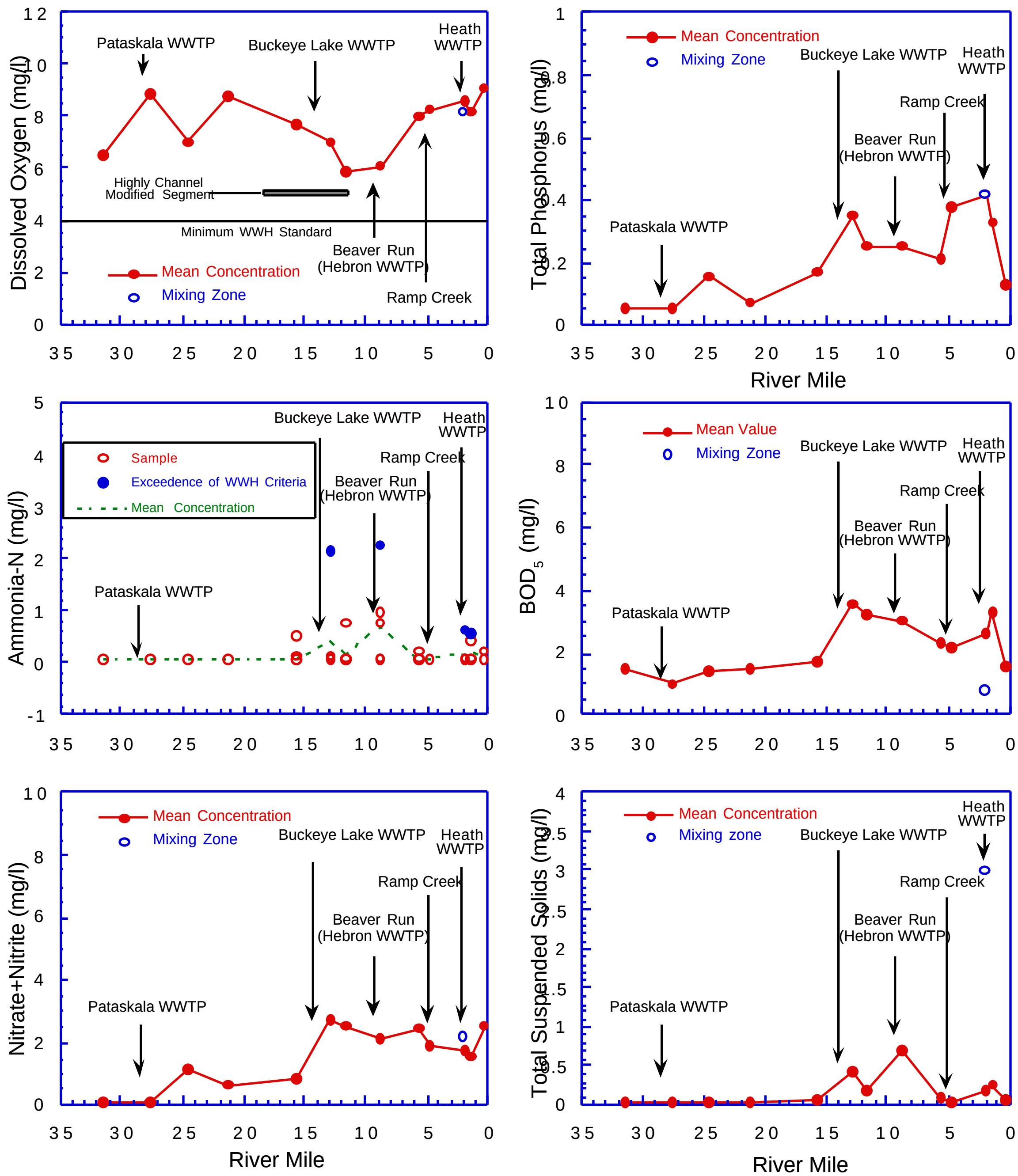


Figure 16. Longitudinal mean concentrations of dissolved oxygen, ammonia-N, nitrate-N, total phosphorus, $BOD_5$, and TSS in the South Fork Licking River study area, 1993.

***Sediment Chemistry***

- To evaluate the extent of sediment contamination within the South Fork Licking River, sediment samples were collected at four locations. Sediment analysis included selected heavy metals, semi-volatile organic compounds, PCBs, and pesticides. All four sediment sampling stations received sediment metal analysis. Two of the four stations were analyzed for semi-volatile, PCBs, and pesticide residues, while the remaining two organic sediment stations were subject to semi-volatile analysis only.

- Nearly all metal parameters within the South Fork Licking River were found to occur at concentrations ranked as non-elevated or slightly elevated (Kelly and Hite 1984). Only zinc and iron were detected at levels ranked as elevated (Table 15). The elevated iron value was recorded at RM 31.55, and was most likely reflective of natural background levels. Zinc was elevated at RM 12.96 (downstream of Buckeye Lake WWTP). The source of zinc contamination was not clear. The concentration observed may have been a result of the low gradient and highly modified character of the South Fork Licking River between RM 18.9 and RM 11.7. Portions of this reach contained considerable deposits of clayey silts as a result of the reduced gradient. Contaminants bound to the exchange complexes of colloidal solids would likely accumulate through increased deposition of bedload and suspended sediments. Additionally, given the silt and clay deposits, sediments samples collected at RM 12.96 likely contained a higher percentage of colloidal clays which possess a greater potential to bind cations. Regardless of the ultimate source(s) or cause(s), the concentrations of heavy metals at all stations were well below the ER-M values presented by Morgan and Long (1991), and no impact associated with sediment metal contamination was evident within the South Fork Licking River.

- Results from the sediment organic analysis indicated that the majority of organic parameters occurred at concentrations at or near laboratory detection limits (Table 16). One Polycyclic Aromatic Hydrocarbon (PAH) was found at a level above the detections limits, however, the ambient concentrations within the sediments were quite low, and well below the ER-M values presented by Morgon and Long (1991). Though PAHs are known carcinogens, the level of PAH contamination within the South Fork Licking River appeared insignificant. Several organochlorine pesticide residues were found at concentrations above laboratory detection limits, though ambient levels were ranked as non-elevated (Kelly and Hite 1984), and were well below the ER-M values provided by Morgon and Long (1991). Given the historical and prevailing agricultural land use within the South Fork Licking River basin the occurrence of organochlorine pesticide residues within the sediments is likely related to past agricultural application of these persistent compounds.

Table 15. Dry weight concentrations of heavy metals (mg/kg) in sediments of the South Fork Licking River, 1993. All parameter concentrations (excluding Nickel) were ranked based on the stream classification system described by Kelly and Hite (1984).

| River Mile | As | Cd | Cr | Cu | Fe | Pb | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| ***South Fork Licking River*** | | | | | | | | |
| 31.55 | 10.4[b] | 0.59[b] | 16.7[b] | 18.0[a] | 24000[c] | 14.7[a] | 15.6 | 93.3[b] |
| 12.96 | 10.4[b] | 0.43[a] | 10.2[a] | 13.5[a] | 16700[a] | 13.0[a] | 12.3 | 125.0[c] |
| 5.71 | 8.0[b] | 0.34[a] | 9.3[a] | 9.9[a] | 13400[a] | 9.6[a] | 10.0 | 93.3[b] |
| 4.75 | 11.1[b] | 0.58[a] | 12.3[a] | 17.8[a] | 18700[b] | 14.0[a] | 16.6 | 99.2[b] |

[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.

Table 16. Dry weight concentrations of semi-volatile organic and pesticide pollutants detected in the sediments of the South Fork Licking River, 1993.

| Parameter | RM 31.55* | RM 12.96* | RM 5.71* | RM 4.75* |
|---|---|---|---|---|
| ***South Fork Licking River*** | | | | |
| **PAHs** (mg/kg or ppm) | | | | |
| Phenanthrene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Anthracene | ND (0.5) | ND (3.0) | ND (3.0) | ND (0.5) |
| Flouranthene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Pyrene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Benzo (A) Anthracene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Chrysene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Benzo (K) Fluoranthene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Benzo (A) Pyrene | ND (0.5) | ND (0.6) | 0.7 | ND (0.5) |
| Indeno (1, 2, 3, - CD) Pyrene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| Benzo (G, H, I) Perylene | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |
| **PHTHALATES** (mg/kg or ppm) | | | | |
| Bis (2 - Ethylhexyl) Phthalate | ND (0.5) | ND (0.6) | ND (0.6) | ND (0.5) |

Table 16. continued.

| **Parameter** | **RM 5.71*** | **RM 4.75*** |
|---|---|---|
| ***South Fork Licking River*** | | |
| **PESTICIDES and PCBs** (µg/kg or ppb) # | | |
| a - BHC | ND (0.6) | ND (0.57) |
| d - BHC | 3.45 | 1.79 |
| Heptachlor | ND (1.81) | ND (0.57) |
| Aldrin | ND (0.60) | ND (0.57) |
| Dieldrin | 1.83[a] | ND (0.57) |
| Endrin | ND (0.60) | ND (0.57) |
| Methoxychlor | ND (3.02) | ND (2.85) |
| Mirex | ND (3.02) | ND (2.85) |
| DDT (sum) ** | ND (1.81) | 4.5[a] |
| PCBs (total) | ND (30.20) | ND (28.54) |

\# All pesticide concentrations, unless indicated, were ranked with the following stream sediment classification system described by Kelly and Hite (1984). [a]Non-elevated; [b] Slightly elevated; [c]**highly elevated**; [d]**Extremely elevated**.

* Corrected method detection limits based on weight and dilutions of sample, non-detected (ND) are presented in parenthesis.

** Sum DDT is the total of 4, 4’ - DDE, 4, 4’ -DDD, and 4, 4’ - DDT.

### *Physical Habitat for Aquatic Life*

- During the 1993 field sampling efforts the macrohabitats of the South Fork Licking River were evaluated at 12 fish sampling stations. Qualitative Habitat Evaluation Index values ranged between 39.0 at RM 13.1 (downstream Buckeye Lake WWTP) and 85.5 at RM 4.3 (downstream Ramp Creek), with a mean reach QHEI score of 69.7. A mean QHEI value greater than 60.0 suggested that the macrohabitats of the South Fork Licking River were of a sufficient quality to support and maintain a community of aquatic organisms consistent with the WWH use designation (Rankin 1989).

- Macrohabitats of fairly high quality were generally maintained throughout the study area. Warmwater habitat attributes were predominant, reflective of the overall physical heterogeneity encountered at the majority of the sampling stations (Table 8). Positive aspects of near and instream habitats of the South Fork Licking River study area included: abundant coarse substrates, good/fair channel development, moderate to high functional sinuosity, abundant instream cover, persistent wooded riparian corridor, and numerous riffle/run/pool complexes.

- The reach between approximately RM 18.9 and RM 11.7 contained habitats of a significantly diminished quality. This 7.2 mile segment was located south of US 40/north of Buckeye Lake within southern Licking county, and contained two sampling stations (RM 15.4 and RM 13.1).

This reach retained much evidence of past channelization, with little recovery evident. Within this highly modified segment the active channel appeared trenched and trapezoidal, greatly limiting both channel development and the positive aspects of functional sinuosity. The substrates within this segment were primarily shifting and unstable sand and silts, and instream cover was sparse. In addition, the majority of this reach lacked a mature wooded riparian corridor. The predominance of these moderate and high influence modified habitat attributes resulted in QHEI values near or below 60.0 (Table 8). Compounding the habitat deficit observed, as well as limiting the natural recovery process from direct physical modification, was the reduced gradient of this segment. A mean gradient of 2.5 feet/mile (study area mean was 8.4 feet/mile), increased the retention time of suspended and bedload sediments entering this reach, allowing considerable deposition of sands and clayey silts. The resulting accretion has reduced depth heterogeneity and embedded natural substrates.

- Though both the stations at RM 15.3 and RM 13.1 were located within this modified reach, the macrohabitats at RM 13.1 appeared to be in a much worsened condition than that encountered at RM 15.1. Very little recovery was evident at RM 13.1, reflected in a QHEI value of 39.0. In contrast, the macrohabitats encountered at RM 15.1 (though highly modified) demonstrated limited physical recovery, evidenced by a QHEI value of 59.5. Typically, in streams where quality habitat is predominant, relatively short segments of diminished habitat are populated and utilized by emigrant fishes from the more productive, physically intact areas (Rankin 1989 and Rankin 1995). However, given the extent of modification encountered between RM 18.9 and RM 11.7, it is likely that the diminished habitats of this 7.2 mile segment may have exerted a negative influence on ambient biological performance, particularly at RM 13.1.

- The station at RM 0.5 located within the lower segment of the South Fork Licking River. This reach was channelized, levied, and appeared actively maintained through the city of Newark. Despite the highly modified appearance of this segment many positive habitat attributes were maintained, reflected in a QHEI value of 60.1. Warmwater habitat attributes observed at this station included: abundant coarse (native and glacial) substrates, developed pooled areas, and minimal embedding of coarse substrates.

- In summary, despite the two highly modified segments, the over all integrity of the macrohabitats of the South Fork Licking River study area appeared maintained. Near and instream habitat of the majority of the study were generally diverse and reflective of a natural free flowing system, fully capable of supporting a community of aquatic organisms consistent with the WWH use designation.

### *Biological Assessment: Macroinvertebrate Community*

- Macroinvertebrates were collected in 1993 from the South Fork Licking River at 13 stations located between RM 31.6 and RM 0.4. The invertebrate community Index (ICI) scores and narrative evaluations ranged from 32 (marginally good) at RM 28.4 (Ust. Pataskala WWTP) to 46 (exceptional) at RM 2.2 (Heath WWTP mixing zone). Due to the loss of the artificial substrates at two stations (RM 31.6 and RM 24.1) qualitative benthic invertebrate samples were employed for the purpose of assessment. All stations contained a macroinvertebrate community that met or exceeded WWH biocriteria or qualitative ecoregional expectations (Table 9; Figure 17).

- There was no apparent impact to the macroinvertebrate community in the South Fork Licking River from the Pataskala WWTP. Upstream from the city of Pataskala at RM 31.6 the qualitative sample had a QCTV score of 38.7 with 10 EPT taxa, and received a narrative evaluation of good. The next downstream station located in Pataskala at RM 28.4 (upstream Pataskala WWTP performed at a level consistent with WWH biological criteria (ICI score of 32). The benthic macroinvertebrate community at RM 27.6 (downstream Pataskala WWTP) achieved an ICI score of 36, consistent with the WWH biological criteria.

- The proposed South-West Licking County regional WWTP is expected to discharge just upstream from Gale Road at RM 21.2. Two macroinvertebrate stations were set at RM 24.1 and RM 21.1 to evaluate preconstruction water quality conditions. The artificial substrates at RM 24.1 achieved an ICI score of 40. Upon retrieval, the quantitative samplers at RM 21.1 were found on the stream bank (vandalized). Macroinvertebrates collected from the natural substrates at RM 24.1 and 21.1 produced QCTV score of 35.7 and 37.1, with 15 and 11 EPT taxa, respectively. Both stations were evaluated as good in the 1993 survey.

- Stations located at RM 15.4 and RM 13.0 bracketed the discharge from Buckeye Lake WWTP. The ICI score dropped from 50 (exceptional) at RM 15.4 to 34 (good) at RM 13.0. The flow over the substrates was similar at these two sites. Although both sites were channelized with steep grassy banks, RM 15.4 showed indications of recovery with moderate riffle development and good margin quality. The condition of the the South Fork Licking River at RM 13.0 was more “ditch-like” with sparse riffle development and poor margin quality. Reductions in QCTV scores, 35.7 to 33.1, and total EPT taxa, 16 to 13, occurred between these up and downstream stations. The reduced condition of the benthic macroinvertebrate community downstream of Buckeye Lake WWTP appeared to reflect both nutrient enrichment and modified habitats. Despite the decline, community performance consistent with WWH biological criteria was observed.

- Macroinvertebrates collected from artificial substrates from RM 9.9 to RM 1.7 indicated very good to exceptional community performance. The ICI scores ranged form 42 to 46, fully achieving the WWH biocriteria. No impact to the benthic macroinvertebrate communities was evident in the South Fork Licking River from the Hebron WWTP (Beaver Run), Ramp Creek, or the Heath WWTP. Benthic macroinvertebrate samples collected from the Heath WWTP mixing zone achieved a ICI score of 46, QCTV score of 38.6, with 12 qualitative EPT taxa, indicating near exceptional community performance.

- Despite the highly modified habitats encountered near the mouth, the benthic macroinvertebrate community samples collected from the station at RM 0.4 (Second St.) achieved an ICI score of 36, fully consistent with the WWH biological criteria.

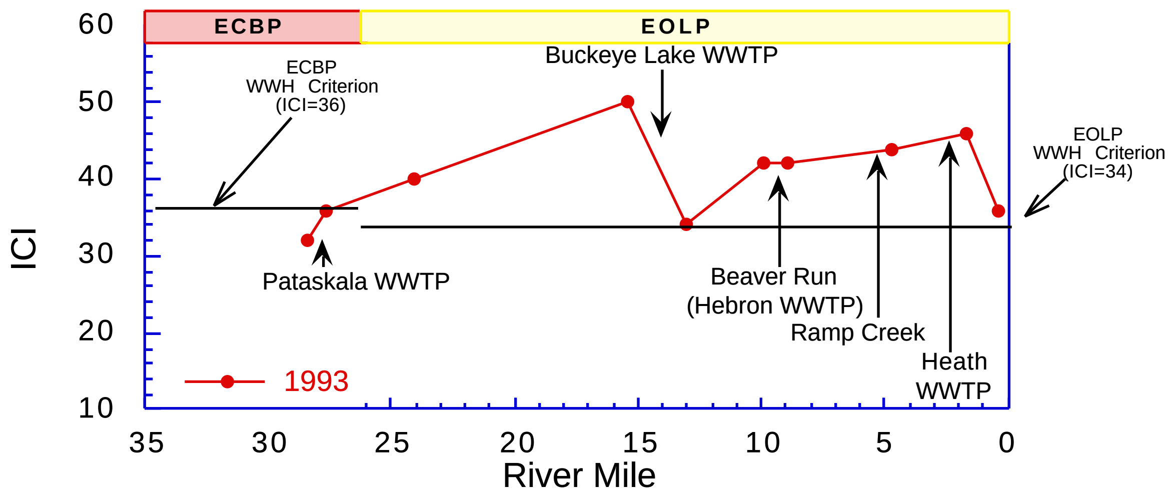


Figure 17. Longitudinal performance of the Invertebrate Community Index (ICI) from the South Fork Licking River, 1993.

***Biological Assessment: Fish Community***

- A total of 18,846 fish, comprised of 49 species and nine hybrids was collected from the South Fork Licking between July 1 and September 23, 1993. The sampling effort included a total of 50.0 Km at 13 sampling stations between RM 31.5 (Cable Rd.) and RM 0.5 (Second St.).

- The numerically predominate fish species were: central stoneroller (12.9%), bluntnose minnow (8.33%), striped shiner (7.86%), greenside darter (5.28%), creek chub (5.25%), sand shiner (5.05%). Species that predominated in terms of biomass were: common carp (29.2%), white sucker (11.2%), silver redhorse (10.4%), black redhorse (8.96%), northern hog sucker (8.86%), and golden redhorse (8.0%).

- In terms of relative abundance the predominance of herbivorous (central stoneroller) and tolerant, omnivorous/generalized feeding (bluntnose minnow and creek chub) minnow species was suggestive of modest nutrient enrichment. However, environmentally sensitive species (greenside darter and sand shiner) were well represented within the predominant groups. In terms of biomass the tolerant and omnivorous common carp and white sucker were most abundant, although sensitive species (other round-bodied suckers) were well represented within the biomass of the South Fork Licking River. Despite the prevalence (both relative abundance and biomass) of tolerant, omnivorous, and generalized feeding fishes, the cumulative abundance of the environmentally sensitive sucker, minnow, and darter species was indicative of good water quality and intact macrohabitats.

- The station at RM 31.5 represented the headwaters of the South Fork Licking River (*i.e.* drainage area ≤20 mile$^2$). In headwater areas only the IBI was used to evaluate the condition of the fish assemblage. Fish community samples from the stream reach between RM 28.3 and RM 15.3 were collected with the standard wading methodology, while the reach between RM 13.1 to RM 0.5 was sampled with the standard boat methodology. Community samples collected by both wading and boat methods evaluated the ambient biological condition with the use of IBI and MIwb (Ohio EPA 1989b).

- Community indices and narrative evaluations ranged between exceptional at RM 21.3 and RM(s) 9.4 - RM 1.7 (MIwb range 9.6-10.2; IBI range 48-52) and good/marginally good at RM 13.1 (MIwb=8.9; IBI=37) (Table 10). Viewed in the aggregate (all stations) the fish community was characterized as very good. Community performance as measured by the MIwb and IBI meet or exceeded the WWH biological criteria at all sampling stations within the South Fork Licking River study area.

- Longitudinal performance of the fish assemblage did not portray any impacts to the fish community associated with the discharge of treated waste water from Pataskala WWTP, Hebron WWTP or Heath WWTP (Figure 18). The fish assemblages both upstream and downstream of these facilities were characteristic of good water quality and high quality macrohabitats. The fish community was diverse and demonstrated a high degree of functional and structural organization, with intolerant or sensitive species well represented at each sampling station.

- The only significant decline in community performance was observed downstream of Buckeye Lake WWTP at RM 13.1 (SR 79). Community performance as measured by the MIwb displayed little difference between RM 15.3 (upstream Buckeye Lake WWTP) and at RM 13.1 (downstream of Buckeye Lake WWTP) (Figure 17). The MIwb indicated a high degree of evenness within the community at both stations (*i.e.* distribution of relative abundance and biomass within the assemblage). In contrast, community performance as measured by the IBI was reduced from very good (IBI=49) at RM 15.3 to marginally good (IBI=37) at RM 13.1. In comparison with the upstream station, species richness and the number of intolerant species were reduced at RM 13.1. Despite the decline in species richness and the loss of *some* intolerant forms, insectivory was the predominant feeding guild and carnivory was maintained at a level comparable with ecoregional expectations.

- The diminished performance of the fish community at RM 13.1 appeared related to the poor condition of physical habitat encountered at this station. The South Fork Licking River has been subject to significant channel modification between approximately RM 18.9 and RM 11.7. Although this segment contained both the stations at RM 15.3 and RM 13.1, the physical habitat encountered at RM 15.3, though highly modified, demonstrated a greater degree of physical heterogeneity than that encountered at RM 13.1. The active channel retained the “trenched” appearance common to channelized streams; however, many positive habitat attributes have been reestablished within the wetted channel (*i.e.* riffle/run/pool complexes, depth heterogeneity). The high performance of the fish community at RM 15.3 appeared related to the recovering macrohabitats encountered at this station and more significantly its juxtaposition to the relatively intact macrohabitats within upstream segments. In contrast, the condition of the macrohabitats at RM 13.1 were poor. Shifting and unstable, sands and silts were the predominant substrates. Channel development was fairly monotonous, reflective of past channelization, and the reach lacked developed riffle/run/pool complexes. The habitat deficit at RM 13.1 appeared to be the most significant factor affecting performance within the fish community (as measured by the IBI). The influence of Buckeye Lake WWTP appeared, at worst, secondary. Despite the punctuated decline within the fish assemblage at RM 13.1, community performance consistent with WWH biological criteria was maintained.

- This highly modified segment between approximately RM 18.9 and RM 11.7 was atypical when compared with the majority of the subbasin, which generally contained macrohabitats of a high quality. Typically, in streams where quality habitat is predominate, relatively short segments of diminished habitat are populated and utilized by emigrant fishes from the more productive, physically intact areas (Rankin 1989 and Rankin 1995).

- In summary, the fish assemblage performed at level that either met or exceeded the WWH biological criteria at every station. The fish community was diverse and well organized with intolerant and/or sensitive species being represented throughout the South Fork Licking River study area. Performance as measured by the IBI and MIwb appeared fully reflective of instream macrohabitats and ecoregional expectations. No significant impact to the fish community could be attributed to: Pataskala WWTP, Buckeye Lake WWTP Hebron WWTP or Heath WWTP.

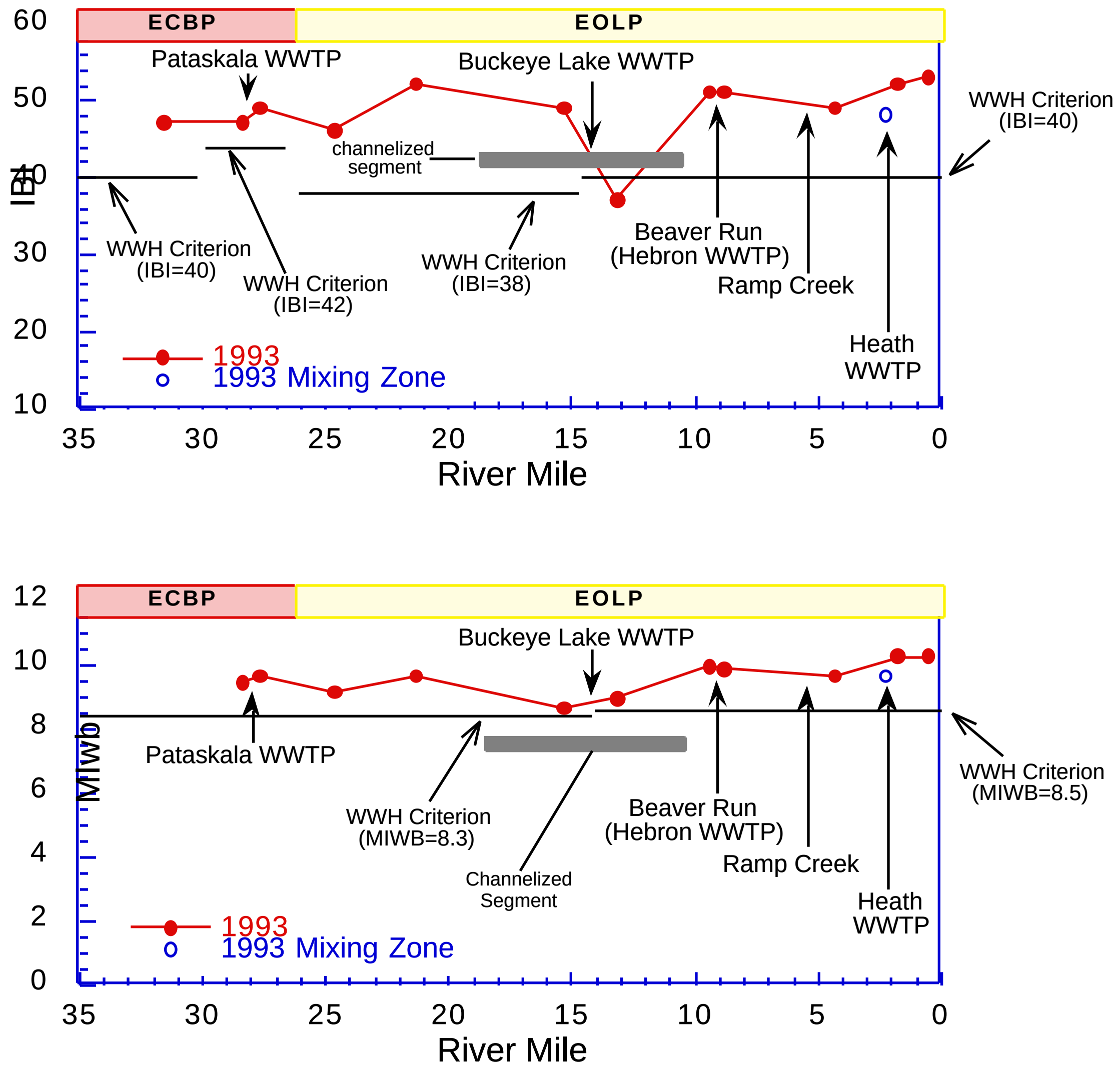


Figure 18. Longitudinal performance of the Index of Biotic Integrity (IBI, upper plot) and the Modified Index of Well-being (MIwb, lower plot) within the South Fork Licking River, 1993.

# Ramp Creek

### *Chemical Water Quality*

- Ramp Creek, originating in southwestern Licking County, drains 17.4 miles of watershed before it confluences with South Fork at RM 5.58. A cluster of industrial (public and private) sources are located adjacent to Ramp Creek, west of the city of Heath. These entities include: Union Oil/Ashland Petroleum, Newark Air Force Base, Kopper Co., and Kaiser Aluminum. A review of the Monthly Operating Reports (MORs) revealed no significant chemical impact from these entities. However, field crews did detect a slight petroleum odor emanating from the stream during all sampling runs. Kaiser Aluminum and Ashland Oil discharged a combined 384 kg of oil and grease during third quarter, 1993. Water column nitrate and phosphorus values were near detection at all sample sites during the third quarter, 1993.

### *Sediment Chemistry*

- To evaluate the extent of sediment contamination within Ramp Creek, sediment samples were collected at four locations. Sediment analysis included selected heavy metals, semi-volatile organic compounds, PCBs, and pesticides. The specific objective of the sediment analysis was to evaluate and characterize the extent of contamination associated with Union Oil/Ashland Petroleum, Newark Air Force Base, Kopper Co., and Kaiser Aluminum.

- Nearly all metal parameters within Ramp Creek were found to occur at concentrations ranked as non-elevated or slightly elevated (Kelly and Hite 1984). Only arsenic was detected at a level ranked as elevated at RM 1.32 (downstream Kopper Co.) (Table 17). The elevated concentration of arsenic was likely reflective of background levels associated with past agricultural use of arsenic based pesticides, herbicides, and defoliants. Despite the elevated ranking, the ambient level observed was below the ER-Median reported by Long and Morgan (1991). No impact associated with sediment metal contamination was evident within Ramp Creek associated with the public and private entities evaluated.

- Results from sediment organic analysis indicated that the majority of organic parameters occurred at concentrations near or below laboratory detection limits (Table 18). Four PAH compounds were found at levels above the laboratory detections limits at RM 0.77 (downstream of Kaiser Aluminum). The ambient concentrations within the sediments were quite low, and well below the ER-M values presented by Morgon and Long (1991). Petroleum laden seepage from the north stream bank of Ramp Creek and oil contaminated sediments were observed at RM 0.77 by Ohio EPA field staff during the 1993 summer sampling effort. This station was located within the ground water plume (near the western margin) emanating from the Union Oil/Ashland Petroleum facility. Though Kaiser Aluminum did contribute oil and grease loads to Ramp Creek during the third quarter, 1993, oil contamination was not apparent within the Kaiser Aluminum mixing zone or from the Kaiser landfill (south stream bank). Contaminated seepage from the Union Oil/Ashland Petroleum facility appeared a more probable source of the petroleum-PAH contamination. Additional organic contaminants included several organochlorine pesticide residues. Ambient levels of these compounds were ranked as non-elevated (Kelly and Hite 1984), and were well below the ER-M values provided by Morgan and Long (1991). The occurrence of organochlorine pesticide residues within the sediments is likely related to past application of these persistent compounds.

Table 17. Dry weight concentrations of heavy metals (mg/kg) in sediments of the 1993 Licking River study area. All parameter concentrations (excluding Nickel) were ranked based on the stream classification system described by Kelly and Hite (1984).

| River Mile | As | Cd | Cr | Cu | Fe | Pb | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| ***Ramp Creek*** | | | | | | | | |
| 2.01 | 8.7[b] | 0.48[a] | 8.5[a] | 15.6[a] | 18500[b] | 12.1[a] | 12.9 | 70.7[a] |
| 1.32 | 11.7[c] | 0.04[a] | 9.8[a] | 16.3[a] | 22800[b] | 12.2[a] | 14.5 | 70.4[a] |
| 0.77 | 10.5[b] | 0.38[a] | 9.7[a] | 14.1[a] | 17900[a] | 14.6[a] | 10.5 | 70.2[a] |
| 0.12 | 9.8[b] | 0.37[a] | 8.9[a] | 14.1[a] | 15200[a] | 13.8[a] | 11.1 | 97.0[b] |

[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.

Table 18. Dry weight concentrations of semi-volatile organic and pesticide pollutants detected in the sediments of the Ramp Creek, 1993.

| Parameter | RM 2.01* | RM 1.32* | RM 0.77* | RM 0.12* |
|---|---|---|---|---|
| ***Ramp Creek*** | | | | |
| **PAHs** (mg/kg or ppm) | | | | |
| Phenanthrene | ND (0.6) | ND (0.5) | 0.6 | ND (0.5) |
| Anthracene | ND (0.6) | ND (0.5) | ND (0.5) | ND (0.5) |
| Fluoranthene | ND (0.6) | ND (0.5) | 1.0 | ND (0.5) |
| Pyrene | ND (0.6) | ND (0.5) | 0.7 | ND (0.5) |
| Benzo (A) Anthracene | ND (0.6) | ND (0.5) | ND (0.5) | ND (0.5) |
| Chrysene | ND (0.6) | ND (0.5) | 0.5 | ND (0.5) |
| Benzo (K) Fluoranthene | ND (0.6) | ND (0.5) | ND (0.5) | ND (0.5) |
| Benzo (A) Pyrene | ND (0.6) | ND (0.5) | ND (0.5) | ND (0.5) |
| Indeno (1, 2, 3, - CD) Pyrene | ND (0.6) | ND (0.5) | ND (0.5) | ND (0.5) |
| Benzo (G, H, I) Perylene | ND (0.6) | ND (0.5) | ND (0.5) | ND (0.5) |

Table 18. continued.

| **Parameter** | **RM 2.01*** | **RM 1.32*** | **RM 0.77*** | **RM 0.12*** |
|---|---|---|---|---|
| ***Ramp Creek*** | | | | |
| **PHTHALATES** (mg/kg or ppm) | | | | |
| Bis (2 - Ethylhexyl) Phthalate | ND (0.6) | ND (0.6) | ND (0.5) | ND (0.5) |
| **PESTICIDES and PCBs** (µg/kg or ppb)# | | | | |
| a - BHC | ND (0.56) | ND (0.57) | 1.61 | ND (0.52) |
| d - BHC | 3.31 | 1.28 | 2.60 | 1.87 |
| Heptachlor | ND (0.56) | ND (0.48) | 1.04[b] | ND (0.52) |
| Aldrin | ND (0.56) | ND (0.48) | 1.59 | ND (0.52) |
| Dieldrin | 2.15[a] | ND (0.48) | 0.87[a] | ND (0.52) |
| Endrin | 0.85[a] | ND (0.48) | ND (0.50) | 2.03 |
| Methoxychlor | ND (2.79) | ND (2.39) | ND (2.50) | 2.61 |
| Mirex | ND (2.79) | ND (2.39) | ND (2.50) | ND (2.59) |
| DDT (sum) ** | ND (1.67) | ND (1.44) | ND (1.50) | 4.85[a] |
| PCBs (total) | ND (27.89) | ND (23.93) | ND (25.02) | ND (25.88) |

\# All pesticide concentrations, unless indicated, were ranked with the following stream sediment classification system described by Kelly and Hite (1984). [a] Non-elevated; [b] Slightly elevated; **[c] highly elevated**; **[d] Extremely elevated**.

* Corrected method detection limits based on weight and dilutions of sample, non-detected (ND) are presented in parenthesis.

** Sum DDT is the total of 4, 4’ - DDE, 4, 4’ -DDD, and 4, 4’ - DDT.

### *Physical Habitat For Aquatic Life*

- Physical habitats in the lower two miles of Ramp Creek were predominated by warmwater attributes, including fairly equal distributions of well developed run, riffle, and pool areas. Bottom substrates were predominated by gravel, sand and cobble. Instream cover consisted of boulders, woody debris and deep pools along with undercut banks and bankside rootwads. Overall, instream cover occurred in moderate amounts. One section of Ramp Creek within the study area (RM 0.75-0.30) was channelized within the last 30 years, as the direct result of the construction of Irving-Wick Road. The channelized section has shown some recovery to natural stream morphology conditions; however, some reduction in instream cover amounts were noted in this area compared to natural upstream and downstream locations. Qualitative Habitat Evaluation Index (QHEI) scores for Ramp Creek ranged between 66.5 and 80.5 were reflective of good to excellent stream habitat (Table 8).

***Biological Assessment: Benthic Macroinvertebrate Community***

- The macroinvertebrate faunas in Ramp Creek were sampled at four locations in August and September, 1993. Artificial substrate samplers were placed at all four locations; however, the artificial substrates at RM 0.7 were vandalized. As a result only qualitative invertebrate data from natural substrates is available for this location.

- The results from qualitative sampling at the RM 0.7 (downstream from Kaiser Aluminum) indicated an impact. A decrease in the number of taxa present in the qualitative sample was evident in comparison with the qualitative samples from the other stations. The number of qualitative taxa from three stations ranged between 30 and 31, while the station at RM 0.7 supported only 24. The other three sites, on Ramp Creek, each had 9 or 10 taxa of Ephemeroptera (mayflies), while RM 0.7 failed to support any. The Qualitative EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa richness (a measure of the presence of pollution sensitive taxa) ranged from 8, 6 and 9 from the upper stations (RM 2.0) to the mouth (RM 0.1) while the RM 0.7 site had an EPT taxa richness of 2 (Table 9). It is unfortunate that the Hester-Dendy samplers were vandalized at this location; however, based on a comparison of qualitative data from each of the four sites, an impact to the macroinvertebrate community was clearly indicated. The probable cause for the diminished condition of the benthic invertebrate community appeared to be petroleum contamination from the Union Oil/Ashland Petroleum facility.

- The upper two sites on Ramp Creek meet the WWH biocriteria each scoring an ICI value of 42. The upper most station (RM 2.0) had the highest total number of quantitative taxa (51), but lacked Trichoptera (caddisflies) and Ephemeroptera (mayflies) were poorly represented. The site at RM 1.4 had the total number of quantitative taxa at 35 but scored low in three matrices in the ICI percent mayflies, percent caddisflies and qualitative EPT taxa richness. The site near the mouth RM 0.1 exceeded the Exceptional Warmwater Habitat (EWH) biocriteria and was reflective of exceptional quality with an ICI score of 52. The near proximity of this site to the impacted site at RM 0.7 indicates that the impact is very localized.

***Biological Assessment: Fish Community***

- A total of 9,593 fish comprised of 25 species and one hybrid was collected from Ramp Creek between July 14 and September 23, 1993. The sampling effort included four sampling stations between RM 2.0 and RM 0.1. The numerically predominant fish species were central stoneroller (30.5%), creek chub (13.7%), blacknose dace (13.6%), and rainbow darter (12.2%).

- All 1993 Ramp Creek sampling stations supported fish assemblages characterized as exceptional. The IBI scores ranged between 51 and 55, and exceeded the WWH biological criteria (Table 10). Fish species sensitive to environmental disturbance were well represented within the community (*e.g.* six species of darters). The sampling results indicated that the Union Oil/ Ashland Petroleum, Newark Air Force Base, and Kaiser Aluminum landfills along with the wastewater discharges from Koppers Co. and Kaiser Aluminum did not have a negative impact on the fish community of Ramp Creek.

# Raccoon Creek

## *Pollutant Loadings*

### Granville WWTP

- The Granville WWTP process involves extended aeration, secondary treatment, and final effluent disinfection through chlorination. The plant is designed to remove 93% of the raw $BOD_5$ and 90% of raw TSS with a design flow of 1.224 MGD. Effluent from Granville WWTP discharges to Raccoon Creek at RM 11.50.

- Third quarter pollutant loadings to Raccoon Creek were generally elevated between 1979 and 1985, with 50th and 95th percentile loads reaching their highest values between 1983 and 1985 (Figure 19). By April, 1986 upgrades to the Granville WWTP were operational, with significant reduction of pollutant loads, while conduit flow remained fairly stable through time. Since 1987, Granville WWTP appears to have achieved an effective level of waste treatment. The Granville WWTP contributed 32 % (104 kg) of $NH_3$-N, 0.6% (23.9 kg) of $NO_3$-N, 18 % (322 kg) TSS, and less than 1% (23 kg) $BOD_5$ loadings to Raccoon Creek.

### Johnstown WWTP

- The Johnstown WWTP is considered a major NPDES permit entity, with a design flow of 0.75 MGD. Normal mean daily flows range from 0.20 to 0.46 MGD. The treatment process includes a primary settling tank, primary trickling filters, an intermediate settling tank, a secondary trickling filter, and final settling before the treated water is sand filtered and released. Permit records reveal that the plant is operating at half its design flow on peak flow days.

- Despite remaining plant capacity, the 1993 third quarter $BOD_5$, and $NH_3$-N effluent concentrations were in violation of NPDES limits, though TSS effluent concentrations remained within the permit limits. Third quarter MOR derived conduit flow (discharge) through the Johnstown WWTP has generally increased through the period of record and reached the highest measured 50th and 95th percentile values between 1992 and 1993 (Figure 20). The permit violations recorded in 1993 may have been related to increased influent loading. The Johnstown WWTP discharge accounted for 38% (819 kg) of the TSS, 60% (190 kg) $NH_3$-N, 15.3% (573.2 kg) $NO_3$-N and 43% (1037 kg) of the total $BOD_5$ loadings to Raccoon Creek.

### Owens Corning Fiberglass

- Owens Corning Fiberglass (Ohio Permit # 4IN00047) effluent was the only industrial discharger assessed due to its potential impact on Raccoon Creek. The wastewater treatment system is facultative lagoon based, designed to treat 0.171 MGD of waste water from boiler blowdown, cooling water, and sanitary/miscellaneous sources. The effluent is discharged to an unnamed tributary of Raccoon Creek. With the current treatment system, Owens Corning has had some difficulty in complying with TSS permit limits. As a result, the lagoon based treatment system is currently being upgraded to bring the facility into compliance.

- The compiled MOR data did not show any consistent problems with the effluent quality. The 50th percentile loadings all appeared low and relatively stable through time (Figure 21). Forty-five percent (819 kg) of the TSS, and 31% (761 kg) of the $BOD_5$ loadings to Raccoon Creek were released from the Owens Corning.

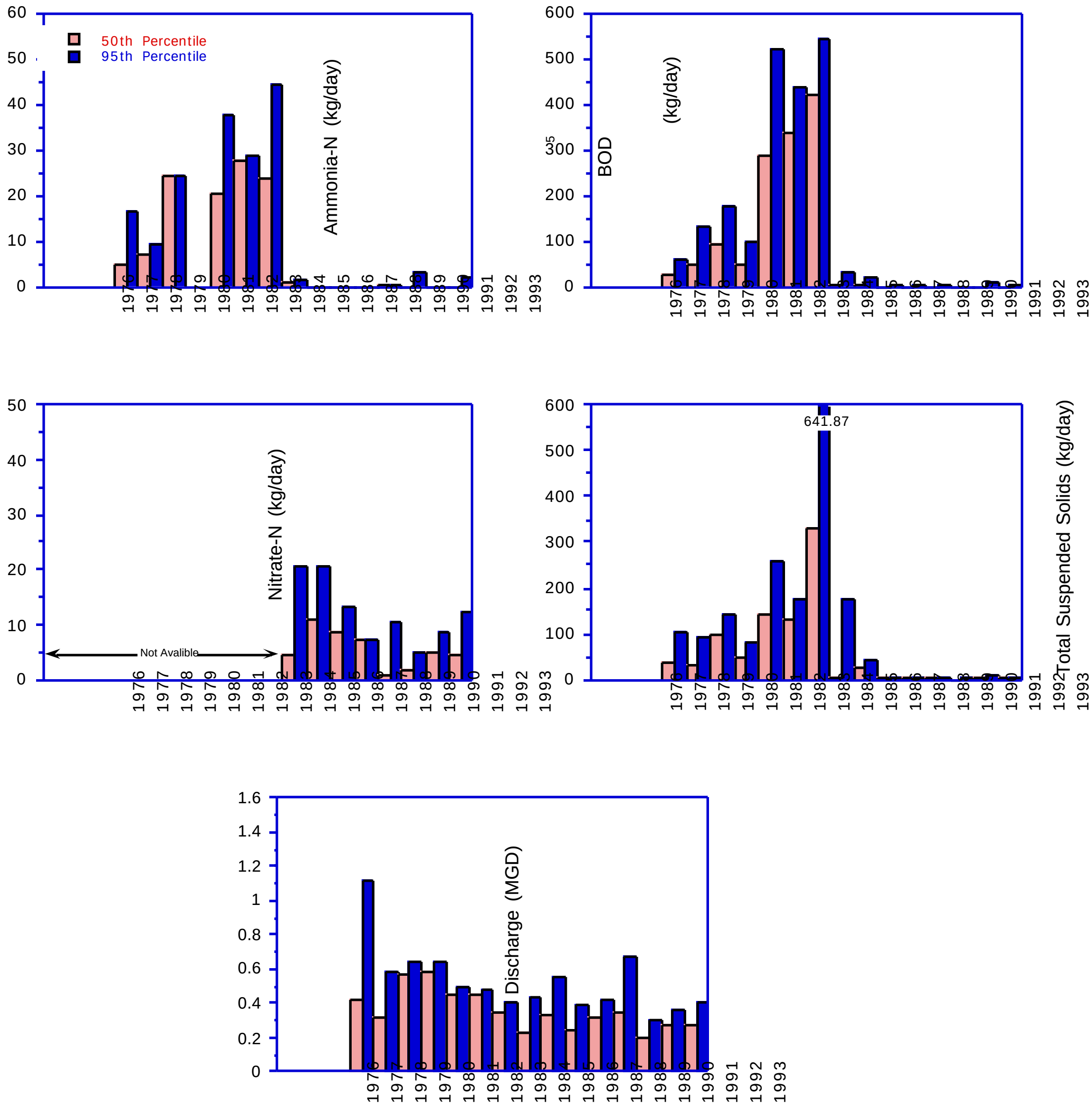


Figure 19. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, nitrate-N, TSS, and $BOD_5$ from the Granville WWTP, 1976-1993, Raccoon Creek.

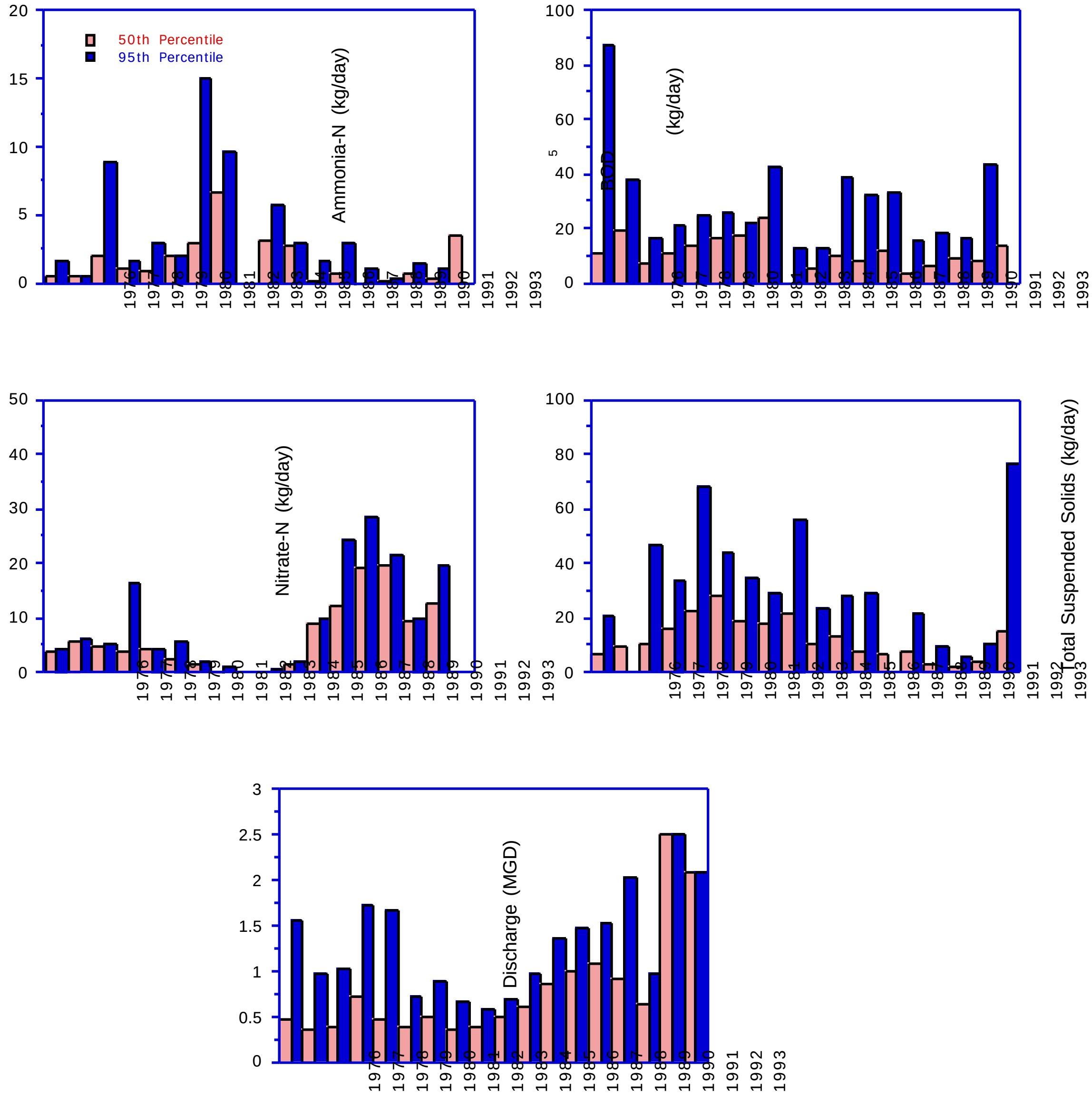


Figure 20. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of ammonia-N, nitrate-N, TSS, and $BOD_5$ from the Johnstown WWTP, 1976-1993, Raccoon Creek.

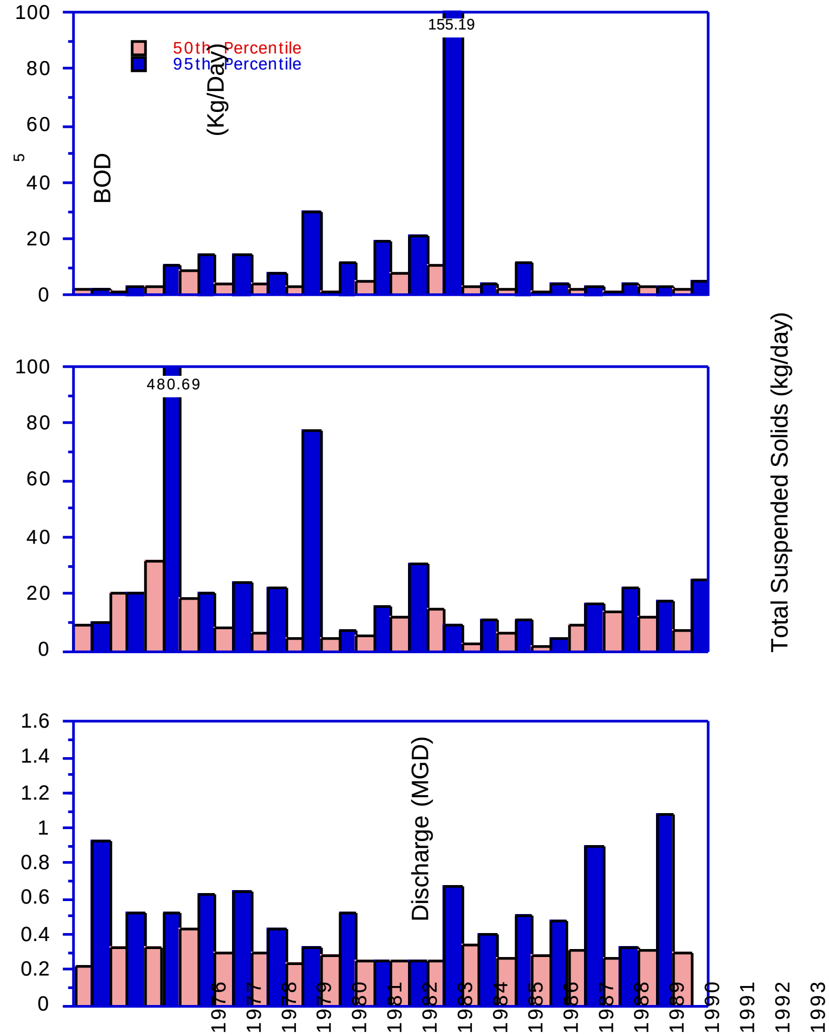


Figure 21. Annual third quarter 50th and 95th percentile discharge and pollutant loadings of TSS, and $BOD_5$ from the Owens Corning, 1976-1993, Raccoon Creek.

***Chemical Water Quality***

- The chemical water quality sampling effort within the Raccoon Creek subbasin included three stations located at RM 11.70 (upstream of Granville), RM 5.70 (downstream of Granville), and at RM 0.35 (near the mouth).

- Three exceedences of the primary contact fecal coliform criteria were recorded within Raccoon Creek during the 1993 sampling effort. Elevated levels of fecal bacteria were recorded at all three sampling stations on June 29. Though, direct flow data was not available from Raccoon Creek, reasonable inference as to the water stage on this date may be made by examining flow data from the South Fork and Licking River mainstem USGS gauge stations. Stream flows were clearly elevated on June 28 on both the South Fork and Licking River (Figures 4 and 14), and it appeared as though the fecal coliform exceedences observed on Raccoon Creek were reflective of urban, agriculture, and other diffuse pollutant sources commonly associated with high flow events. Additionally, the concentration of conventional nutrient parameters demonstrated a marked increase at all stations within the Raccoon Creek subbasin on June 29, in comparison with other sampling dates at the same locations. These values were most likely reflective of diffuse sources as well.

***Sediment Chemistry***

- To evaluate the extent of sediment contamination within the the lower reach of Raccoon Creek, sediment samples were collected at two locations. Sediment analysis included selected heavy metals and semi-volatile organic compounds.

- Nearly all metal parameters within Raccoon Creek were found to occur at concentrations ranked as non-elevated or slightly elevated (Kelly and Hite 1984). Only arsenic was detected at level ranked as elevated at RM 5.7 (upstream Newark-CSOs) (Table 19). The elevated concentration of arsenic was likely reflective of background levels associated with past agricultural use of arsenic based pesticides, herbicides, and defoliants. Despite the elevated ranking, the ambient level observed was below the ER-M reported by Long and Morgan (1991). No impact associated with sediment metal contamination was evident within Raccoon Creek.

- Results from sediment organic analysis indicated that the majority of organic parameters occurred at concentration near or below laboratory detection limits (Table 20). Two PAH compounds were found at levels above the laboratory detections limits at RM 0.35 (downstream CSOs). The ambient concentrations within the sediments were quite low, and well below the ER-M values presented by Morgon and Long (1991). Several organochlorine pesticide residues were found at concentrations above laboratory detection limits, though ambient levels were ranked as non-elevated (Kelly and Hite 1984), and were well below the ER-M values provided by Morgon and Long (1991). Given the prevailing agricultural land use within Raccoon Creek subbasin, the occurrence of organochlorine pesticide residues within the sediments is likely related to past agricultural application of these persistent compounds.

Table 19. Dry weight concentrations of heavy metals (mg/kg) in sediments from Raccoon Creek, 1993 All parameter concentrations (excluding Nickel) were ranked based on the stream classification system described by Kelly and Hite (1984).

| River Mile | As | Cd | Cr | Cu | Fe | Pb | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| ***Raccoon Creek*** | | | | | | | | |
| 5.70 | 14.2[c] | 0.56[b] | 16.5[b] | 19.8[a] | 22400[b] | 20.8[a] | 15.8 | 75.3[a] |
| 0.35 | - | 0.44[a] | 18.9[b] | 15.1[a] | 18700[a] | 20.1[a] | 10.8 | 54.3[a] |

[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.

Table 20. Results from Raccoon Creek sediment priority pollutant scan during summer, 1993. Detection limits for values listed as ND (non-detection), are presented in parenthesis.

| Parameter | RM 5.7 | RM 0.35 |
|---|---|---|
| ***Raccoon Creek*** | | |
| **PAHs** (mg/kg) | | |
| Phenanthrene | ND (0.6) | ND (0.6) |
| Anthracene | ND (0.6) | ND (0.6) |
| Flouranthene | ND (0.6) | 0.7 |
| Pyrene | ND (0.6) | ND (0.6) |
| Benzo (A) Anthracene | ND (0.6) | ND (0.6) |
| Chrysene | ND (0.6) | ND (0.6) |
| Benzo (K) Flouranthene | ND (0.6) | 0.6 |
| Benzo (A) Pyrene | ND (0.6) | ND (0.6) |
| Indeno (1, 2, 3, - CD) Pyrene | ND (0.6) | ND (0.6) |
| Benzo (G, H, I) Perylene | ND (0.6) | ND (0.6) |
| **PHTHALATES** (mg/kg) | | |
| Bis (2 - Ethylhexyl) Phthalate | ND (0.6) | ND (0.6) |

### *Physical Habitat for Aquatic Life*

- During the 1993 field sampling efforts the macrohabitats of Raccoon Creek were evaluated at two sampling stations located at RM 5.6 (Cherry Valley Rd.) and RM 0.3 (near mouth). Both station achieved a QHEI values greater than 60.0, which suggested that the near and instream physical habitat of Raccoon Creek were of a sufficient quality to support a community of aquatic organisms consistent with the WWH use designation (Rankin 1989).

- The upper most sampling station at RM 5.6 achieved a QHEI score of 77.5, where warmwater habitat attributes were overwhelmingly predominant (Table 8). The macrohabitats encountered at RM 5.6 were diverse and characterized as being of high quality. The condition of the physical habitats encountered at RM 0.3 were somewhat diminished in comparison. The lower reach of Raccoon Creek has been subject to channelization and urban encroachment through the city of Newark. The impact of these activities were reflected in a reduced QHEI value of 65.0. Though much remaining evidence of past modification was present within the lower reach of Raccoon Creek, substantial recovery has occurred within the wetted channel. Though the active channel retained the trenched character associated with modified streams, the wetted channel appeared to have reestablished many characteristics associated with unmodified streams (*e.g.* riffle/run/pool complexes). As a result, the instream habitats within the lower reach (though modified) appeared to be of fair/good quality.

### *Biological Assessment: Benthic Macroinvertebrate Community*

- Quantitative samples were set at RM 5.8 and RM 0.2 on Raccoon Creek to assess the urban impact from the City of Newark. The upstream station at RM 5.8 achieved an ICI score of 46, indicating performance consistent with the WWH biocriteria (Table 9). Upon retrieval of the artificial substrates at RM 0.2, the samplers appeared to have been relocated from the original position of the set, in an area with no discernible stream flow. As a result the sample collected from the artificial substrates were invalidated. The condition of the invertebrate community at RM 0.2 was determined from the qualitative sample only. The qualitative sample from natural substrates indicated marginally good conditions, meeting the minimum WWH biological criteria.

### *Biological Assessment: Fish Community*

- A total of 3,751 fish comprised of 30 species and two hybrids was collected from Raccoon Creek between July 29 and August 20, 1993. The sampling effort included two station located at RM 5.6 (Cherry Valley) and RM 0.3 (near mouth, downstream CSOs).

- The numerically predominant fish species were: central stoneroller (28.9%), silver shiner (9.66%), striped shiner (9.04%), white sucker (8.59%), and northern hog sucker (6.73%). In term of biomass the predominant species were: white sucker (28.6%), common carp (22.3%), northern hog sucker (10.2%), black redhorse (7.10%), smallmouth bass (6.55%). The numerical abundance of the central stone roller (herbivore) and white sucker (highly tolerant omnivore) was suggestive of modest nutrient enrichment. However, the abundance of environmentally sensitive species within the predominant group (silver shiner and northern hog sucker) indicated that water quality and macrohabitats were in good condition. The highly tolerant white sucker and common carp yielded the most biomass, though the environmentally sensitive species (northern hog sucker, black redhorse, and smallmouth bass) were well represented within the assemblage. Both in terms of abundance and biomass tolerant omnivorous species were predominant. Nevertheless, the cumulative abundance and biomass of sensitive species indicated that water quality and macrohabitats were maintained within the Raccoon Creek study area.

- Both stations within the Raccoon Creek were sampled with the standard boat methodology, where both the MIwb and IBI were employed to evaluate ambient biological condition (Ohio EPA 1989b). Community indices and narrative evaluation were exceptional/good (MIwb=10.0; IBI=43) at RM 5.6 and exceptional (MIwb=10.2; IBI=50) at RM 0.3 (Table 10). Both station were fully reflective of ecoregional expectations and instream habitats. Performance of fish community as measured by the MIwb and IBI exceeded the WWH biological criteria. No impact to the fish assemblage was evident downstream from the numerous CSOs from the city of Newark at RM 0.3.

## Lobdell Creek

### *Physical Habitat for Aquatic Life*

- The macrohabitats of Lobdell Creek were evaluated at two fish sampling station located at RM 1.6 (Lobdell Rd.) and RM 0.2 (Raccoon Valley Rd.). The quality of macrohabitats at RM 1.6 appeared less than optimal, achieving a QHEI score of 51.5 (Table 8). The predominant substrates were shale bedrock, which greatly limited channel depth heterogeneity and provided limited benthic interstices. Structural heterogeneity was limited by the lack of instream cover. Despite a drainage area of 16.7 mile$^2$ the summer stream flow was diminished. This station did not appear to have been subject to anthropomorphic modification in the past, rather the marginal quality of the physical habitats likely reflected natural conditions.

- The macrohabitats encountered at RM 0.2 were considerably improved in comparison with the upstream station. Warmwater habitat attributes were predominant, reflected in a QHEI score of 70.5. Positive habitat attributes included: cobbles and sand substrates, mixed cover types, persistent wooded riparian corridor, and modest channel development. The macrohabitats encountered at this station appeared capable of supporting a community of aquatic organisms consistent with the WWH biological criteria.

### *Biological Assessment: Fish Community*

- A total of 2,020 fish comprised of 18 species was collected from Lobdell Creek between October 20 and October 22, 1993. The sampling effort included two station, located at RM 0.2 and RM 1.6. Fish community samples from Lobdell Creek were collected with the standard wading methodology. The Lobdell Creek study area was situated within the headwater of the subbasin, where only the IBI was employed to evaluate ambient biological condition.

- Both stations supported fish communities that demonstrated structural and functional organization consistent within ecoregional expectations. Community performance as measured by the IBI met or exceeded the headwater WWH biological criteria. Despite the depauperate habitats encountered at RM 1.6, a the fish community consistent with the WWH biological criteria was maintained (Table 10).

# Trend Assessment

## Licking River (mainstem)

### *Chemical Water Quality 1981-1993*

- Historical water column chemistry data from the Licking River mainstem was employed to perform a long term water quality trend assessment. The most comprehensive data sets available were collected by Ohio EPA during the summers of 1981 and 1988 in support of intensive water resource surveys. The 1981 survey included the stream reach between RM 29.1 and RM 18.9, and the 1988 survey included the stream reach between RM 26.75 and RM 0.35. Additional water quality information was provided by the third quarter fixed station monitoring water column chemistry data collected between 1974 and 1993 from RM 26.75 (Stadden Rd./downstream Newark WWTP). This data characterized water quality at one location, through time, downstream of Newark WWTP.

- Between 1981 and 1993 the changes in the concentrations of conventional pollutants within the Licking River mainstem appeared reflective of improved waste water treatment at the Newark WWTP, and reduced pollutant loadings from other upstream point sources within the basin.

- In 1981, $NH_3$-N, and $BOD_5$ displayed a marked increase downstream of Newark WWTP. During the early and mid-1980s the Newark WWTP had significant operational and pretreatment problems, resulting in numerous permit and water quality exceedences (Ohio EPA 1986). The results from the 1988 and 1993 surveys indicated incremental reduction (through time) of the ambient concentrations of the these conventional pollutants (Figure 22). The reduced loadings of BOD and $NH_3$-N were a result of treatment upgrades, which included advanced nitrification and BOD removal, as well as an aggressive implementation of an industrial pretreatment program by the city of Newark. As expected, $NO_3$-N displayed a marked increase downstream of Newark WWTP, commensurate with improved nitrification provided by Newark WWTP. Total phosphorous concentrations demonstrated a significant increase downstream of the Newark WWTP in 1993 when compared with historic data from 1981 and 1988. Standard wastewater treatment facilities are incapable of removing phosphorus, thus, influent and effluent concentrations are often similar. The elevated concentrations observed were likely related to an increased service populous. Regardless, phosphorus loadings appeared to be rapidly assimilated further downstream to levels consistent with the available historic, and more recent background levels. Dissolved oxygen concentrations between 1981 and 1993 appeared comparable and fairly stable. Mean values remained well above water quality standards longitudinally as well as through time. Excluding the stream reach under the influence of the Newark WWTP, ambient concentrations of all conventional parameters appeared comparable and fairly stable through time. A modest increase in $BOD_5$ and $NH_3$-N was evident in both the 1988 and 1993 data sets downstream of Dillon Dam. The concentrations observed were most likely related to hypolimnetic discharge from the reservoir.

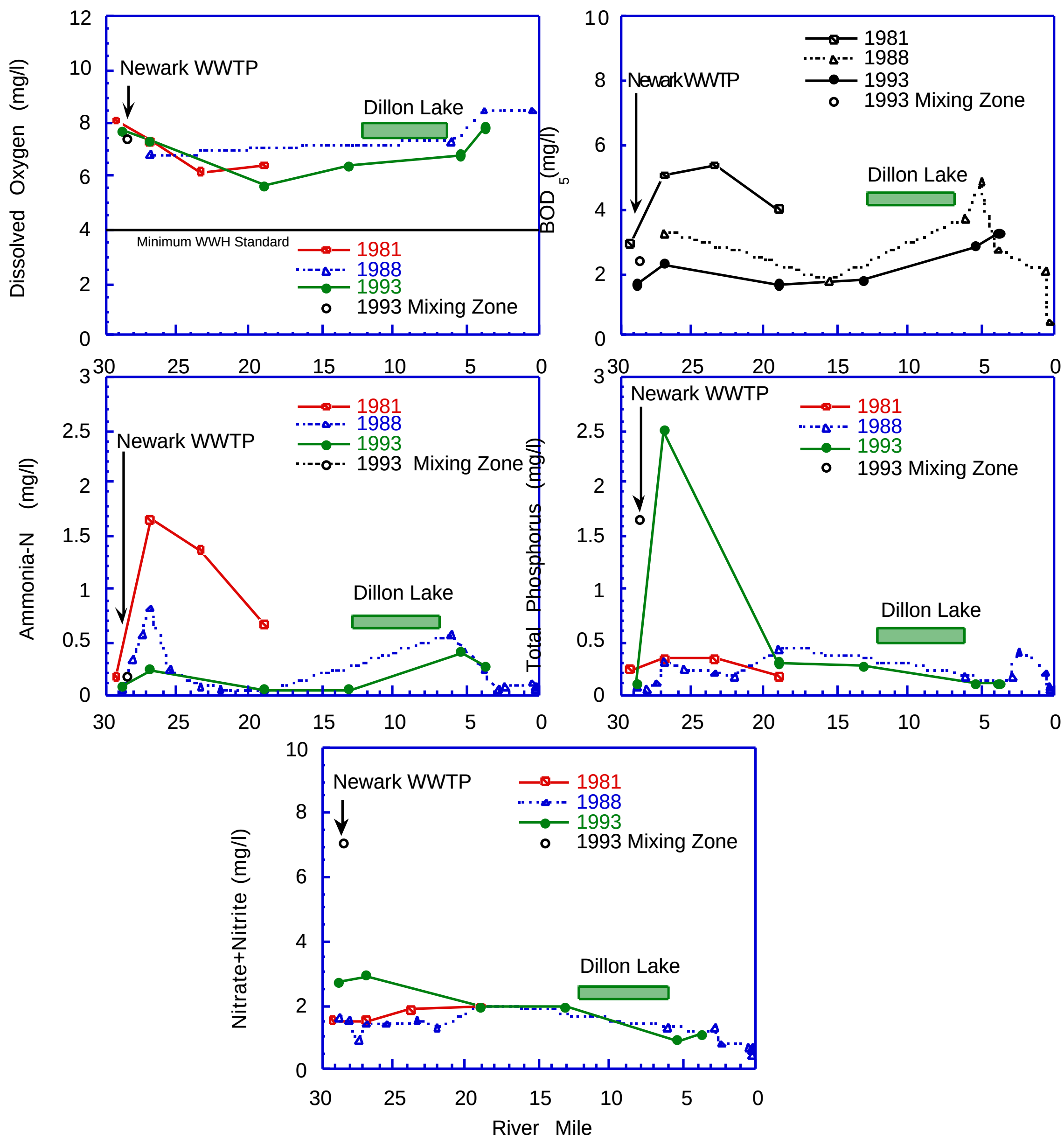


Figure 22. Longitudinal trend of mean concentrations of dissolved oxygen, ammonia-N, nitrate-N, $BOD_5$, and total phosphorus in the Licking River mainstem, 1981-1993.

- Fixed station monitoring data was employed to analyze long term trends in third quarter ambient water quality between 1974 and 1993 at RM 26.75 (Stadden Rd./downstream Newark WWTP). With the exception of total phosphorous, the greatest variability and highest median values of conventional pollutants generally occurred between the late 1970s and mid-1980s ($NH_3$-N, $BOD_5$, and TSS) (Figure 23). It was during this period of time pollutant loadings to the Licking River mainstem from Newark WWTP and other point sources located upstream on the major tributaries were at the highest levels. After 1988, variability and the median values of $NH_3$-N, $BOD_5$, and TSS displayed a marked decline. The recent trend of reduced variability and lower median values of these parameters and a modest increase of D.O. was indicative of improved water quality, commensurate with improved wastewater treatment and the subsequent reduction of pollutant loadings from Newark WWTP and other upstream point sources.

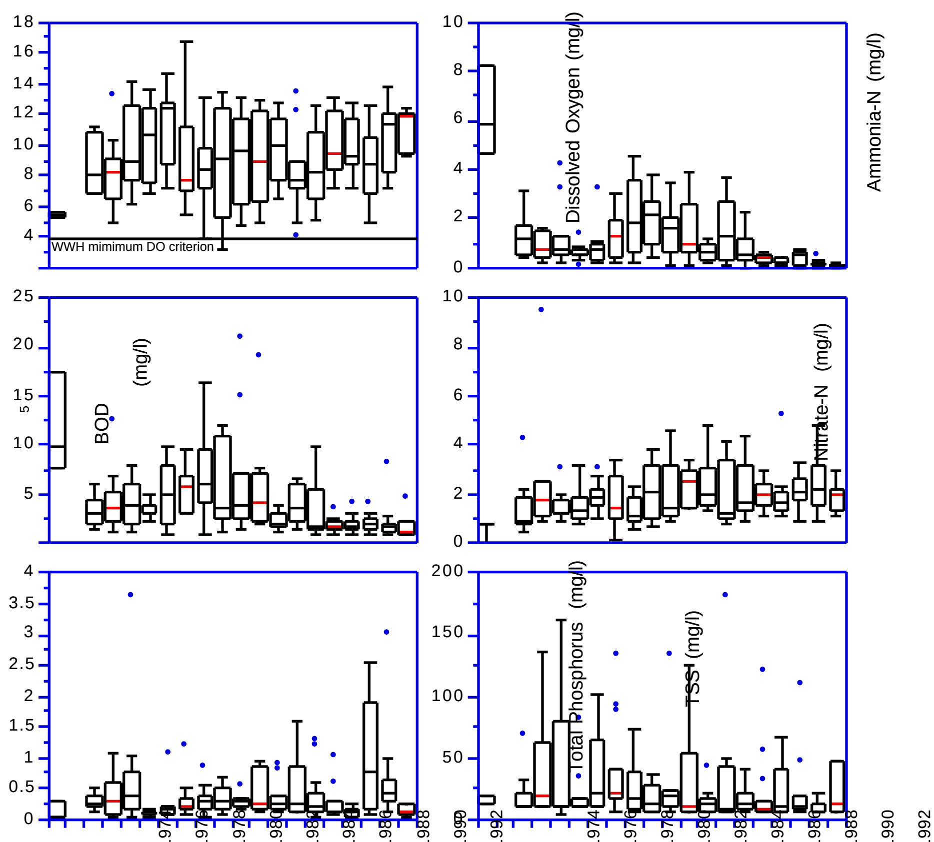


Figure 23. Trends for dissolved oxygen, $BOD_5$, total phosphorus, ammonia-N, nitrate-N, and TSS from the National Ambient Water Quality Monitoring Station at Stadden bridge (RM 26.75), Licking River mainstem, 1974-1993.

***Benthic Macroinvertebrate: 1979-1993***

- There was an overall increase of 4 to 8 ICI units in the Licking River mainstem between the 1981 and 1988 surveys and the 1993 survey (Figure 24). This corresponds with noticeable decreases in ammonia and BOD loadings from the Newark WWTP between 1988 and 1989. Macroinvertebrate communities collected in 1993 in the Licking River from RM 26.8 to RM 14.8 were in the exceptional range of ICI scores.

- Macroinvertebratedatacollected from the National Ambient Station (NAS) at Licking River RM 26.8 was consistent with the WWH biocriterion for the sampling years 1981, 1988, 1990, and 1993 with ICI values ranging from 38 to 46. The only year that was sampled that did not achieve the WWH biocriterion was 1979 which had an ICI score of 28.

- The Area of Degradation Values (ADV) for the ICI suggested little change between 1981 and 1993 (Table 20). The ADV/mile in 1981 was 0.0, indicating community performance consistent with the WWH biological criteria. The 1981 study area included only to the stream reach between RM 30.1 (upstream Newark WWTP) and RM 16.1 (upstream Dillon Reservoir).

- In 1993 the ADV/mile did increase to 9.3, however, this value was not indicative of worsening environmental conditions, rather, it was reflective of the larger stream reach evaluated in 1993. The impact evidenced by the ADV statistic in 1993 was a result of hypolimnetic discharge from Dillon Reservoir (an influence not evaluated in 1981). The effects of Dillon reservoir were modest and highly localized.

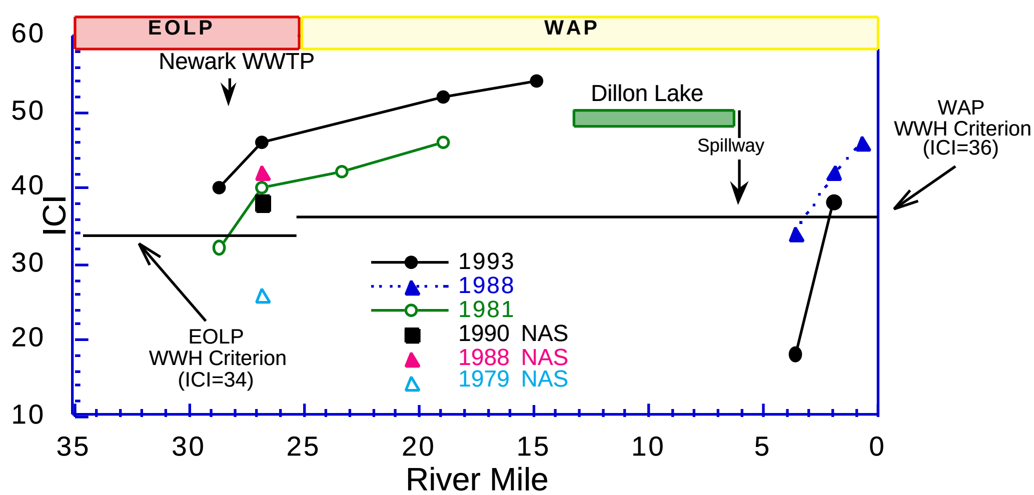


Figure 24. Longitudinal trend of the Invertebrate Community Index (ICI) from the Licking River mainstem 1979-93.

Table 20. The Area of Degradation (ADV) statistics for the Licking River and the South Fork Fork Licking River, 1981-1993.

| | Biological Index Values | | | | ADV Statistics | | | Attainment Status (miles)[a] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Stream*** Index | Upper RM | Lower RM | Mini-mum | Maxi-mum | ADV | ADV/ Mile | Poor/VP ADV | FULL | PARTIAL | **NON** | Poor/VP |
| ***Licking River (1981)*** | | | | | | | | | | | |
| IBI | | | 24 | 33 | 1236 | 68.7 | 11 | | | | |
| MIwb | 30.1 | 16.1 | 6.4 | 7.2 | 1020 | 56.7 | 0 | 0.0 | 7.7 | 6.9 | 3.4 |
| ICI | | | 32 | 46 | 0 | 0.0 | 0 | | | | |
| ***(1985)*** | | | | | | | | | | | |
| IBI | | | 32 | 40 | 148 | 9.4 | 0 | | | | |
| MIwb | 28.1 | 13.4 | 8.3 | 10.0 | 0 | 0.0 | 0 | *9.6* | *6.1* | *0.0* | *0.0* |
| ICI[b] | | | - | - | - | - | - | | | | |
| ***(1993)***[c] | | | | | | | | | | | |
| IBI | | | 39 | 50 | 0 | 0.0 | 0 | | | | |
| MIwb | 28.6 | 3.4 | 9.3 | 10.0 | 0 | 0.0 | 0 | 16.6 | 1.8 | 0.0 | 0.0 |
| ICI | | | 18 | 54 | 171 | 9.3 | 0 | | | | |
| ***South Fork Licking River (1981)*** | | | | | | | | | | | |
| IBI | | | 31 | 35 | 235 | 32.2 | 0 | | | | |
| MIwb | 0.4 | 7.2 | 7.3 | 7.9 | 265 | 36.3 | 0 | 0.0 | 3.7 | 3.6 | 0.0 |
| ICI | | | 24 | 38 | 93 | 12.7 | 0 | | | | |
| ***(1984)*** | | | | | | | | | | | |
| IBI | | | 34 | 47 | 3 | 0.2 | 0 | | | | |
| MIwb | 12.7 | 31.6 | 8.2 | 10 | 0 | 0.0 | 0 | 15.0 | 4.0 | 0.0 | 0.0 |
| ICI | | | 20 | 42 | 174 | 9.2 | 0 | | | | |
| ***(1993)*** | | | | | | | | | | | |
| IBI | | | 37 | 53 | 0 | 0.0 | 0 | | | | |
| MIwb | 0.4 | 31.6 | 8.6 | 10.2 | 0 | 0.0 | 0 | 31.7 | 0.0 | 0.0 | 0.0 |
| ICI | | | 32 | 50 | 0 | 0.0 | 0 | | | | |

a - Attainment status determined by one organism group are in italics.
b - The macroinvertebrate community was not assessed in 1985.
c - The reach evaluated excluded the Dillon Reservoir dam pool.

### *Fish Community Trend: 1981-1993*

- Fish community data were collected from the Licking River mainstem in 1981, 1985, 1988, and 1993. Both the 1981 and 1985 surveys evaluated the upper and middle segment of the Licking River mainstem, from upstream of the Newark WWTP to Dillon Lake. Fish community samples were collected at one station in 1988 at RM 3.6. The 1993 Licking River survey extended from upstream of the Newark WWTP (RM 28.6) to downstream of Dillon Fall (RM 3.4). Longitudinal performance of recent and historic fish community data delineated substantial improvement from the degraded conditions documented in 1981 (Figure 25).

- The results from the 1981 fish surveys revealed a community characterized as fair. Community indices and narrative evaluations ranged between poor (MIwb=5.4; IBI=25) at RM 11.0 and fair (MIwb=7.1; IBI=33) at RM 30.1, where performance consistent with the WWH biological criteria *was not* observed at any station within the study area (Table 10). It must be noted that the station at RM 11.0 was located within Dillon Lake, and the poor performance observed at this station was reflective of simplified lentic habitats associated with on-stream impoundment. The fish assemblage within the remaining portions of the study area did not perform at a level consistent with the quality of stream macrohabitats.

- The 1985 survey was not as robust as that conducted in 1981, but did evaluate a similar river segment. The results from the 1985 sampling effort indicated improvement throughout the study area. The fish assemblage in 1985 was characterized as very good/marginally good and performance consistent with the WWH biological criteria was observed at two of the three stations sampled.

- The results from the 1993 survey indicated additional improvement, with community performance at or near an exceptional level throughout the free flowing portions of the study area (*i.e.* excluding Dillon Lake). The fish assemblage appeared fully reflective of in stream habitats and ecoregional expectations. Based upon the 1993 results the fish community appeared to have fully recovered from the degraded conditions encountered in 1981.

- Shifts in the composition and structural and functional organization of the assemblage was indicative of reduced loadings of conventional pollutants. In 1993 only 35.7% of the biomass and 6.66% of relative abundance consisted of the highly tolerant common carp and white sucker. In contrast, 71.3% of the biomass and 21.2 % of relative abundance were common carp and white sucker in 1981. In 1993, the trophic structure within the community appeared intact. Insectivory was predominant, carnivores were well represented, and omnivory occurred at levels consistent ecoregional reference conditions. In contrast, the trophic structure of the fish community in 1981 was strongly skewed, with omnivory as the predominant feeding guild (Figure 26). Typically, omnivorous and generalized feeding species predominant in areas where environmental disturbance has disrupted or simplified the food base. Additional shifts within the assemblage that were indicative of improved condition included a substantial increase in the percent occurrence of environmental sensitive species (*e.g.* Round-bodied Suckers) and decline in percent occurrence of environmentally tolerant species.

- The ADV/mile for both fish community indices (IBI and MIwb) indicated considerable improvement between 1981 and 1993. In 1981 the ADV/mile for the IBI and MIwb were 68.7 and 56.7 respectively (Table 20). In 1985 the ADV/mile for the IBI and MIwb were 9.4 and 0.0. By 1993 all evidence of of the impact to the fish community in 1981 was gone, with ADV/mile values of 0.0 for both indices.

- In summary, it was clear that the fish assemblage of the Licking River mainstem has fully recovered. The results from the 1993 sampling effort found that the fish community was diverse and well organized, with environmentally sensitive species well represented throughout the study area, fully reflective of macrohabitat potential and ecoregional expectations.

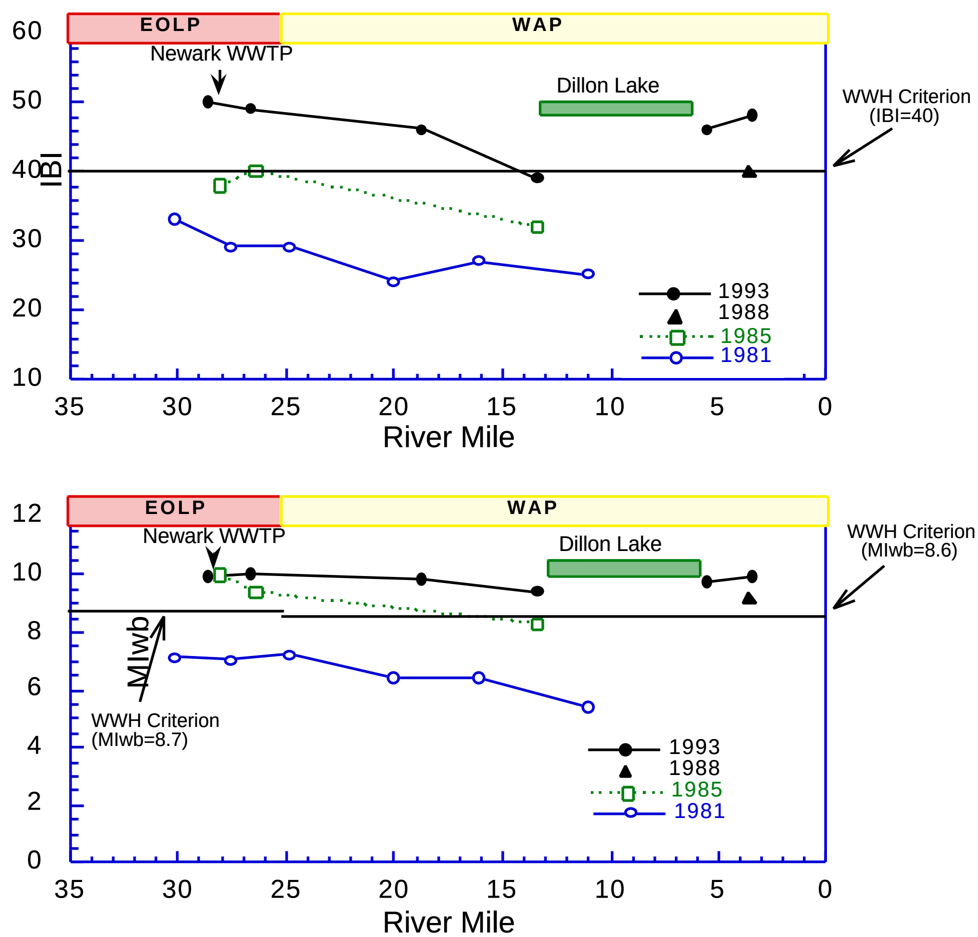


Figure 25. Longitudinal trend of the Index of Biotic Integrity (IBI, upper plot) and the Modified Index of Well-being (MIwb, lower plot) from the Licking River mainstem, 1981-1993.

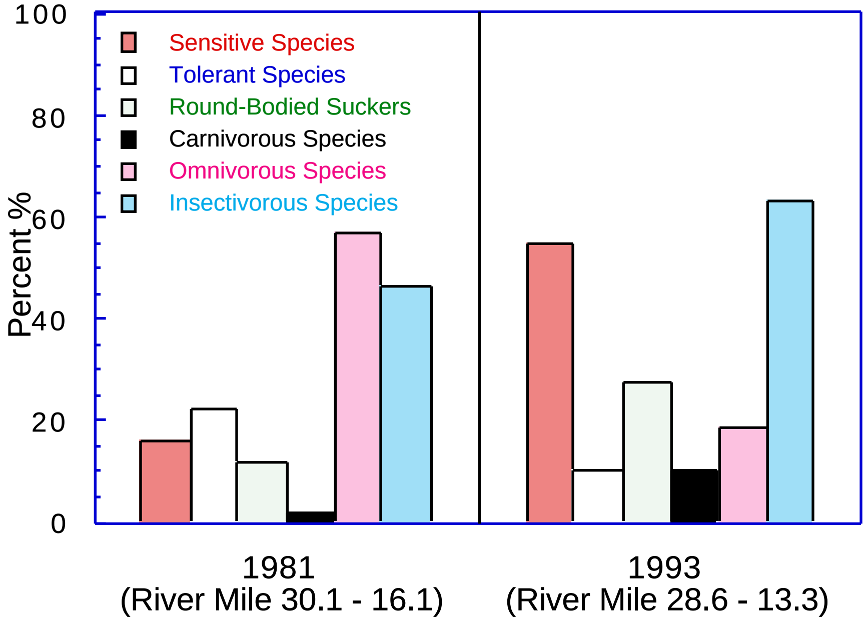


Figure 26. Comparison of the mean percent occurrence of various components of the fish assemblage from the Licking River mainstem, upstream of Dillon Lake between 1981 and 1993. (Note: individual species may be included within one or more functional and/or compositional groupings.)

## North Fork Licking River

### *Benthic Macroinvertebrate Community 1981-1993*

- Macroinvertebrates collected at RM 2.8 and RM 0.2 on the North Fork Licking River showed similar trends in 1982 and 1993. The ICI scores were 44 (1993) and 42 (1982) at the upstream station (RM 2.8), both scores were consistent with the WWH biological criterion. At RM 0.2 (near the mouth), the macroinvertebrates suggested fair conditions in both 1982 and 1993. In 1981, however, the macroinvertebrate quantitative sampler yielded an invertebrate assemblage consistent with the WWH biological criterion (ICI of 38), compared to the fair conditions observed in 1982. One possible explanation is that the CSOs in the Newark urban area had less of an impact on the macroinvertebrate communities during higher flow years. Flow data from the Licking River USGS gauge station below the Dillon Reservoir had greater flows during the summer of 1981 than in 1982, which suggests that flow in the North Fork Licking River was greater in 1981 than in 1982.

### *Fish Community 1981-1993*

- Fish community data were collected from the North Fork Licking River in 1981, 1982, 1985, and 1993. The 1981 survey included the stream reach between RM 7.4 and RM 0.2. The 1982 sampling effort was considerable larger and included the stream reach between RM 20.4 and RM 0.2. The 1993 sampling effort included only two stations, located at RM 2.5 and RM 0.2. Given the limited scope of the 1993 sampling effort, for the purpose of comparison, only the data from the lower reach of the North Fork Licking River was employed for trends analysis.

- In 1981 the fish community performance within the lower reach of the North Fork Licking was characterized as fair (MIwb=7.7; IBI=31) at RM 0.7 and good/marginally good (MIwb=8.7; IBI=39) at RM 2.0 (Table 10). Only the station at RM 2.0 supported a assemblage of fishes consistent with the WWH biological criteria. In 1982 only one fish sampling station was located within the lower portion of the study area at RM 2.4. Community performance at this station was characterized as good (MIwb=9.3; IBI=41). In 1985 only one station was located within the lower portion of the study area at RM 0.9. Community performance at this station was characterized as exceptional (MIwb=9.5; IBI=52). In 1993 the fish communities at RM 2.5 and RM 0.2 performed at a level fully consistent with the WWH biological criteria. In comparison with the results from the 1981 and 1982 survey results, it appeared that performance of the fish community near the mouth (RM 0.2) has improved considerably, from fair in 1981 to near exceptional in 1993. Performance within the fish assemblage at RM 2.4/2.5 appeared fairly stable, consistent with the WWH biological criteria both in 1982 and 1993.

## South Fork Licking River

### *Chemical Water Quality 1984-1993*

- Historical water column chemistry data from the South Licking River was employed to perform a long term water quality trend assessment. The most comprehensive data set available was collected during the summer of 1984 in support of intensive water resource survey and included the stream reach between RM 30.75 and RM 12.7.

- In comparison with the 1984 water column chemistry data, the results from the 1993 survey indicated little change in chemical water quality of the South Fork Licking River through time. Only the stream reach under the influence of Pataskala WWTP demonstrated notable improvements. In 1984, ambient $NO_3$-N, $NH_3$-N, and total phosphorus concentrations were elevated downstream of Pataskala WWTP, while D.O. concentration was markedly reduced. Though adequate D.O. levels were maintained in 1984, the diminished level was clearly a result of modest nutrient enrichment related to the facultative lagoon based treatment operated by city of Patatskala until 1992. In the spring of 1992 the lagoon based treatment was replaced by a modern waste water treatment facility. Results from the 1993 water quality survey were reflective of significant treatment upgrades. Ammonia-N, $NO_3$-N, and total phosphorus levels were reduced to background levels, and mean D.O. concentrations were improved considerably in 1993 (Figure 27). Within the remaining portions of the study area concentrations of conventional discharge constituents appeared comparable and fairly stable, longitudinally as well as through time.

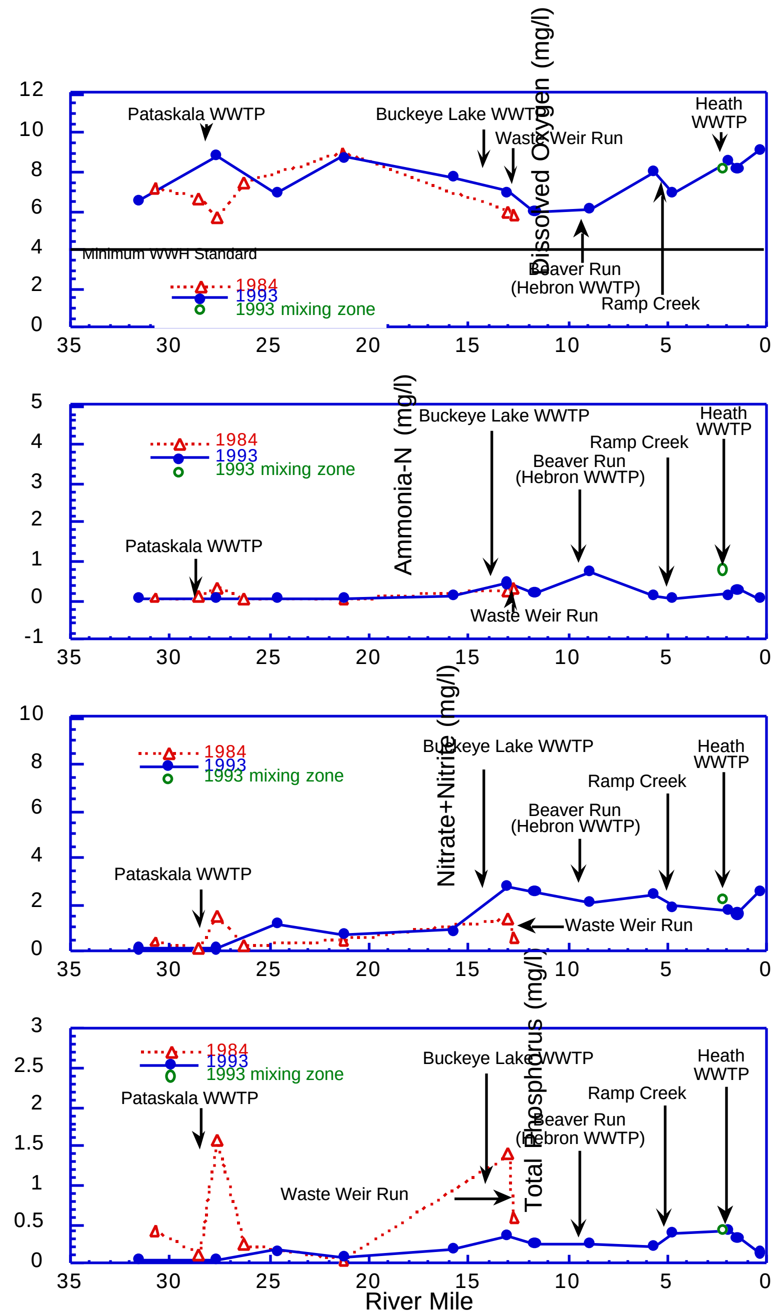


Figure 27. Longitudinal trend of mean concentrations of dissolved oxygen, ammonia-N, nitrate-N, and total phosphorus in the South Fork Licking River study area, 1984-1993. [Note: In 1984 Waste Weir Run was the recieving stream for Buckeye Lake WWTP effluent. The discharge has since changed, and currently Buckeye Lake WWTP discharges directly to the South Fork Licking River at RM 14.2.]

***Benthic Macroinvertebrate Community 1981-1993***

- Macroinvertebrates collected from the South Fork Licking River between RM 31.6 (upstream Pataskala) and RM 18.9 (upstream Buckeye Lake WWTP) showed similar trends during the survey years 1984 and 1993 (Figure 28). The benthic invertebrate community appeared to decline both years at RM 28.4/28.5, upstream of the Pataskala WWTP, compared to RM 31.6. However, the ICI of 32 at RM 28.4 in 1993 indicated nonsignificant departure from the WWH biological criterion.

- In 1993, biological improvement was observed in the South Fork Licking River within the highly modified section between RM 18.9 and RM 11.7, compared to the 1984 survey year. The benthic invertebrate communities performed at a level consistent with the WWH biological criterion both up and downstream of Buckeye Lake WWTP (RM 14.2) in 1993. In 1984, the Buckeye Lake WWTP effluent entered the South Fork Licking River via Waste Weir Run which confluenced with the South Fork at RM 12.83. The benthic invertebrate community indicated fair performance both up and downstream from Waste Weir Run in 1984. At RM 13.0 (now downstream of Buckeye Lake), the ICI scores increased from 22 (1984) to 34 (1993).

- The lower section of the Licking River showed an increase between 4 and 10 ICI units from the 1981 survey to the 1993 survey. In 1993, ICI scores from RM 9.9 and RM 1.7 ranged from 42 to 46, compared with an ICI score of 38 at RM 5.6 in 1981. At RM 0.4 (near the mouth), the benthic invertebrate community performed at a level consistent with WWH biological criterion (ICI=36) in 1993. This represented improvement from the fair conditions (ICI=24) reported in 1981

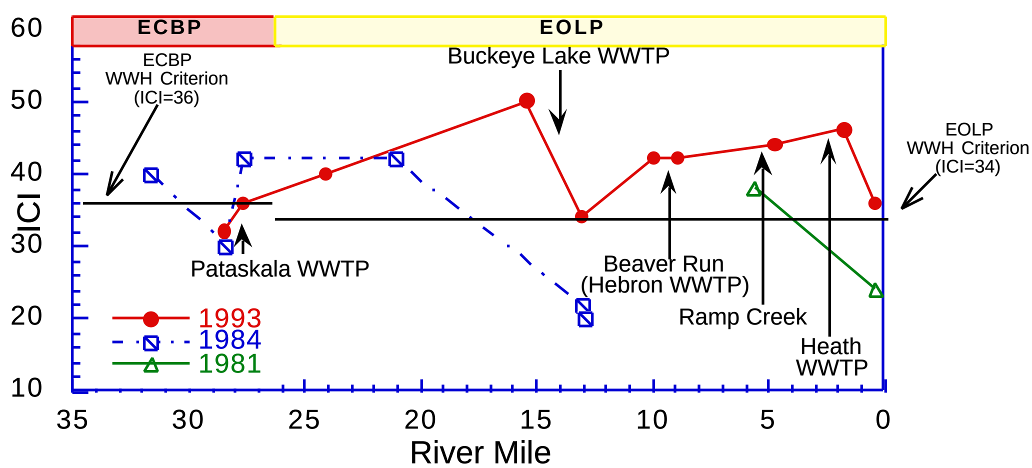


Figure 28. Longitudinal trend of the Invertebrate Community Index (ICI) from the South Fork Licking River study area, 1981-1993.

- The ADV values for the ICI indicated improvement within the benthic invertebrate community between 1981 and 1993 (Table 20). The 1981 study area was limited to the lower reach only, between RM 7.2 and RM 0.4. The ADV/mile within this segment in 1981 was 12.7. The area of impact appeared associated Heath WWTP and CSOs within the city of Newark. The 1984 study area included the upper portion of the South Fork, between RM 31.6 (upstream Pataskala WWTP) and RM 12.7 (downstream Buckeye Lake WWTP). The ADV/mile within this reach in 1984 was 9.2. The areas of impact included the segment downstream of Pataskala WWTP and the channel modified segment surrounding the discharge location of Buckeye Lake WWTP. The ADV/mile was reduced to 0.0 in 1993. The benthic invertebrate community has clearly recovered from the impacts observed in 1981 and 1984.

***Fish Community 1981-1993***

- Fish community data were collected from the South Fork Licking River in 1981, 1984, 1988, and 1993. The 1981 sampling effort included the lower reach between RM 7.2 and RM 0.9, while the 1984 sampling effort included the upper and middle segments between RM 31.5 and RM 12.7. The 1988 sampling effort included only two stations located RM 19.1 and RM 15.3. The 1993 sampling effort included the stream reach between RM 31.5 and RM 0.5, a segment comparable with the combined study areas of both 1981 and 1984. For the purpose of trends analysis, the coverage provided by the 1981 and 1984 study areas enabled an evaluation of longitudinal performance (through time) within the majority South Fork Licking River.

- The results from the 1981 survey indicated that the fish community within the lower reach of the South Fork Licking River performed at a level no better than fair, and failed to fully achieve the WWH biological criteria at any station (Table 10). This segment appeared impacted by Hebron WWTP and Heath WWTP .

- Within the upper and middle segments, the results from the 1984 sampling effort found the fish assemblage in fairly good condition. Both fish community indices generally indicated performance consistent with the applicable WWH biological criteria, except at RM 12.7 (downstream Waste Weir Run/Buckeye Lake WWTP) where the IBI was in significant departure from WWH criteria.

- The results from the 1993 survey indicated substantial recovery in comparison with the evaluations conducted in 1981 and 1984. The fish community performed at a level that meet or exceeded the applicable WWH biological criteria throughout the study area (Figure 29). Only the station at RM 13.1 (downstream of the Buckeye Lake WWTP *direct discharge*) demonstrated significantly reduced performance in comparison to the other stations within the 1993 study area. The observed decline appeared mostly related to the depauperate habitats encountered at this station.

- In the past the Buckeye Lake WWTP discharged into Waste Weir Run which confluenced with the South Fork Licking River at RM 12.8. Recently, a direct discharge to the South Fork Licking River has been installed at RM 14.2. The change in discharge location provided an opportunity to evaluate the habitat influence on ambient biological performance at RM 13.1, in the absence of Buckeye Lake WWTP discharge. In 1984 the station at RM 13.1 was located upstream of the confluence of Waste Weir Run (Buckeye Lake WWTP). The fish assemblage at this station was influenced primarily by the poor condition of the macrohabitats, and performed at a level characterized as good/marginally good (MIwb=9.0; IBI=39). In 1993 the station at RM 13.1 was situated downstream of the newly installed (direct) discharge from

Buckeye Lake WWTP, and performance appeared virtually unchanged (MIwb=8.9; IBI=37). Thus, it appeared as though the diminished performance observed at RM 13.1, both in 1984 and 1993, appeared to be mostly a function of disrupted habitat.

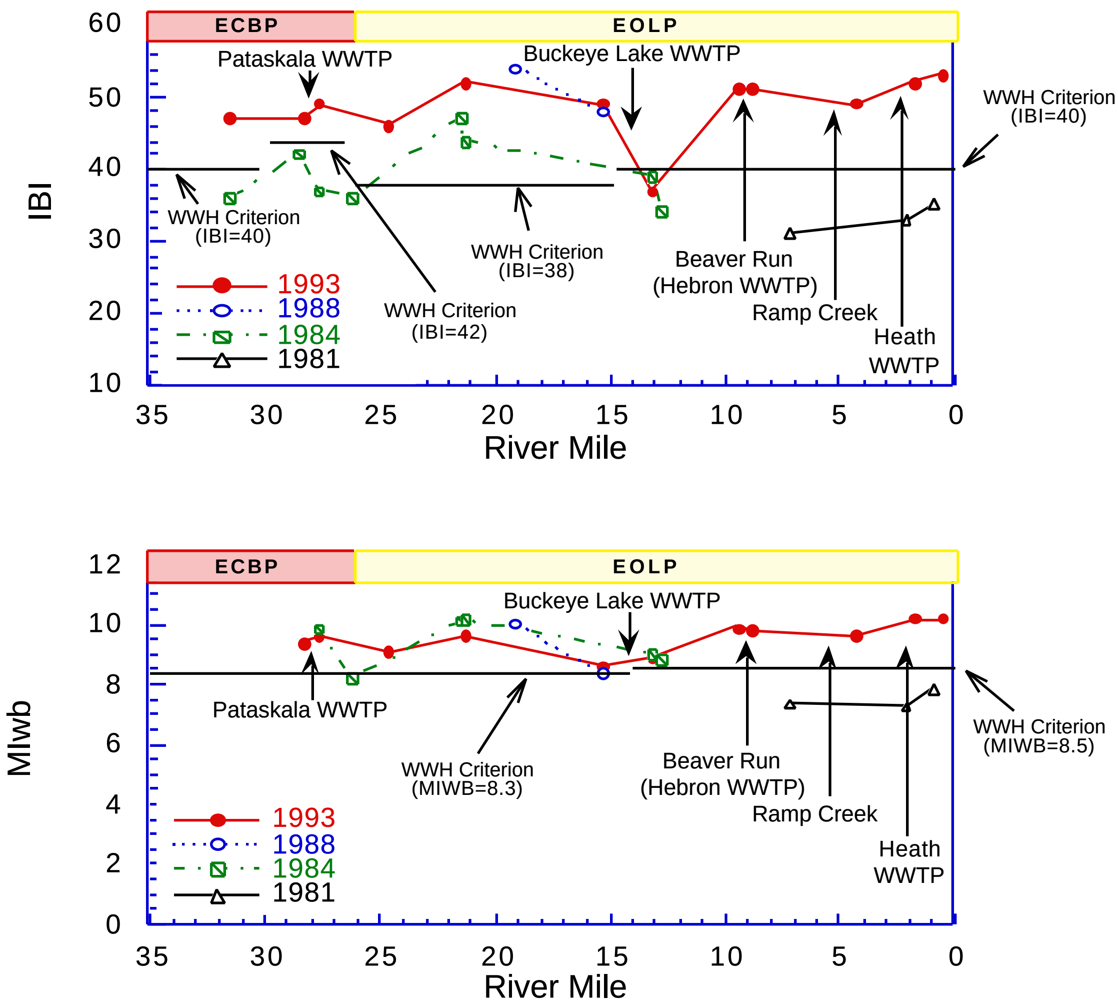


Figure 29. Longitudinal trend of the Index of Biotic Integrity (IBI, upper plot) and the Modified Index of Well-being (MIwb, lower plot) from the South Fork Licking River, 1981-1993.

- No significant impact was evident in 1993 associated with the Pataskala WWTP, Buckeye Lake WWTP, Hebron WWTP, or Heath WWTP. With the exception of RM 13.1, improvement within the fish assemblages was observed throughout the South Fork Licking River study area downstream of these entities. As within other portions of the 1993 Licking River study area, shifts within the composition and functional organization of the fish assemblage from the 1993 community samples were suggestive of recovery associated with reduced pollutant loading (Figure 30). In term of relative abundance, the 1993 survey results indicated that the trophic structure within the fish community appeared intact. Insectivory was predominant, carnivores were well represented, and omnivory occurred at levels consistent ecoregional reference conditions. In contrast, the trophic structure of the fish community in 1981 was strongly skewed, with omnivory as the predominant feeding guild. Typically, omnivorous and generalized feeding species predominant in areas where environmental disturbance has disrupted or simplified the food base. Additional shifts within the assemblage that were indicative of improved condition included a substantial increase in the percent occurrence of environmental sensitive species (*e.g.* round-bodied sucker, darter, and minnow species) and decline in percent occurrence of environmentally tolerant taxa.

- The ADV values for the fish community indices (IBI and MIwb) indicated improvement between 1981 and 1993. The ADV/mile values in 1981 for the IBI and MIwb were 32.2 and 36.3 respectively. The 1984 study included the upper and middle portion of the South Fork, and ADV/mile (0.2 and 0.0) indicated only modest impairment. The 1993 ADV/mile values for the IBI and MIwb were 0.0 for both indices, and indicated complete recovery from the degraded conditions observed within the lower reach in 1981.

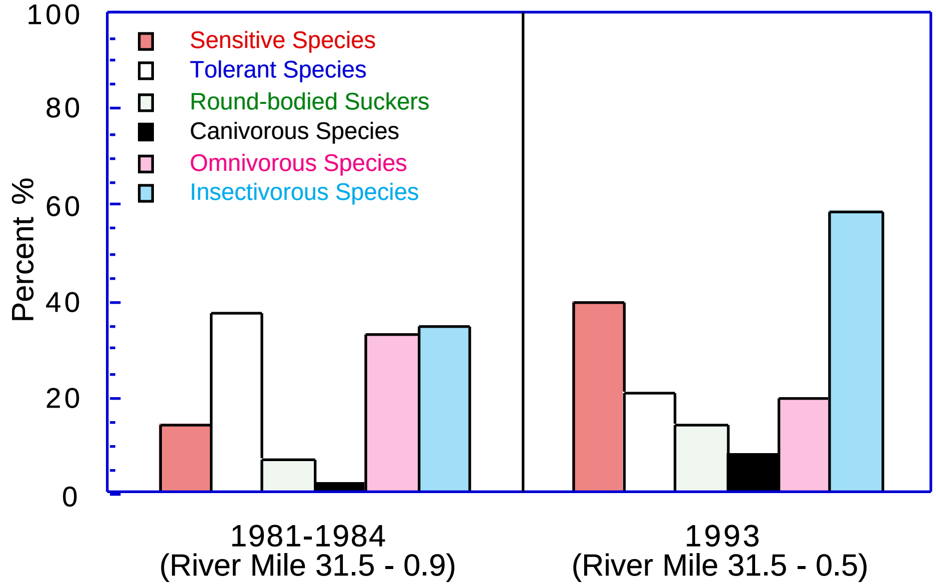


Figure 30. Comparison of the mean percent occurrence of various components of the fish assemblage from the South Fork Licking River between 1981-84 and 1993. (Note: Individual species may be included within one or more functional and/or compositional groupings.)

## Raccoon Creek

***Fish Community 1981-1993***

- Only fish community information was available to evaluate changes in the ambient biological conditions of Raccoon Creek through time. Fish community data were collected from the Raccoon Creek in 1981, 1987, and 1993. The sampling effort in 1981 included only one fish sampling station at RM 0.6. The 1987 sampling effort was more robust and included the stream reach between RM 26.3 and RM 18.6. The 1993 sampling effort was limited to two fish sampling station located at RM 5.6 and RM 0.3. Given the limited size of the 1993 sampling effort, only the community samples collected from RM 0.6 in 1981 and RM 0.3 in 1993 were suitable for trend analysis.

- The lower reach of Raccoon Creek through the city of Newark is subject to the influence of numerous CSOs. In comparison with the 19816 community samples from RM 0.6, it appeared as though the fish assemblage within the lower reach of Raccoon Creek has improved. In 1981 the community at RM 0.6 in 1981 was characterized as fair (MIwb=7.6; IBI=31), and failed to perform at a level consistent with the WWH biological criteria. In 1993 the fish assemblage at RM 0.3 performed at an exceptional level (MIwb=10.2; IBI=50). The performance observed in 1993 within the lower reach indicated full recovery within the fish community from impact likely associated with CSO discharges from the city of Newark and and possibly Granville WWTP in 1981.

- Shifts within the composition and functional organization of the fish assemblage from the 1993 samples in the lower reach were indicative of recovery associated with reduced pollutant loadings (Figure 31). In term of relative abundance, the 1993 survey results indicated that the trophic structure within the fish community appeared intact. Insectivory was predominant, carnivores were well represented, and omnivory occurred at levels consistent ecoregional reference conditions. In contrast, the trophic structure of the fish community in 1981 was strongly skewed, with omnivory as the predominant feeding guild. Typically, omnivorous and generalized feeding species predominate in areas where environmental disturbance has disrupted or simplified the food base. Additional shifts within the assemblage that were indicative of improved condition included a substantial increase in the percent occurrence of environmental sensitive species (*e.g.* round-bodied suckers, darter, and minnow species) and decline in percent occurrence of environmentally tolerant species.

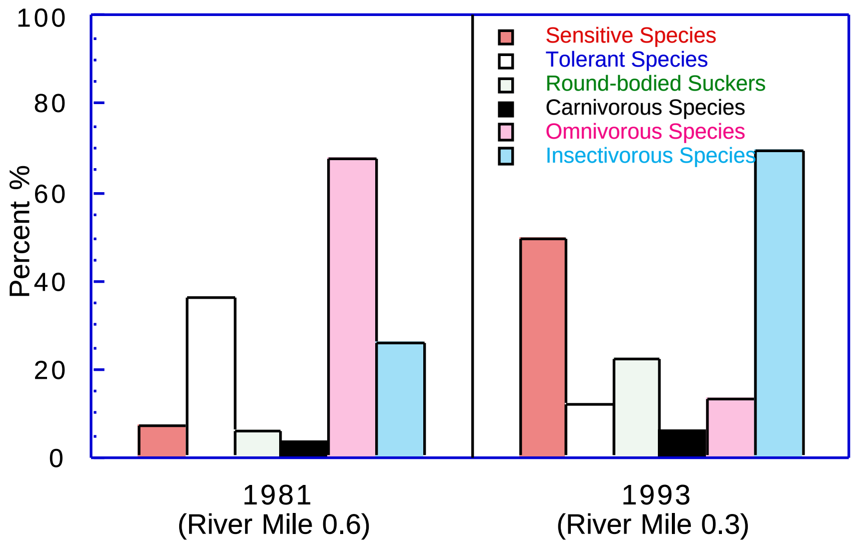


Figure 31. Comparison of the mean percent occurrence of various components of the fish assemblage from the lower reach of Raccoon Creek between 1981 and 1993. (Note: Individual species may be included within one or more functional and/or compositional groupings.)

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