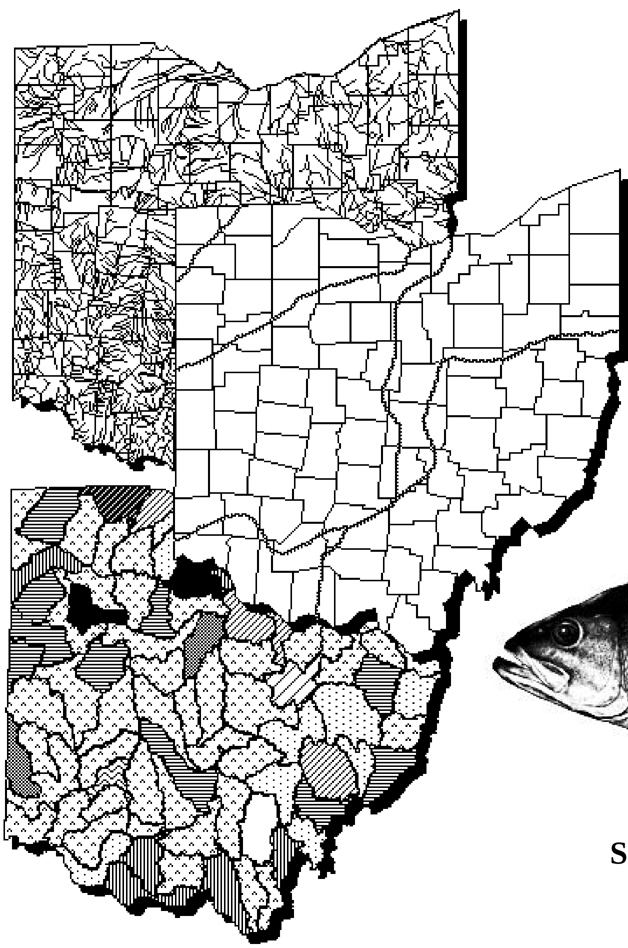
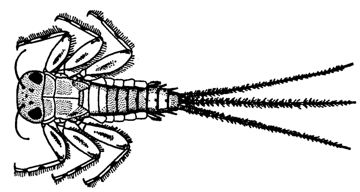
State of Ohio
Environmental Protection Agency

Ecological Assessment Unit
Division of Surface Water

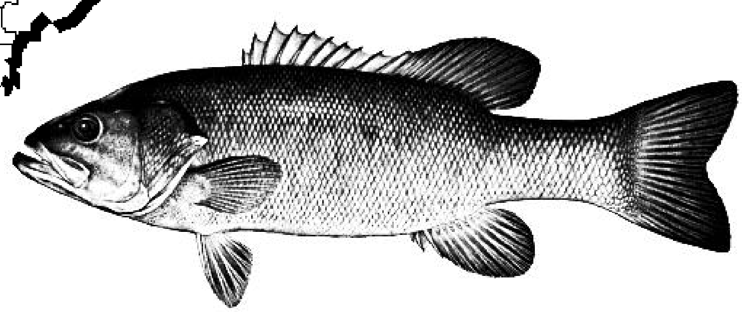
Biological and Water Quality Study of The Portage River Basin

Hancock, Ottawa, Sandusky, and Wood Counties, Ohio





Mayfly (*Stenacron sp.*)



Smallmouth Bass (*Micropterus dolomieui*)

December 7, 1995

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43216-1049

Biological and Water Quality Study of the Portage River and Selected Tributaries

Hancock, Ottawa, Sandusky, Seneca and Wood Counties

OEPA Technical Report MAS/1995-12-7

December 7, 1995

prepared by

State of Ohio Environmental Protection Agency
Division of Surface Water
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NOTICE TO USERS

Ohio EPA added biological criteria to the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (Effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish, and the Invertebrate Community Index (ICI), which is based on macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the chemical and whole effluent toxicity evaluation methods, figure prominently in the assessment of Ohio's surface water resources.
Several documents support the adoption of the biological criteria by outlining the rationale for using biological information, the specific methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results. These documents are:

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

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

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

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

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

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

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

Ohio EPA, Monitoring & Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228
(614) 728-3377

ACKNOWLEDGEMENTS

The following Ohio EPA staff are acknowledged for their contributions to this report.

Clint Shuff and Robert Miltner- Study Area Description and Map
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Biological and Water Quality Survey of the Portage River Basin

(Hancock, Ottawa, Sandusky, Seneca and Wood Counties, Ohio)

State of Ohio Environmental Protection Agency
Division of Surface Water
1800 WaterMark Drive
Columbus, Ohio 43266-0149

INTRODUCTION

The Portage River mainstem from Pemberville (River Mile [RM] 35.8) to Port Clinton (RM 0.0), the East Branch Portage River from RM 17.8 (upstream of Fostoria) to the confluence with the South Branch Portage River, and sites in selected tributaries were studied in this survey.

Specific objectives of the study were:

1) evaluation of the physical habitat, the quality of the water and underlying sediments, and the biological integrity of the Portage River study area.

2) assessment of impacts from nonpoint sources of pollution, combined stormwater and sewage overflows (CSOs), municipal and industrial wastewater treatment plants (WWTP), and habitat alterations.

3) determination of attainment status of aquatic life use and non-aquatic use designations, and recommend changes where appropriate.

4) results comparison of this survey with previous surveys for trends in water resource quality.

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

SUMMARY

A biological and water quality survey of the Portage River basin was conducted between July 6 and October 7, 1994. Most of the locations fully attained the Warmwater Habitat (WWH) use designation (Table 1). Exceptions were the East Branch of the Portage River and Rocky Ford, both of which had significant areas of non-attainment. Nutrient enrichment from wastewater treatment plants, unsewered areas, agricultural runoff, and wide-spread habitat modifications throughout the Portage River basin have resulted in biological communities that only marginally attain the WWH use designation (Table 1).

Portage River Mainstem

The Portage River mainstem exhibited full attainment of the applicable WWH biocriteria at 15 of 21 locations resulting in 31.2 river miles considered to be in full attainment of the WWH use

designation. One location (RM 24.2) exhibited partial attainment due to the impacts of organic enrichment from the Woodville WWTP on the composition of the macroinvertebrate community (Table 1). Fish community performance was only marginally consistent with the WWH biocriteria because of the combined effects of organic enrichment and habitat modification resulting from the low head dam at RM 20.8. Nutrient loadings from the Bowling Green WWTP, particularly for phosphorus, also contributed to the organically enriched conditions in the Portage R. mainstem, and likely exacerbated the situation downstream from Woodville. Point source discharges throughout the basin can comprise as much as 25 percent of the flow in the Portage R. mainstem during normal summer-fall low flow periods. Reduced macroinvertebrate community performance was also associated with combined sewer overflow (CSO) impacts from Pemberville, but this was not severe enough to result in an impairment of the WWH use. Twelve miles of the Lake Erie influenced portion of the river (*i.e.*, the estuarine portion) were in non-attainment of the interim WWH biocriteria as a result of silt deposition, organic enrichment, and an increased biochemical oxygen demand loadings.

Nutrient enrichment from agricultural nonpoint source runoff, as evidenced by elevated ambient levels of nitrate+nitrite-N and total phosphorus, in combination with altered stream habitat (hydromodification and siltation) has taxed the assimilative capacity of the mainstem, and thus influenced the composition of the fish community. As a consequence, many locations only marginally attained the WWH biocriteria for either or both fish community indices, demonstrating the pervasiveness of these nonpoint source influences throughout the mainstem. The performance of the macroinvertebrate community, however, was near exceptional at several locations on the mainstem. This combination of marginal fish community performance and near exceptional macroinvertebrate community performance is a signature of pervasive agricultural nonpoint source impacts and has been observed in other mainstem rivers in the Huron/Erie Lake Plain ecoregion.

Organochlorine pesticides were detected in virtually all surface water grab samples (including the tributaries). Lindane, endosulfans and heptachlor, commonly used agricultural inseciticides, were detected most frequently. Residues of environmentally persistant pesticides (*i.e.*, aldirn, DDT, endrin) no longer in general commercial use, or thier metabolites (*e.g.*, DDE, dieldrin) were also detected frequently. The frequency of detections reflects the lack of retaining mechinisms, specifically riparian buffers, throughout the watershed.

Sediment collected from the Brush Wellman mixing zone (at the mouth of Hyde Run) revealed highly elevated levels of polycyclic aromatic hydrocarbons (PAHs), PCBs, and heavy metals (beryllium and copper). The effects of these contaminated sediments on biological performance were minimal as evidenced by lack of aquatic life use impairment. While a number of toxic substances were detected in various outfalls, the aggregate impact of Brush Wellman was negligible on the mainstem, being restricted to the mixing area at the mouth of Hyde Run. Although effects of contaminated sediments on the biological community performance were minimal, concentrations of PCBs were found in fish tissue samples collected from the contaminated area, that pose a moderate health risk for human consumption.

East Branch Portage River

The East Branch Portage River was grossly polluted by loadings from combined sewer overflows (CSOs) and the Fostoria WWTP. As a result, 16.0 miles (nearly the entire length of the East

Branch Portage River) were in non-attainment of WWH use and only 0.9 miles exhibited partial attainment. One (1) mile exhibited full attainment. Elevated levels of PAHs, PCBs, and organochlorine pesticides in sediments collected upstream from the Fostoria WWTP indicate that untreated discharges are entering the East Branch via combined sewer overflows which further contribute to the severe and extensive aquatic life use impairment. The biological response signatures are indicative of acutely toxic impacts.

Rocky Ford

The biological communities in Rocky Ford were impacted by flow alteration (dewatering) and CSOs. Stream flow ceased downstream from VanBuren Reservoir during the summer-fall sampling period which resulted in intermittent and interstitial flows through the North Baltimore area upstream from the WWTP. Discharges of raw sewage from CSOs in North Baltimore coupled with the lack of sustained summer-fall flows resulted in 2.2 miles of non-attainment. Stream flow was eventually re-established by the North Baltimore WWTP, which resulted in improved biological performance and full (2.0 miles) or partial (2.1 miles) attainment of the WWH use. An unsewered discharge at RM 5.1 resulted in non-attainment downstream from Cygnet. The biological response signatures were generally indicative of an organic enrichment impact.

Table 1. Aquatic life use attainment status for stations sampled in the Portage River basin based on data collected July - October, 1994. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are based on the performance of the fish and macroinvertebrate communities. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

River Mile Fish/Invertebrate	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Comment
Portage River (1994)						
	Huron-Erie Lake Plain Ecoregion WWH Use (Existing)					
35.8/35.8	32	8.7	48	55.0	FULL	Ust. Pemberville CSOs
35.6/ --	34	8.4	--	61.5	(FULL)	Ust. Pemberville CSOs
35.0/ --	38	9.1	--	65.0	(FULL)	Adj. Pemberville CSOs
34.8/34.9	33	7.6	36	59.0	FULL	Dst. Pemberville CSOs
34.6/34.6	36	8.5	38	63.0	FULL	Dst. WWTP discharge
29.5/29.3	34	9.0	40	63.5	FULL	Ust. Woodville CSOs
27.7/27.3	34	8.2	50	65.5	FULL	Dst. Woodville CSOs
-- /27.1	--	--	46	--	(FULL)	Dst. Woodville WWTP
24.2/24.0	38	7.9	28*	81.0	PARTIAL	Ust. Elmore CSOs
22.2/22.7	29[ns]	6.8[ns]	32	43.5	FULL	Dst. Elmore CSOs
22.1/22.0	28[ns]	7.1[ns]	50	57.5	FULL	Dst. Elmore WWTP
17.6/17.7	37	8.7	48	59.5	FULL	Reference/Ambient
17.4/ --	31[ns]	7.1[ns]	--	58.5	(FULL)	Reference
16.8/17.0	39	9.0	52	67.0	FULL	Ust. Brush Wellman
16.5/16.5-south [b]	*31*	*7.9*	*34*	--		*Brush Wellman mixing zone*
-- /16.5-north	--	--	30	--	(FULL)	Opposite Brush Cr.
16.2/ --	33[ns]	8.3[ns]	--	68.0	(FULL)	Dst. Brush Wellman
Portage River Estuarine Zone						
			Interim Criteria for Lake Erie Estuaries			
13.3/13.8	37	9.8	16*	64.5	PARTIAL	Ust. Oak Harbor WWTP
12.3	37	9.8	6*	51.5	**NON**	Dst. Oak Harbor WWTP
5.9/6.8	23*	6.4*	6*	49.0	**NON**	Near mouth of L. Portage
0.6/0.7	31[ns]	8.4	10*	52.5	**NON**	Ust. Port Clinton WWTP
0.2/0.1	33	8.4	18[ns]	57.0	FULL	Dst. Port Clinton WWTP
Little Portage River						
0.6/ --	18*	4.1*	--	--	**NON**	At mouth
East Branch Portage River						
17.4/17.8	17*	NA	12*	31.0	**NON**	Nonpoint impacts
12.5/12.5	22*	NA	34	53.0	**NON**	Ambient, ust.CSOs

Table 1. (continued)

River Mile Fish/Invertebrate	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Comment
East Branch Portage River (cont'd)						
10.5/10.4	18*	NA	P*	50.5	**NON**	Fostoria CSOs
10.2/10.2	15*	NA	0*	52.0	**NON**	Dst. Fostoria WWTP
9.1/9.0	12*	NA	2*	31.0	**NON**	Impact
4.9/6.2	24*	4.8*	2*	48.0	**NON**	Impact
0.8/0.8	29ns	7.4ns	32ns	63.0	Full	Recovery, nonpoint impacts
Rocky Ford						
- /15.4	--	--	F*		(**NON**)	Regional Reference Site
10.8/10.15	22*	7.0ns	F*	35.5	**NON**	Ust. N. Baltimore CSOs
9.8/9.8	26*	6.8*	4*	42.5	**NON**	Dst. N. Baltimore CSOs
- /9.5	--	--	14*		(**NON**)	Dst N Balt. WWTP
5.2 /7.5	36	7.2ns	42	38.5	FULL	Recovery
- /5.1	--	--	16*	--	(**NON**)	Cygnet (unsewered)
- /2.9	--	--	MG	--	(FULL)	Recovery
Nichol's Ditch *(KOA trib. to Rocky Ford)*						
0.4/ --	32	--	--	28.0	(FULL)	Reference
North Branch Portage River						
- /17.9	--	--	P*	--	(**NON**)	Nonpoint source
6.6/5.0	32	7.0ns	44	29.0	FULL	Use designation info.
1.3/0.7	40	8.4	MG	59.5	FULL	Nonpoint source
Middle Branch Portage River						
-- /8.7	--	--	MG		(FULL)	Nonpoint source
South Branch Portage River						
8.35/8.35	30ns	7.6	F*	56.5	PART.	Regional Reference Site
Sugar Creek						
13.4/ --	32	8.1	MG	44.5	FULL	Nonpoint source
8.9/8.8	36	8.6	MG	63.5	FULL	Nonpoint source
Bull Creek						
0.6/0.6	24*	7.5	MG	24.5	**NON**	Nonpoint source
Needles Creek						
1.3/ --	28ns	8.8	MG	25.0	FULL	Nonpoint source

Table 1. (continued)

Ecoregion Biocriteria: Huron-Erie Lake Plain (HELP)

INDEX	WWH	EWH	MWH[c]
IBI -headwaters	28	50	20
IBI - wading	32	50	22
IBI - boat	34	48	20
IBI - interim estuary	32	NA	NA
MIwb - wading	7.3	9.4	5.6
Miwb - boating	8.6	9.6	5.7
MIwb - interim estuary	7.5	NA	NA
ICI - all streams/rivers	34	46	22
ICI - interim estuary	22	NA	NA

* indicates significant departure from biocriteria, poor and very poor scores are underlined.

ns nonsignificant departure from established criteria (≤ 4 IBI or ICI units; ≤ 0.5 MIwb units).

[a] Narrative evaluation based on assessment of qualitative samples used in lieu of ICI (MG = marginally good, F = fair, P = poor).

[b] Biocriteria do not apply in mixing zones.

[c] Modified Warmwater Habitat for channel modified areas.

NA Not applicable.

Various Tributaries

Biological community performance in the North Branch Portage River from RMs 6.6 to 0.7 indicated full attainment of the existing WWH use designation. One qualitative macroinvertebrate sample from a channel modified reach (RM 17.9) exhibited non-attainment. Fish and macroinvertebrate communities in tributaries with historical channel modifications (*e.g.*, Needles Creek, Sugar Creek, Nichol's Ditch) exhibited full attainment of the WWH use thus demonstrating compliance with the less stringent biological criteria established for wadeable streams the Huron-Erie Lake Plain (HELP) ecoregion. The non-attainment observed in Bull Creek reflected recent channel modifications. Partial attainment in the South Branch was attributed to nonpoint source enrichment and low stream flows. Sediment metal concentrations in Poe Ditch were elevated as a result of urban inputs and possibly from untreated industrial discharges into the sewer system. Results of chemical surface water samples demonstrated a serious problem with the McComb WWTP as fecal coliform counts exceeded 10,000 per 100 ml in one sample collected in the WWTP mixing zone.

CONCLUSIONS

- Nutrient enrichment from the Woodville WWTP contributed to an impairment of the WWH aquatic life use in a 0.2 mile segment of the Portage River mainstem. The Bowling Green WWTP also contributed to organically enriched conditions in the mainstem. Organic enrichment derived from combined sewer overflows, and nonpoint sources (agriculture and unsewered residential areas) tax the assimilative capacity of themainstem, and also contribute to aquatic life use impairment.

- The East Branch Portage River is grossly polluted for 17.7 miles by raw sewage and industrial effluents discharged via CSOs and by the poor performance of the Fostoria WWTP.

- Flow desiccation caused by a public water supply reservoir, sewage from CSOs in North Baltimore, and an unsewered area resulted in extensive impairment of the WWH aquatic life use in Rocky Ford.

- Highly elevated fecal coliform counts in the McComb WWTP mixing zone indicate that discharges of raw or poorly treated sewage are being discharged to Algire Creek and Rader Creek.

- Extensive historical and recent channel modifications, the loss of wooded riparian corridors, tile drainage of agricultural lands, and intensive row crop tillage practices throughout the Portage River watershed accumulate to impair and/or threaten aquatic life uses in several tributaries and contribute to the marginal condition of the fish community in the mainstem.

RECOMMENDATIONS

Portage River Mainstem

Status of Aquatic Life Uses
The Portage River mainstem is presently designated as Warmwater Habitat (WWH). Performance of the biological indicators demonstrate that this use designation is appropriate, and therefore, should be maintained.

Status of Non-aquatic Life Uses
All non-aquatic life uses (*i.e.,* Primary Contact Recreation, Agricultural Water Supply, etc.) should remain as presently designated in the Ohio Water Quality Standards.

Other Recommendations
The Woodville WWTP should reduce loadings of ammonia-nitrogen, and reduced loadings of phosphorus should be examined for both the Woodville and Bowling Green WWTPs. Conservation tillage and other agricultural best management practices, and re-establishment of wooded riparian habitats throughout the watershed are needed to help assimilate and reduce the effects of nutrients contributed from both point and nonpoint sources. The low-head dam downstream of Elmore should be removed to improve instream habitat and facilitate the free passage of fish including seasonal migrants from Lake Erie.

Future Monitoring Concerns
The reach of the mainstem from Woodville to Elmore should be monitored at the next opportunity afforded by the Five-Year Basin Approach to determine the status of biological communities, given the marginal biological performance documented in 1994. Data on pollutant loadings from CSOs in Pemberville, Woodville, Elmore, Oak Harbor and Port Clinton are needed to accurately assess their contributions to the organically enriched conditions in the mainstem. Nonpoint source contributions of nitrogen and phosphorus should be evaluated, and done so in light of the capability to restore degraded riparian habitats.

East Branch Portage River

Status of Aquatic Life Uses
The available habitat and the performance of the fish and macroinvertebrate communities at RM 0.8 demonstrate that the East Branch Portage River is potentially capable of supporting biological communities consistent with WWH criteria for the Huron/Erie Lake Plain. Extensive reductions in pollutant loadings will be needed to fully achieve this goal, however.

Status of Non-aquatic Life Uses
All non-aquatic life use designations (*i.e.*, Primary Contact Recreation, Agricultural Water Supply, etc.) should remain as listed. This includes the part of the E. Branch from which the city of Fostoria fills an upground water supply reservoir.

Other Recommendations
Because the East Branch Portage River was grossly polluted by raw sewage from CSO discharges in Fostoria and bypasses by the WWTP while under expansion, and because it has a Primary Contact use designation, advisories about human contact (swimming or wading) should be discussed with the Seneca Co. Health Dept. Also, the city of Fostoria fills its water supply reservoirs from the East Branch Portage River. A program for assuring the pretreatment of industrial wastewater from industries discharging to the Fostoria sewer system should be implemented.

Future Monitoring Concerns
The East Branch Portage River should be assessed following completion of the Fostoria WWTP upgrade to determine the extent of any improvements which may occur as the result of reduced pollutant loadings. A short-term intensive monitoring effort for fecal coliform and *E. coli* levels in the East Branch Portage River should be undertaken and continued as long as the current problems with CSOs and the WWTP persist. Mercury loadings from the Fostoria WWTP needs to be quantified and an attempt to determine the source(s) made. The sediments and surface waters in Lakes Lamberjack and Mottram should be analyzed for contamination by organochlorine pesticides, especially for DDT and metabolites, as these were detected in the study area.

Rocky Ford

Status of Aquatic Life Uses
The performance of the fish and macroinvertebrate communities from RMs 7.6 to 5.2 demonstrate that Rocky Ford is capable of supporting biological communities consistent with the WWH criteria for the Huron/Erie Lake Plain, thus the WWH use should be retained.

Status of Non-aquatic Life Uses
All non-aquatic life use designations (*i.e.*, Primary Contact Recreation, Agricultural Water Supply, etc.) should be maintained as presently listed in the Ohio Water Quality Standards. This includes the extant Public Water Supply designation for the Van Buren Reservoir.

Other Recommendations
Because Rocky Ford has a Primary Contact use designation, and is significantly polluted by CSO discharges from the city of North Baltimore and an unsewered area near Cygnet Road (RM 5.1), advisories about human contact (swimming or wading) should be discussed with the Wood Co.

Health Dept. The North Baltimore WWTP needs to be upgraded to handle larger volumes of wastewater and to reduce the amount of raw sewage discharged via CSOs. A minimum discharge from the Van Buren Reservoir should be established during summer-fall low flow periods to alleviate the impairment caused by flow desiccation.

Future Monitoring Concerns
A short-term intensive monitoring effort for fecal coliform and *E. coli* levels in Rocky Ford in and downstream from N. Baltimore and near Cygnet Rd. should be undertaken and continued as long as the current problems with CSOs and the unsewered area persist. The residential area contributing untreated discharges at Cygnet Road should be assessed for improperly maintained or inappropriately located on-site septic systems.

Other Tributaries

Status of Aquatic Life Uses
All of the various tributaries evaluated are currently designated as Warmwater Habitat (WWH). The available habitat and the demonstrated performance of the biological communities warrants that this use designation be maintained. Although the biological communities inhabiting the recently channelized section of the North Branch Portage River did not attain the WWH biocriteria, other segments with less recent channel modification histories (*e.g.*, Needles and Sugar Creeks) support biological community performance consistent with the biological criteria established for wadeable streams in the Huron/Erie Lake Plain ecoregion.

Status of Non-aquatic Life Uses
All present non-aquatic life uses (*i.e.,* Primary Contact Recreation, Agricultural Water Supply, etc.) listed in the Ohio Water Quality Standards should be retained.

Recommendations
Channel maintenance programs on headwaters and smaller tributaries should be limited so as to maximize recovery of riparian habitat and minimize the downstream export of nutrients and undesirable biomass. A cataloging of the various stream segments presently under ditch maintenance and those proposed for ditch maintenance would help facilitate this recommendation.

Future Monitoring Concerns
Issues exist in Poe Ditch regarding CSO and pretreatment concerns. This area should be targeted for follow-up monitoring at the next opportunity afforded by the Five-Year Basin approach. Whenever possible, site or stream specific monitoring should be conducted in advance of channel maintenance projects and become part of the decision making process where Ohio EPA has regulatory authority or informational input. Algire Creek should be more thoroughly evaluated to assess impacts from the McComb WWTP via a District biosurvey.

STUDY AREA

The Portage River and tributaries drain 602 square miles of land area in the Lake Erie drainage basin in northwest Ohio (Figure 1). In addition to the mainstem, tributaries in the study area included: Little Portage River, Sugar Creek, South Branch, Middle Branch, North Branch, East Branch Portage River, Bull Creek, Rocky Ford, and Needles Creek. Wood, Sandusky, Hancock, Ottawa, and Seneca counties lie within the Portage River watershed. Major population concentrations within the watershed include Port Clinton, Oak Harbor, Elmore, Woodville, Pemberville, Bowling Green, North Baltimore, McComb, and Fostoria.

The Portage River basin lies entirely within the Huron/Erie Lake Plain (HELP) ecoregion. The HELP is very flat having little relief, the soils are poorly to very poorly drained and consist of parent material derived from glacial tills and lacustrine deposits associated with the Wisconsin glaciation era. The glacial till is predominantly in the form of ground moraine overlies limestone bedrock. The thickness of the glacial drift varies from about 25m to only a few centimeters. The uppermost bedrock strata consists of Silurian dolomite and dolomitic limestone. The predominant soil associations in the study area include the clay rich Hoytville, Toledo, and Sloan soils. These poorly drained soils are in the humic gley family that developed in fine textured calcareous glacial till. The Toledo association is characterized by silty clay and clay which contains fine layers of sand or silty materials. The Sloan series occurs along most of the streams in the study area. These are dark-colored soils that formed in alluvium derived from calcareous Wisconsin glacial till (U.S. Dept. of Agriculture 1966). The soils contain high amounts of organic matter and provide some of the most productive farm land in the state.

Forested wetlands, fens, and wet prairies once covered the HELP ecoregion prior to European settlement, but were cleared and drained for agriculture purposes during the 19th and early 20th centuries. Row crop agriculture (corn, soybeans, and other grain crops), specialty crops (*e.g.*, tomatoes), and livestock and dairy operations are the primary agricultural activities in the basin. To facilitate drainage, thousands of miles of drain tile and conversion of natural stream channels into a drainage ditch systems have resulted in the present-day highly modified stream and riparian habitats. The extensive system of modified streams is maintained through county sponsored maintenance programs authorized under the Ohio Drainage Law (ORC 6131) that includes periodic dredging and vegetation control or removal. Wooded riparian buffer areas along the streams of the study area are either very narrow or nonexistent since trees are frequently viewed as an impediment to efficient drainage.

Historical accounts of the Portage River indicate that pollution did not appear to significantly impact the basin until the oil boom of the late 19th century (Luebke 1975). During the oil boom, the variety of fishes that were abundant in the river were devastated. Waste oil and brine overflowed containment ponds and was discharged with impunity into the mainstem and tributaries causing fires and damaging intake pipes and machinery in water dependant industries. Dead and rotting fishes killed by these oil spills created a widespread nuisance.

Today, sediments and nutrients in agricultural runoff are the principal constituents of nonpoint source pollution in the Portage basin. Fortunately, farming practices and attitudes about nonpoint source runoff in most of the study area are changing. Conservation tillage practices, which tends to retard sediment runoff into streams, is being increasingly employed in the watershed. More than one-third of Wood County acres (34.6%) and nearly one-half (41.8%) of Ottawa County acres are in no till (1994 SWCD transect tillage surveys). Areas of concern in the Portage River basin include the specialty crop production in Ottawa county where conservation tillage is not a widely adopted practice. In the Needles Creek and Radar Creek watersheds of Wood county intensive row crop farming is predominated by traditional tillage practices more than conservation tillage.

The Portage River and the major tributaries included in the study area (Table 2) have aquatic life use designations of Warmwater Habitat. The Ohio Nonpoint Source Assessment document (Ohio

EPA 1988) indicates 44% of the segments in the Portage River basin are considered to be impacted based on water quality data and modeling results. Of these 14% are considered as impaired by nonpoint sources. These results are based on past biological and chemical assessments which only covered a small portion of the watershed.

Unsewered areas in the Portage River basin (Table 2) also contribute to water quality problems. These areas have no centralized wastewater treatment or collection facilities and individual residences utilize septic tanks, sub-surface sand filters, or home aeration systems for the treatment of sanitary wastes. Many of the residences have small lots which do not allow for leaching fields or have failing on-site systems. This generally results in discharges of raw or poorly treated sewage to receiving streams. While residential water usage by household varies the average daily wastewater flow from a typical residential dwelling is approximately 45 gallons/person/day. There are three major categories of household waste: garbage disposal wastes, toilet wastes, and detergent wastes (*e.g.*, washing machines). Residential areas and villages within the basin which are contributing to this type of problem are: The Nugents Canal area, Lake Shore Drive, and Lacarne in Ottawa county; Rising Sun, Wayne, West Milgrove, Jerry City, Cygnet, Mermill, Bardstown, Rudolph, Cloverdale, Scotch Ridge, New Rochester, Stearns Crest, Flechtner Heights, Parkview Nursery subdivision, Madison addition, Caldwell addition, and Balderson subdivision in Wood county.

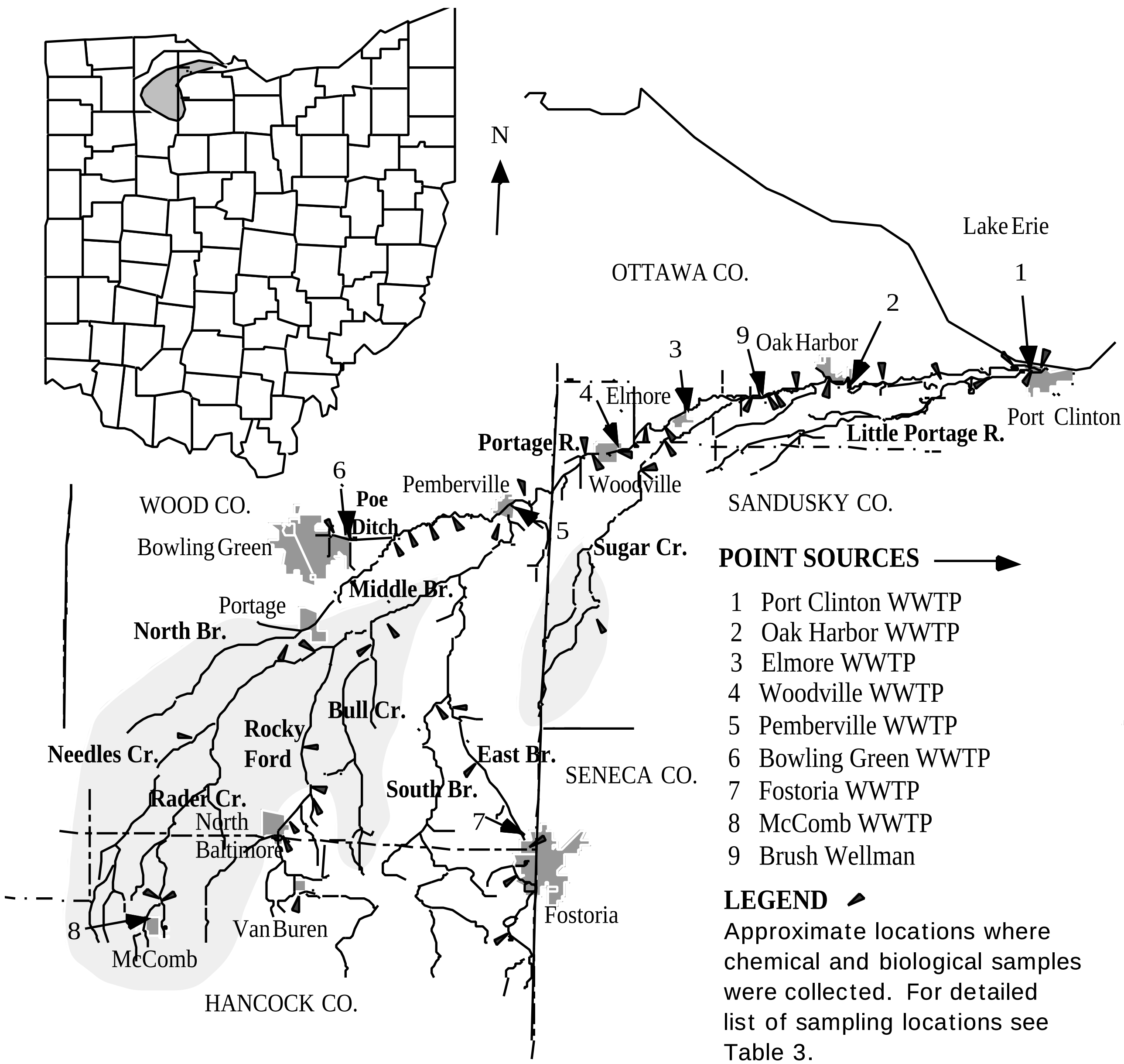


Figure 1. The Portage River drainage basin showing geographical locations, urban areas, major point source discharges, and generalized sampling locations. The stippled area depicts the portion of the watershed under active channel maintenance. See Table 3 for a description of specific sampling locations.

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

River/Stream	Length (Miles)	Gradient (Ft / Mi.)	Drain. Area (Sq. Mi.)	Nonpoint Sources	Point Sources
Portage River	60.6	3.3	251.78	Agriculture Channelization	Port Clinton WWTP Oak Harbor WWTP Elmore WWTP Woodville WWTP Pemberville WWTP Brush Wellman
North Branch Portage River	25.8	2.0	60.72	Agriculture Channelization Off lot Sewage Disposal	
South Branch Portage River	27.5	5.2	350.0	Agriculture Channelization Off lot Sewage Disposal	
East Branch Portage River	17.2	6.5	38.2	Agriculture Channelization Off lot Sewage Disposal	Fostoria WWTP
Middle Branch Portage River	27.8	2.9	186.6	Agriculture Channelization Off lot Sewage Disposal	
Little Portage R.	14.0	3.1	6.62	Agriculture Channelization	
Poe Ditch	3.97	5.0	2.47	Agriculture Channelization	Bowling Green WWTP
Bull Creek	14.3	7.0	31.0	Agriculture Channelization Off lot Sewage Disposal	

Table 2. Continued.

River/Stream	Length (Miles)	Gradient (Ft / Mi.)	Drain. Area (Sq. Mi.)	Nonpoint Sources	Point Sources
Rocky Ford	22.9	6.2	69.1	Agriculture Channelization Off lot Sewage Disposal	
Nichols Ditch	2.25	13.0	1.36	Agriculture Channelization	
Sugar Creek	17.8	6.3	62.2	Agriculture Channelization Off lot Sewage Disposal	
Needles Creek	10.7	4.1	32.80	Agriculture Channelization	
Rader Creek	14.3	6.3	32.6	Agriculture Channelization	
Algire Creek	4.0	16.3	3.85	Agriculture Channelization Livestock	McComb WWTP

Table 3. Sampling locations in the Portage River study area, 1994 (C - conventional water chemistry, C_o - conventional plus organics; S - sediment metals, additional scans noted by the following subscripts: v = volatile organic compounds, b = base neutral acid extractable compounds, p = pesticide/polychlorinated biphenyls; B - benthic macroinvertebrates, F - fish, T - fish tissue).

Stream/ River Mile	Type of Sampling	Latitude/ Longitude	Landmark	USGS 7.5 minute Quadrangle Map
Portage River				
35.9	BC	41 24 22/83 27 28	Harris Park	Pemberville
35.8	F	41 24 22/83 27 28	Harris Park	Pemberville
35.6	F	41 24 08/83 27 30	Dst. Harris Park	Pemberville
35.29	C	41 24 34/83 27 29	Bridge Street	Pemberville
35.0	C	41 24 45/83 27 17	Pemberville Road	Pemberville
34.9	B	41 24 45/83 27 10	Dst. Pemberville Road	Pemberville
34.8	F	41 24 46/83 27 08	Ust. WWTP discharge	Pemberville
34.75	C	41 24 47/83 26 58	WWTP discharge	Pemberville
34.7	C	41 24 47/83 26 57	WWTP mix zone	Pemberville
34.6	BF	41 24 51/83 26 55	Dst. WWTP discharge	Pemberville
29.5	F	41 26 47/83 23 06	Adj. SR 105, ust SR 582	Pemberville
29.26	BC_oS_{vbp}	41 26 58/83 22 58	Junct. SR 582 + 105	Pemberville
28.3	C_oS_{vp}	41 26 58/83 21 52	At Erie Street	Elmore
28.0	C_oS_{vp}	41 26 57/83 21 33	Dst. US 20	Elmore
27.7	F	41 27 05/83 21 06	Adj. SR 105 E. of town	Elmore
27.3	B	41 27 05/83 20 47	Adj. SR 105, dst Oak st.	Elmore
27.4	C_o	41 27 05/83 20 53	Access road to WWTP	Elmore
27.39	C_o	41 27 04/83 20 52	Access road to WWTP	Elmore
27.1	B	41 27 07/83 20 40	Access road to WWTP	Elmore
24.2	F	41 27 59/83 18 32	Gravel road under I 80/90	Elmore
24.1	C	41 28 05/83 18 29	Gravel road under I 80/90	Elmore
24.0	B	41 28 06/83 18 28	Gravel road under I 80/90	Elmore
22.7	B	41 28 38/83 17 40	Veterans Cemetery	Elmore
22.54	CS_{vpb}	41 28 43/83 17 25	Ust. Elmore WWTP	Elmore
22.2	F	41 28 55/83 17 20	At city park, ust WWTP	Elmore
22.15	C	41 28 58/83 17 13	Elmore WWTP effluent	Elmore
22.14	C	41 28 58/83 17 12	WWTP mix zone	Elmore
22.0	BF	41 28 58/83 17 10	At city park, dst WWTP	Elmore
17.7	B	41 29 29/83 13 58	Portage R. S. Rd.	Lindsey
17.6	F	41 29 29/83 13 57	Portage R. S. Rd, gun range	Lindsey
17.4	F	41 29 31/83 13 39	Portage R. S. Rd.	Lindsey
17.03	C_o	41 29 28/83 13 18	At SR 590	Lindsey
17.0	B	41 29 29/83 13 16	Dst. SR 590	Lindsey
16.8	F	41 29 33/83 12 57	Dst SR 590	Lindsey

Table 3. Continued.

Stream/ River Mile	Type of Sampling	Latitude/ Longitude	Landmark	USGS 7.5 minute Quadrangle Map
16.54	C_o	41 29 30 / 83 12 47	In mouth of Brush Cr.	Lindsey1
6.5-south	BFC_oS_{vbp}	41 29 30 / 83 12 40	Dst Mouth of Brush Cr.	Lindsey
16.5-north	B	41 29 32 / 83 12 46	Opposite Brush Cr.	Lindsey
16.3	F	41 29 33 / 83 12 36	Brush-Well. Campground	Lindsey
Portage River Estuarine Zone				
15.7	C_oS_{vbp}	41 29 41 / 83 11 52	Dst Slemmer-Portage Rd	Lindsey
14.9	C_o	41 29 48 / 83 11 05	Portage R. S. Rd.	Lindsey
14.0	CS_p	41 30 08 / 83 10 11	SR 105 ust Toussaint Portage Rd.	Oak Harbor
13.3	F	41 30 26 / 83 09 31	Adj. to cemetery	Oak Harbor
12.55	CS_p	41 30 18 / 83 08 43	SR 19	Oak Harbor
12.3	F	41 30 11 / 83 08 32	Dst. SR 19	Oak Harbor
12.0	E	41 30 10 / 83 08 11	Oak Harbor WWTP	Oak Harbor
11.95	C	41 30 10 / 83 08 08	WWTP mix zone	Oak Harbor
11.0	C	41 30 16 / 83 07 39	Opposite Golf course	Oak Harbor
5.9	F	41 30 24 / 83 02 84	Mouth of Little Portage	Port Clinton
3.0	C	41 30 44 / 82 59 28	SR 2 Bridge	Port Clinton
0.6	$C_oS_{vb}F$	41 30 55 / 82 56 47	Harrison Avenue	Port Clinton
0.55	C_o	41 30 55 / 82 56 44	Port Clinton WWTP	Port Clinton
0.5	C_o	41 30 55 / 82 56 40	WWTP mix zone	Port Clinton
0.4	C_o	41 30 55 / 82 56 35	SR 163 draw bridge	Port Clinton
0.2	F	41 30 57 / 82 56 30	At mouth of Portage R.	Port Clinton
0.1	CS_{vb}	41 30 57 / 82 56 14	Municipal parking lot	Port Clinton
Little Portage River				
0.5	F	41 30 00 / 83 02 30	Mouth of L.Portage R.	Wightmans Grove
1.79	C	41 29 11 / 83 08 14	County Road 17	Wightmans Grove
East Branch Portage River				
17.8	B	41 06 20 / 83 26 26	County Road 23	Alvada
17.3	CF	41 06 27 / 83 26 43	County Road 216	Alvada
12.5	BF	41 09 19 / 83 26 36	Tiffin Street	Fostoria
12.47	C_oS_{bp}	41 09 21 / 83 26 38	Tiffin Street	Fostoria
10.5	F	41 10 19 / 83 25 25	Ust WWTP access road	Fostoria
10.4	$C_oS_{bp}B$	41 10 22 / 83 25 26	Ust WWTP access road	Fostoria
10.2	C_o	41 10 28 / 83 25 40	WWTP access road	Fostoria
10.19	C_oS	41 10 30 / 83 25 41	WWTP mix zone	Fostoria
10.15	BF	41 10 28 / 83 25 43	At city park	Fostoria
9.0	C_oS_bBF	41 11 17 / 83 26 18	Pelton Road	Fostoria
6.2	BC_o	41 13 00 / 83 27 38	Eagleville Road	Fostoria

Table 3. Continued.

Stream/ River Mile	Type of Sampling	Latitude/ Longitude	Landmark	USGS 7.5 minute Quadrangle Map
***East Branch Portage River** (cont'd)*				
4.9	F	41 13 43 / 83 28 32	Baird Road	Fostoria
0.8	C_oBF	41 16 09 / 83 30 28	Bays Road	Jerry City
North Branch Portage River				
17.92	BC	41 18 42 / 83 40 10	Rudolph Road	Bowling Green South
9.73	C	41 22 27 / 83 34 49	Bowling Green Road	Dunbridge
8.5	C	41 22 05 / 83 34 10	Anderson and Poe Ditch Rd.	Dunbridge
6.6	F	41 23 43 / 83 32 38	Silverwood Road	Dunbridge
6.55	C	41 23 38 / 83 32 34	Silverwood Road	Dunbridge
5.0	B	41 24 04 / 83 31 21	Ust. SR 199	Dunbridge
1.3	F	41 24 04 / 83 28 28	SR 105, power lines	Pemberville
0.8	C	41 24 20 / 83 28 09	Adj. SR 105	Pemberville
0.7	B	41 24 23 / 83 27 52	Adj. SR 105	Pemberville
Middle Branch Portage River				
8.7	BC_oS_{bp}	41 18 06 / 83 37 55	Solether Road	Bowling Green South
6.07	C_oS_{bp}	41 19 27 / 83 35 16	Dst Bull Creek	Jerry City
South Branch Portage River				
8.3	FC	41 16 22 / 83 30 57	Portage View Road	Jerry City
Rocky Ford				
15.04	BC	41 07 55 / 83 38 59	County Rd 220	North Baltimore
10.8	FC_oS_{bp}	41 10 19 / 83 40 31	SR 18	North Baltimore
10.15	B	41 10 43 / 83 39 58	Ust Water Street	North Baltimore
9.8	CSBF	41 10 56 / 83 39 49	Eagleville Road	North Baltimore
9.5	B	41 11 07 / 83 39 32	Dst N Balt. WWTP	North Baltimore
6.34	$B_oC_{bp}S$	41 13 14 / 83 38 59	Tank Farm Road	North Baltimore
5.2	F	41 14 20 / 83 39 00	Cygnet Road	North Baltimore
5.1	B	41 14 24 / 83 38 59	Cygnet Road	North Baltimore
2.9	B	41 16 06 / 83 38 21	Solether Road	Bowling Green South
Nichols Ditch (KOA trib)				
0.1	F	41 12 10 / 83 38 22	Steele + Rocky Ford Rd.	North Baltimore
Bull Creek				
0.6	F	41 18 45 / 83 35 12	Greensburg Pike	Jerry City
0.64	BC	41 18 39 / 83 35 09	Greensburg Pike	Jerry City

Table 3. Continued.

Stream/ River Mile	Type of Sampling	Latitude/ Longitude	Landmark	USGS 7.5 minute Quadrangle Map
Poe Ditch				
3.0	CS	41 23 06 / 83 37 21	Poe Rd at Golf Course	Dunbridge
2.46	E	41 23 06 / 83 36 51	BG WWTP, Poe Road	Dunbridge
2.4	CS	41 23 06 / 83 36 48	BG WWTP mix zone	Dunbridge
Rader Creek				
11.8	C	41 07 38 / 83 47 05	SR 235	Hoytville
11.7	C	41 07 40 / 83 47 08	SR 235	Hoytville
Algire Creek				
1.05	E	41 06 56 / 83 47 42	McComb WWTP	McComb
1.0	C	41 06 58 / 83 47 40	WWTP mix zone	McComb
Needles Creek				
1.3	FC	41 13 24 / 83 45 04	Cygnet Road	Hoytville
Sugar Creek				
13.4	F	41 23 43 / 83 21 52	Anderson Road	Elmore
8.9	FC	41 26 12 / 83 19 52	Ust US 20	Elmore
8.8	B	41 26 14 / 83 19 47	at US 20	Elmore
5.68	C	41 27 40 / 83 17 58	SR 51	Elmore

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) (Rankin 1989) for aquatic habitat assessment. Chemical, physical and biological locations listed in Table 3 were sampled in accordance with these procedures.

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, Ohio Environmental Protection Agency 1993). Measures used to judge biological community performance 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 criteria, PARTIAL if one or two of the indices are in the fair category, and does not attain (**NON**) 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 above 75 frequently typify habitats 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 testing and refinement 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 in the Portage River study area, 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. Use of the QCTV in evaluating sites in the Portage River study area was restricted to relative comparisons between sites and was not unilaterally used to interpret quality of the sites or aquatic life use attainment status.

Fish Community Assessment

Fish were sampled using the wading or boat mounted methods each of which utilizes pulsed DC electrofishing gear. The wading method was used at a frequency of one or two times at each site and the boat method was used at a frequency of two or three times at each site within the June 16 - October 15 index period. The specific electrofishing method used and the number of samples for each location are listed in Table 12.

Area of Degradation Value (ADV)

An Area Of Degradation Value (ADV; Rankin and Yoder 1991; Yoder and Rankin 1995) was calculated for delineated segments within 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 ecoregional biocriterion or the upstream level of performance. The total ADV is represented by the area beneath the ecoregional 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. The latter statistic is frequently used to quantify changes between different sampling years in an attempt to demonstrate trends in overall biological community performance.

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 used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, 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 1991; Yoder 1995). 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 1995) 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 success is gaged by 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.

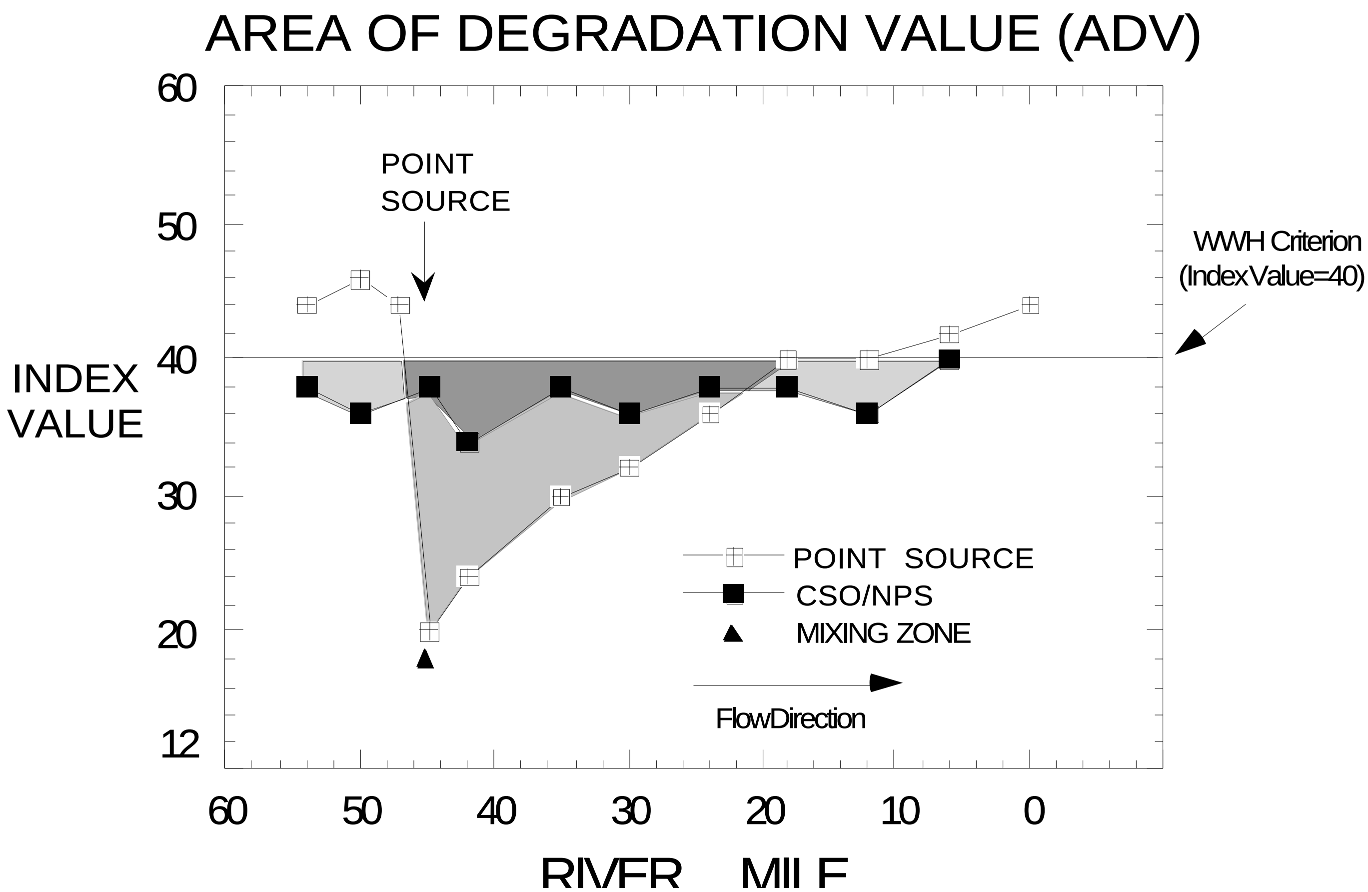


Figure 2. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears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

Pollutant Loadings: 1976-1994

The NPDES permitted facilities within the Portage River basin are described below with a discussion of pollutant loadings based on historical data from monthly operating reports (MORs) submitted by each entity as part of the self-monitoring program. The loadings figures and percentages are based on the process discharges, or in the case of wastewater treatment plants (WWTP), the treated effluent (usually outfall 001). Loadings from combined sewer overflows (CSOs) and/or plant bypasses are not included and represent an additional and potentially significant source of unaccounted for pollutants. Frequently monitoring data is not provided with reports of CSO discharges, making it difficult to estimate the amount of additional pollutants being discharged to the Portage River basin, even though the results of this and previous surveys indicate that CSOs contribute to water quality impacts. Total mean effluent volume reported by discharges throughout the basin can account for as much as 25 percent of the flow in the Portage mainstem during low flows.

Algire Creek

McComb WWTP (2PB00002): Originally constructed in 1937, then upgraded in 1970, the plant was expanded and upgraded again in 1989. The McComb WWTP is a secondary treatment facility, which consists of a comminuter, degritting clarigester, a recirculating trickling filter followed by a nitrification tower, secondary clarification and chlorination. Final effluent is discharged to Algire Creek, a tributary to Rader Creek. Prior to disposal, digested sludge is discharged to sand beds for drying. The plant has a design flow of 0.338 MGD and a hydraulic capacity of 0.720 MGD. The McComb WWTP serves a population of 1350 and also receives about 25% of its influent from Consolidated Biscuit Co., which manufactures crackers and cookies. Combined sewers serve 60% of the village, with 1 bypass (Outfall 002) and 3 overflows (Outfalls 003, 004, 005) to Algire Creek. Separate sewers serve 30% of the village and 10% has no sewer system. All flow to the plant is by gravity.

The McComb WWTP contributed 1.70% of all treated wastewater discharged to the Portage River Basin in 1994 (1.73% from 1992-1994) (Figure 3). Mean annual flow through the plant from 1990-1994 was 0.30131 MGD. Flows have increased since 1989 and frequently exceed design capacity. The plant reported one bypass (002) in August 1994, and no overflows during the June-September 1994 period.

The mean annual NH_3-N load for 1990-1994 was 0.93 kg/day. The plant contributed 0.57% of the total ammonia-N discharged to the Portage River Basin from 1992-1994 (0.61% in 1994 - Figure 17). Excluding the Brush Wellman load (as Brush Wellman was the largest contributor of inorganic nitrogen), the McComb WWTP contributed 1.83% of the flow discharged to the Basin from 1992-1994 (1.81% in 1994 - Figure 18). Mean annual loads of total phosphorus have increased since 1990, and McComb WWTP is the fourth largest contributor of phosphorus to the Portage River Basin (Figures 4 and 19). The plant's average phosphorus load for the period 1990-1994 was 3.01 kg/day. The plant contributed 10.32% of the phosphorus discharged to the Portage River Basin from 1992-1994 (11.1% in 1994), and is therefore, a major source of enrichment in the basin.

Loadings of total suspended solids (TSS), $cBOD_5$ and ammonia-N (NH_3-N) to the Portage River decreased dramatically since the 1989 plant upgrade (Figure 4). The mean annual TSS load for the period 1990-1994 was 3.47 kg/day. The McComb WWTP contributed 0.60% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (0.45% in 1994). The mean annual $cBOD_5$ load for the period 1990-1994 was 13.42 kg/day. The plant contributed 2.72% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (2.76% in 1994).

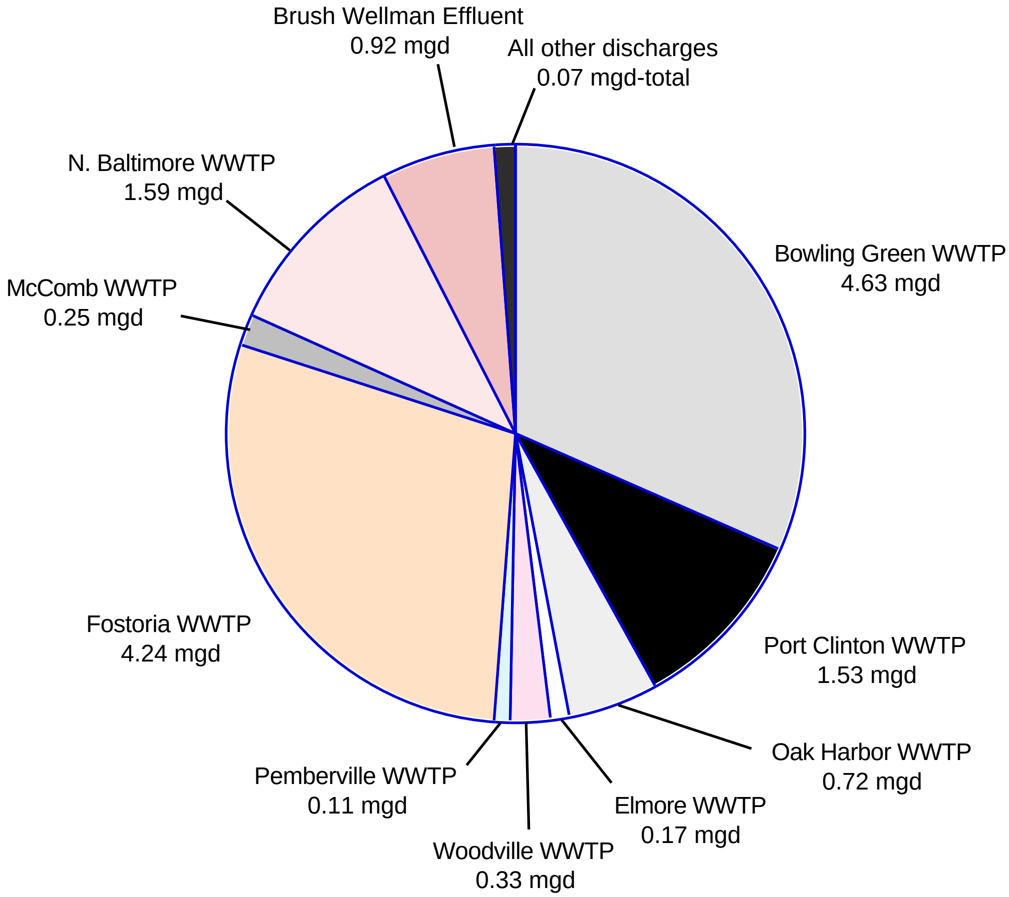
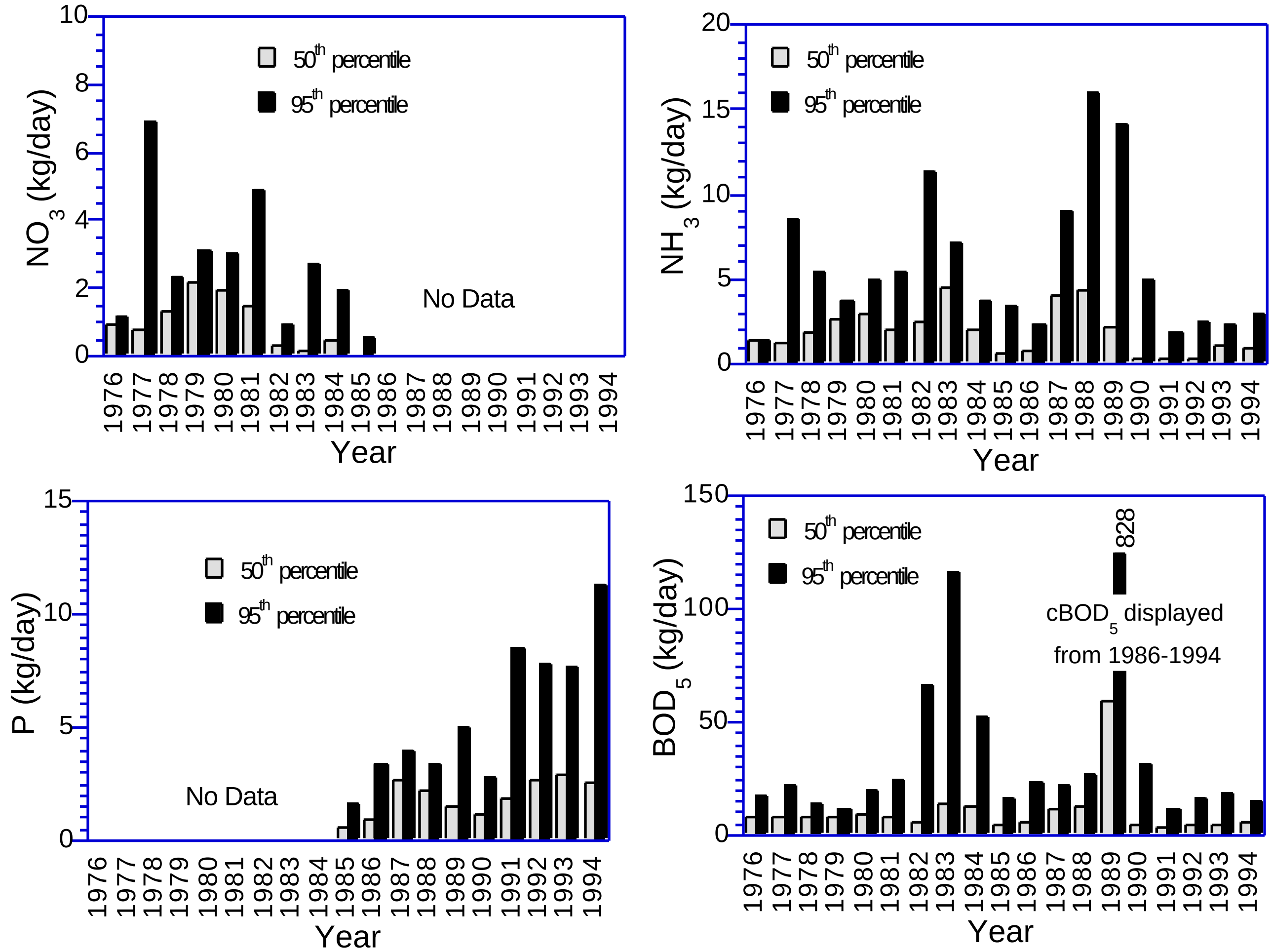


Figure 3. Mean annual daily effluent discharged by major point sources in the Portage River basin in 1994. The total effluent discharged was 15.31 million gallons per day (MGD).



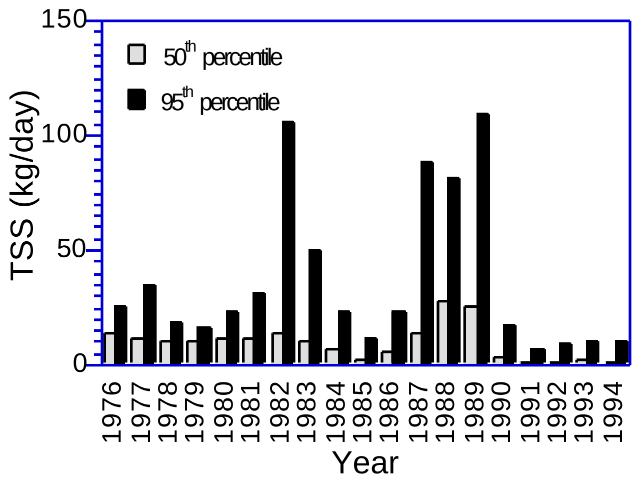


Figure 4. Median and 95th percentile annual loadings of ammonia-N, nitrate-N, total phosphorus, BOD_5, and total suspended solids discharged by the McComb WWTP (outfall 001) during 1976-1994.

Needles Creek

Hoytville WWTP (2PA00083)**:** Constructed in 1990, the Hoytville WWTP is a secondary treatment facility, consisting of a small diameter gravity collection system and a three cell controlled discharge lagoon. The plant serves a population of 350 and is designed for an influent flow of 0.036 MGD with lagoon storage for 180 days. Effluent from the lagoon is only discharged to Needles Creek during high flow periods (the plant discharged for a total of 8 days in 1993 and 7 days in 1994). To calculate a mean annual flow, the total volume discharged was divided over 365 days in order to make comparisons with facilities that discharge on a daily basis (Figures 3, 17 and 18). Pollutant loadings used in comparisons were calculated in the same manner. However, when considering the potential effects of the Hoytville WWTP effluent on Needles Creek, it should be kept in mind that pollutant loadings are all discharged to the stream within the space of one (1) week, rather than spread out over a years time.

North Branch Portage River

Wood Co. Historical Park & Animal Shelter SS #603 (2PG00101)**:** The county operates a 2,500 gpd (0.0025 MGD) extended aeration plant with sand filters and chlorination. The effluent discharges to the North Branch Portage River. There is a force main in front of the building which would connect the facility to the Bowling Green WWTP, but to date, the county has not tied into it. The permit for this facility expires in June 1996, and the new permit will include a compliance schedule for tying into the sewer, if the county has not yet done so.

ODOT I-75 Rest Areas/Northbound & Southbound (2PP00015,16)**:** Both interstate rest areas were connected to the City of Bowling Green Collection System in December 1994. Prior to that connection, each rest area operated a 0.02 MGD extended aeration plant followed by subsurface sand filters and chlorination. Effluent from both plants was discharged into the North Branch Portage River.

Wood Co. Nursing Home, SS #602 (2PG00100)**:** In 1989, the Wood Co. Nursing Home was tied into the City of Bowling Green WWTP. Prior to 1989, the nursing home operated a 40,000 gpd (0.04 MGD) package plant with sand filters which discharged to the North Branch Portage River.

Greenline Produce [formerly Century Marketing] (2IN00123)**:** In 1994, when the Village of Portage installed a collection system to tie into the City of Bowling Green WWTP, Greenline Produce tied into the new sewers. All wastewater (except vegetable wash water) from Greenline Produce is now sent to the Bowling Green WWTP via the Portage sanitary sewers. Prior to that connection, Greenline Produce operated a 3,000 gpd (0.003 MGD) extended aeration plant followed by sand filters and chlorination. The final effluent was discharged to the #467 ditch, a tributary to the North Branch Portage River. Currently, vegetable process water is discharged to a 30,000 gallon settling lagoon. The final effluent from the lagoon discharges to ditch #2432 which flows south along S.R. 25 to the North Branch Portage River.

Village of Portage**:** In 1994, the Village of Portage installed a gravity sewage collection system with a force main to the City of Bowling Green WWTP. Prior to 1994, wastewater treatment consisted of individual septic tanks discharging to the North Branch Portage River either directly or via combined sewers.

Poe Ditch

Bowling Green WWTP (2PD00009)**:** The existing plant was constructed in 1982, completely replacing the original treatment plant. The Bowling Green WWTP is a tertiary treatment facility utilizing a pumping station, stormwater overflow holding basin, comminuter, aerated grit removal tank, two primary settling tanks, four aeration chambers, two final settling tanks, waste sludge system, tertiary filters, chlorination, aerobic digestion and digested sludge pumps. The plant has submitted plans to replace chlorination with UV disinfection in the fall of 1995. The Bowling Green WWTP has a design flow of 8 MGD and a hydraulic flow of 16 MGD, serving a population of 28,176. Average flow through the plant is about 5.4 MGD, including 1-5% from industry. The sewer system is partially combined with 1 overflow (Outfall 002).

The Bowling Green WWTP contributed 32.97% of all treated wastewater discharged to the Portage River Basin from 1992-1994 (31.6% in 1994 - Figure 3). Flows have been fairly consistent from year to year (Figure 5). The average flow through the plant from 1990-1994 was 5.59 MGD, well below design flows. However, the 95th percentile flows have always exceeded design capacity.

Average annual loadings of ammonia-nitrogen (NH_3-N) have also been greatly decreased since 1982, but appear to be quite variable based on the difference between the 50th and 95th percentiles (Figure 5). Levels of nitrate-n (NO_3-N) have only slightly increased since 1982, indicating the overall loading of nitrogen to the stream has been reduced and the treated wastewater may be in a more advanced stage of nitrification at the point of discharge. The average NH_3-N load for 1990-1994 was 30.35 kg/day. The plant contributed 12.72% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (18.3% in 1994) or 21.40% when Brush Wellman loads are excluded (Figures 17 and 18).

Mean annual loads of total phosphorus from the Bowling Green WWTP have only slightly decreased since construction of the new plant in 1982 (Figure 5). The Bowling Green WWTP is the largest identified point source contributor of phosphorus to the Portage River Basin. The average total phosphorus load for the period 1990-1994 was 11.03 kg/day. The plant contributed 34.37% of reported phosphorus discharged to the Portage River Basin from 1992-1994 (32.8% in 1994 - Figure 19), and resulted in elevated phosphorus levels downstream to Pemberville. The phosphorus load from the Bowling Green WWTP contributed directly to the enriched conditions in the Portage mainstem.

Plant data showed a dramatic decrease in total suspended solids (TSS) and $cBOD_5$ loadings to Poe Ditch since construction of the new plant in 1982 (Figure 5). The average annual TSS load for the period 1990-1994 was 46.52 kg/day. The Bowling Green WWTP contributed only 8.48% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (7.56% in 1994). This is low considering the Bowling Green WWTP discharge represents nearly a third of the treated wastewater discharged to the Portage River Basin. The average $cBOD_5$ load for the period 1990-1994 was 59.56 kg/day. The plant contributed 24.37% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (21% in 1994).

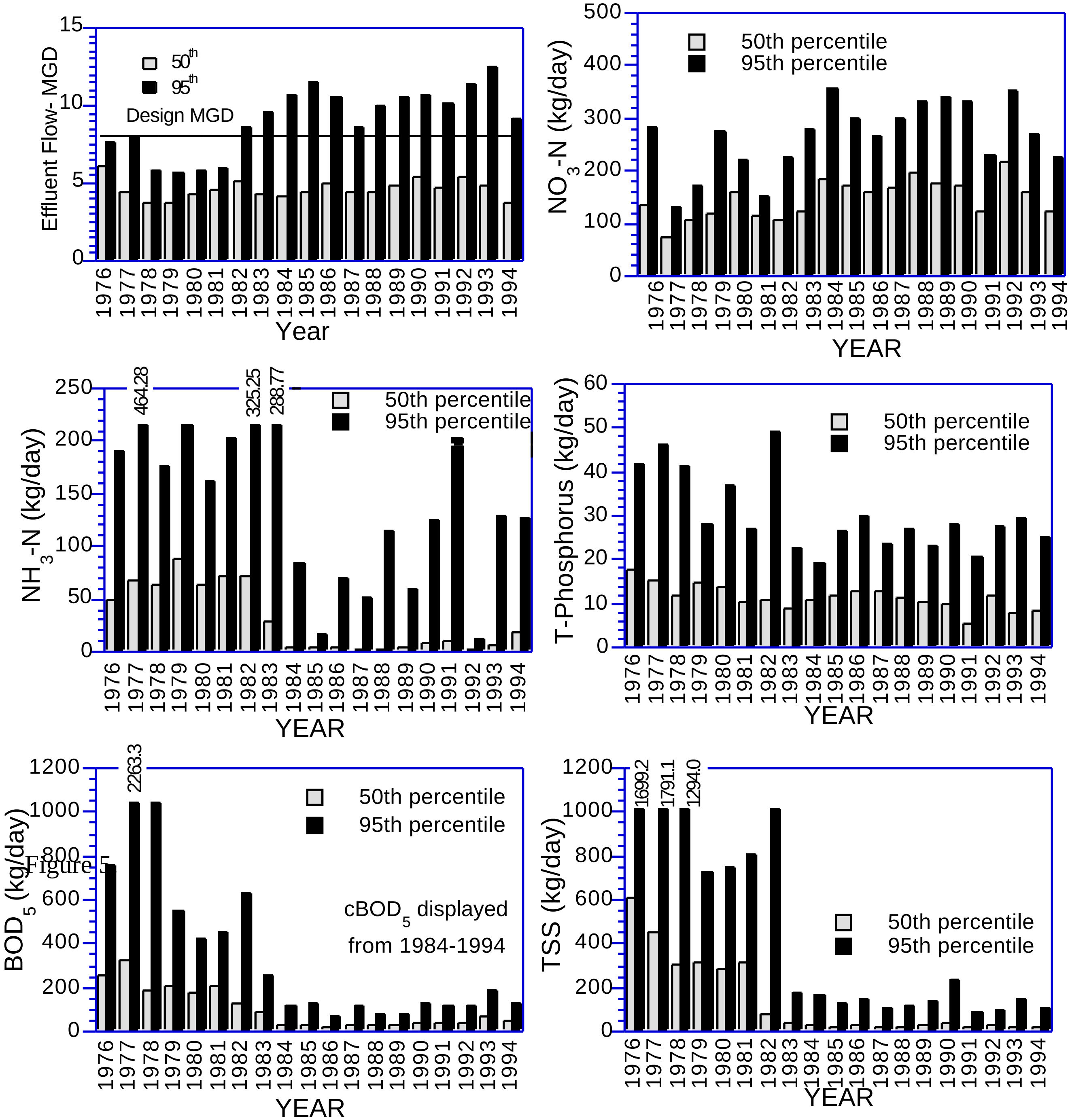


Figure 5. Median and 95th percentile effluent flow and loadings of ammonia-N, nitrate-N, total phosphorus, BOD_5, and total suspended solids from the Bowling Green WWTP (001 outfall) during 1976-1994.

Rocky Ford and Tributaries

Air Products and Chemicals - Buckeye Facility (2IN00041): All wastewater (except non-contact cooling water) is sent to the North Baltimore WWTP. Non-contact cooling water is recycled until it becomes ionized, then is bled to an unnamed tributary of Rocky Ford.

BP Oil/Tank Farm (2IG00022)**:** This facility is operated as a crude oil transfer station. Stormwater from each of the Tank Farms (one north and one south of Tank Farm Rd.) is collected and sent through an oil/water separator, then to a pond, before it is finally discharged to Rocky Ford.

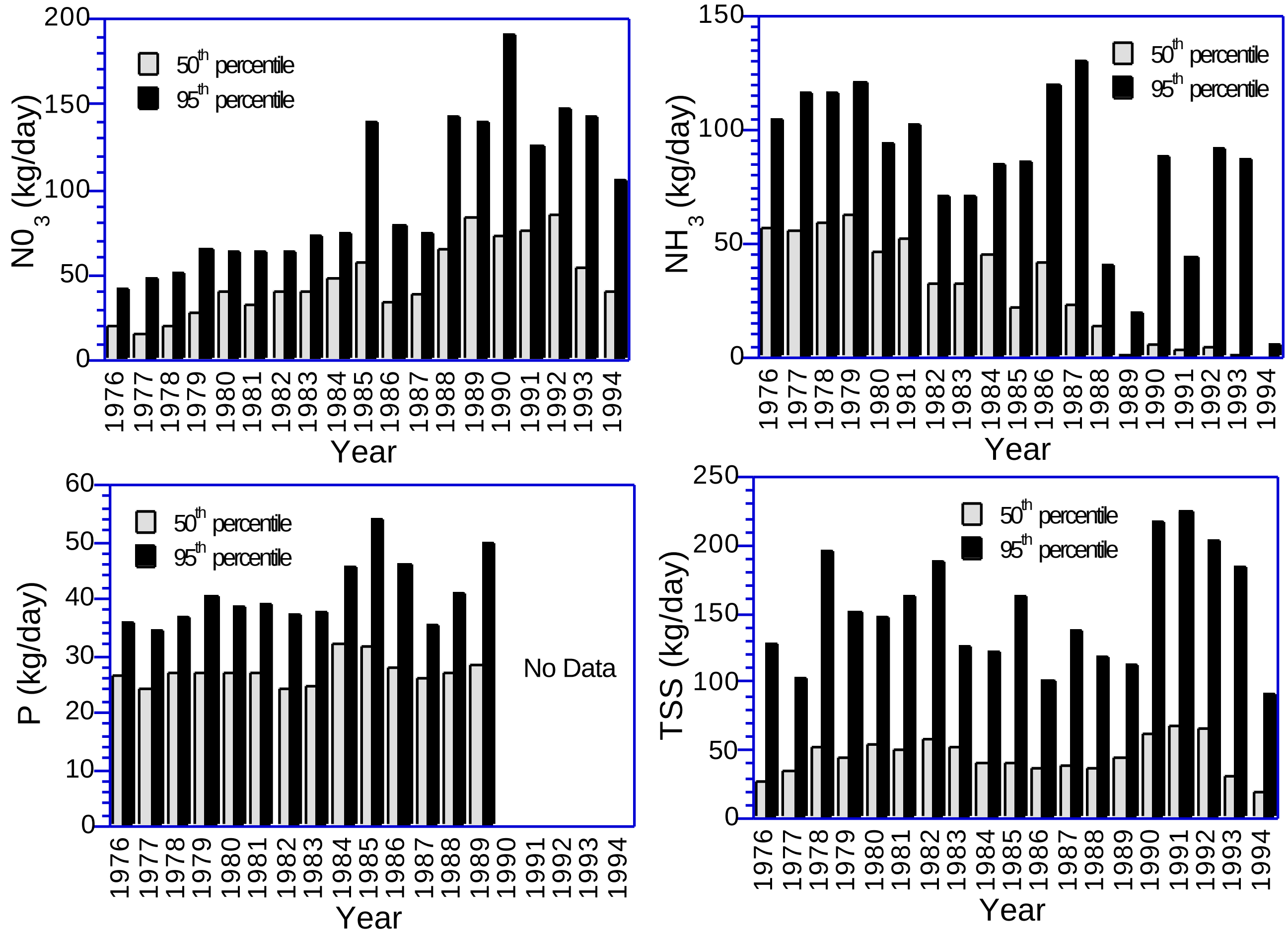
Mid-Valley Pipeline (2II00003)**:** This facility is operated as a crude oil storage and transfer station. Stormwater from each of the three Tank Farms (one west and one south of Rocky Ridge Rd., and one southeast of Tank Farm Rd. and the Penn Central Railroad tracks) is collected and discharged to Rocky Ford. There is no treatment of the stormwater prior to discharge.

Norbalt Rubber/Duramax, Inc.(2IR00010)**:** The Norbalt Rubber facility consists of two plants: Plant #1 on the south side of West Broadway Street, and Plant #2 on the north side of West Broadway. Norbalt Rubber manufactures a wide variety of rubber automotive parts. Powdered rubber is blended, extruded or stamped by presses into the final shape. All process wastewater (contact cooling water) is recirculated. Sanitary wastewater is sent to the North Baltimore WWTP. Discharge to Rocky Ford from Norbalt Rubber is limited to non-contact cooling water.

North Baltimore WWTP (2PD00033)**:** Originally constructed in 1959, then upgraded in 1989, the North Baltimore WWTP is a secondary treatment facility consisting of a comminuter, raw wastewater pumps, grit removal, primary settling, trickling filter solids contact, secondary settling, lift and recirculation pumps, sludge pumps, sludge holding tanks, sludge drying beds, and chlorination/dechlorination. Sludge is digested anaerobically, dewatered and land applied. The plant has a design flow of 0.8 MGD and a hydraulic flow of 0.96 MGD and serves a population of 3,127. The collection system is 100% combined sewers with 2 overflows (Outfalls 002, 003). The plant discharges at RM 9.7. When North Baltimore WWTP's NPDES Permit is renewed in 1995, the permit will include a compliance schedule for addressing CSO problems.

The North Baltimore WWTP contributed 11.4% of all treated wastewater discharged to the Portage River Basin from 1992-1994 (10.9% in 1994 - Figure 3). Average flow through the plant from 1990-1994 was 1.92 MGD with a range of 1.59 - 2.22 MGD, indicating the plant is consistently treating more wastewater than it was designed to handle, and compromising the quality of treatment. In addition, the overflows discharged 68 times in 1994. Overflows, a mixture of storm water and sewage, are discharged directly to Rocky Ford with no treatment, and contribute high levels of pollutants (particularly those associated with raw sewage, such as fecal coliform bacteria and ammonia-N). However, North Baltimore WWTP's current NPDES permit only requires sampling the overflow discharges once per month. Overflows need to be sampled more frequently in order to make reasonably accurate estimates of the additional pollutant loadings and subsequent water quality impacts due to overflows, and to estimate increased capacity needed for future WWTP expansions.

Average annual loadings of ammonia-nitrogen (NH_3-N) from the North Baltimore WWTP have



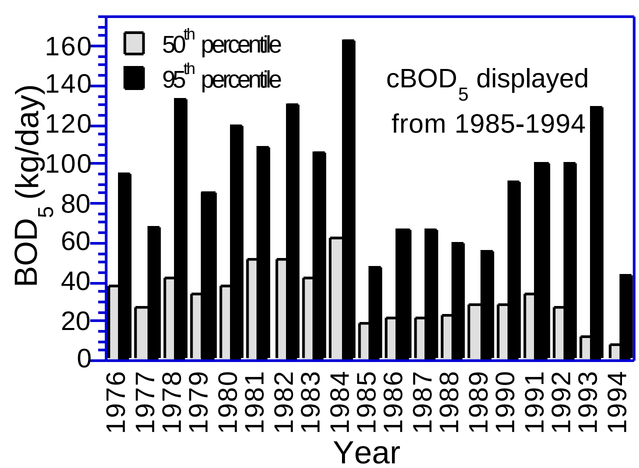


Figure 6. Median and 95th percentile loadings of ammonia-N, nitrate-N, total phosphorus, total suspended solids, and BOD_5 from the North Baltimore WWTP (outfall 001) during 1976-1994.

declined since the 1989 upgrade; however, large differences exist between the 50th and 95th percentiles (Figure 6). There was an increase in nitrate-N (NO_3-N) corresponding with the nitrification treatment. The average NH_3-N load for 1990-1994 was 14.66 kg/day. The plant contributed 8.34% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (1.24% in 1994) or 17.58% of the ammonia-N (1.85% in 1994) when the Brush Wellman loadings are excluded (Figures 17 and 18). (Note: The percent load of ammonia-N from the North Baltimore WWTP in 1994 may appear artificially low as the contribution of ammonia-N from the Fostoria WWTP, due to bypassing while the plant was under construction, was high).

North Baltimore WWTP has not monitored for total phosphorus for the 1990-1994 period. However, phosphorus concentrations downstream from the plant, while above the ambient upstream levels, were not significantly elevated, suggesting the plant upgrade (and phosphorus ban) have reduced loadings. Monitoring for total phosphorus should be required when the North Baltimore WWTP NPDES Permit is renewed.

Plant data showed no apparent trend in total suspended solids (TSS) or $cBOD_5$ loadings to the Rocky Ford from 1976-1994 (Figure 6). Loadings of both parameters increased slightly since 1990, but reflect similar increases in plant flows. The average annual TSS load for the period 1990-1994 was 73.03 kg/day. The North Baltimore WWTP contributed 12.72% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (5.07% in 1994). The average $cBOD_5$ load for the period 1990-1994 was 32.96 kg/day. The plant contributed 10.64% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (5.23% in 1994).

Middle Branch Portage River and Tributaries

Wood Co./Arlington Woods Subdivision, SS #9 (2PG00099)**:** The Subdivision operates a 25,000 gpd (0.025 MGD) extended aeration plant with sand filters, chlorination and a sludge holding facility. The effluent discharges to a tributary of the Middle Branch Portage River.

France Stone Co. (2IJ00035)**:** This quarry is inactive. By agreement with the Village of North Baltimore France Stone Co. is required to prevent it from filling with water. Water is pumped out and discharged at two locations: the south pump discharges on the east side of Mitchell Rd., 250 ft. south of the Cherry St. extension; the north pump discharges on the east side of Mitchell Rd., 1/2 mile north of the Cherry St. extension. A third pump is operated by Norbalt Rubber Co. and provides cooling water for one of their processes.

South Branch Portage River and Tributaries

Village of Bradner WWTP (2PA00077)**:** Constructed in 1988, the Bradner WWTP is a secondary treatment facility, consisting of a gravity collection system and a three cell controlled discharge lagoon. The plant is designed for an influent flow of 0.121 MGD with lagoon storage for 180 days. Effluent from the lagoon is to be discharged to a tributary of the South Branch Portage river during high flow periods only (the plant discharged for a total of 144 days in 1993 and 110 days in 1994). To calculate a mean annual flow, the total volume discharged was divided over 365 days in order to make comparisons with facilities that discharge on a daily basis. However, when considering the potential effects of the Bradner WWTP effluent on the South Branch Portage River, it should be kept in mind that pollutant loadings are discharged over a more compressed time frame, rather than spread out over the entire year.

Bloomdale WWTP (2PA00074): Constructed in 1991, the Bloomdale WWTP is a secondary treatment facility. The plant has a design flow of 0.08 MGD and consists of two aerated lagoons, two clarifiers, chlorination/dechlorination facilities and an aerated sludge holding lagoon. Final effluent is discharged to a tributary of the South Branch Portage River.

Budd Co./Plastics Div. (2IQ00018): The Budd Co. Plastics Division manufactures fiberglass reinforced plastic parts for the automotive and marine recreation industries. These parts are molded, assembled, and painted with a primer at the North Baltimore Plant. Stormwater from parking lots, roof drains, and the loading docks is collected and sent through an oil/water separator before it is finally discharged to Rocky Ford.

Ottawa Rubber Co. (2IR00024): The Ottawa Rubber Co. prepares, cures, and finishes molded rubber parts for the automotive industry. This facility is currently operating without a NPDES permit. Ottawa Rubber Co. submitted a permit application and it is expected that a permit will be issued sometime late in 1995. They discharge process water, boiler blow down, mill room cooling water, press cooling water, and drinking water from one drinking fountain to a ditch which is tributary to the South Branch Portage River.

East Branch Portage River

Fostoria WWTP (2PD00031): Originally constructed in 1927, with improvements to the plant in 1952 and 1988, the Fostoria WWTP was under construction during the 1994 survey to expand and upgrade the treatment facilities. The upgrade in 1988 included replacing the trickling filter rock media with plastic media, and the addition of two clarifiers. Since completion of the most recent upgrade in late 1994, the plant facilities include mechanical bar screening and grit removal, influent pumping, primary and secondary clarification, stormwater diversion chamber and equalization lagoon, trickling filters, aeration and final settling tanks, and ultraviolet disinfection. The design flow is 8.25 MGD and the hydraulic capacity is 12.7 MGD. The plant will average about 5.5 MGD, serving a population of 18,709, including about 14% influent from industry. The collection system is 80% combined sewers, with 5 overflows (Outfalls 004-008), 19% separate sewers, and 1% is unsewered.

The Fostoria WWTP contributed 27.4% of all treated wastewater discharged in the Portage River basin from 1992-1994 (28.9% in 1994 - Figure 3). Average flow through the plant from 1990-1994 was 4.65 MGD. Flows have been increasing since 1990.

Mean annual loadings of ammonia-N (NH_3-N) have decreased since 1989 with a corresponding increase in nitrate-N (NO_3-N; Figure 7). The average NH_3-N load for 1990-1994 was 25.15 kg/day. The plant contributed 17.27% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (28.7% in 1994) or 30.33% of the ammonia-N (42.7% in 1994) when the Brush Wellman loads are excluded (Figures 17 and 18). (Note: Because the Fostoria WWTP contributed very high loadings of ammonia-N during construction and start-up of the new plant, the relative loadings of ammonia-N compared to the other facilities in 1994 may be skewed, even after omitting Brush Wellman data).

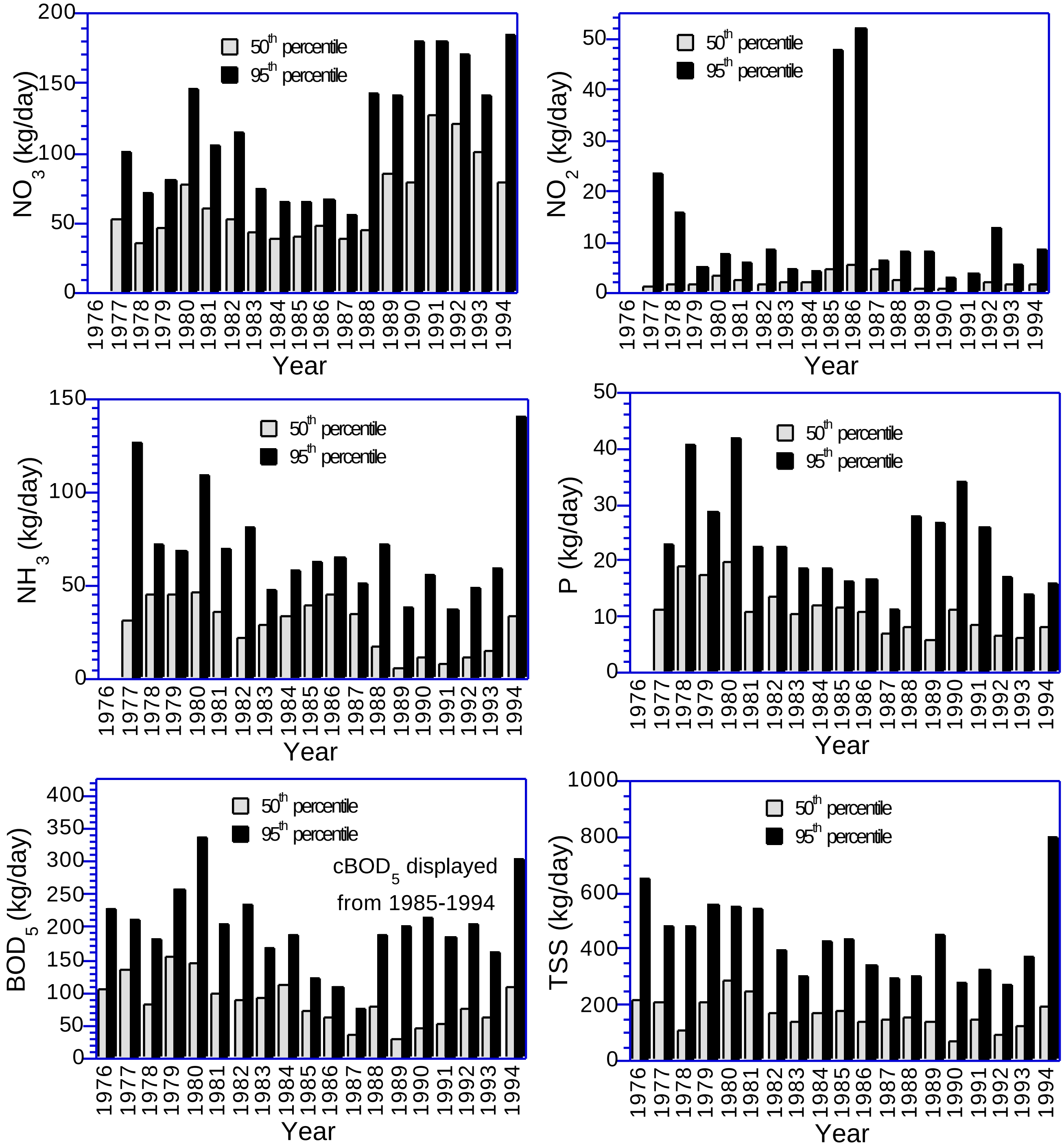


Figure 7. Median and 95th percentile annual loadings of nitrate-N, nitrite-N, ammonia-N, total phosphorus, BOD_5, and total suspended solids discharged by the Fostoria WWTP (outfall 001) during 1976-1994.

The mean annual load of total phosphorus from the Fostoria WWTP for the period 1990-1994 was 9.67 kg/day. The plant contributed 22.6% of reported phosphorus discharged to the Portage River Basin from 1992-1994 (28% in 1994 - Figure 19).

Plant data showed no apparent trend in total suspended solids (TSS), $cBOD_5$, or total phosphorus loadings to the East Branch Portage River from 1976-1994 (Figure 7). However, loadings of these parameters were much higher in 1994, while the WWTP was under construction, and as a result of additional bypassing which occurred while the new plant was being put into service. During this time, wastewater received minimal, if any, treatment before being discharged to the East Branch.

The average annual TSS load for the period 1990-1994 was 159.53 kg/day. The Fostoria WWTP contributed 33.83% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (44.2% in 1994). The average $cBOD_5$ load for the period 1990-1994 was 85.81 kg/day. The plant contributed 34.43% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (44.1% in 1994).

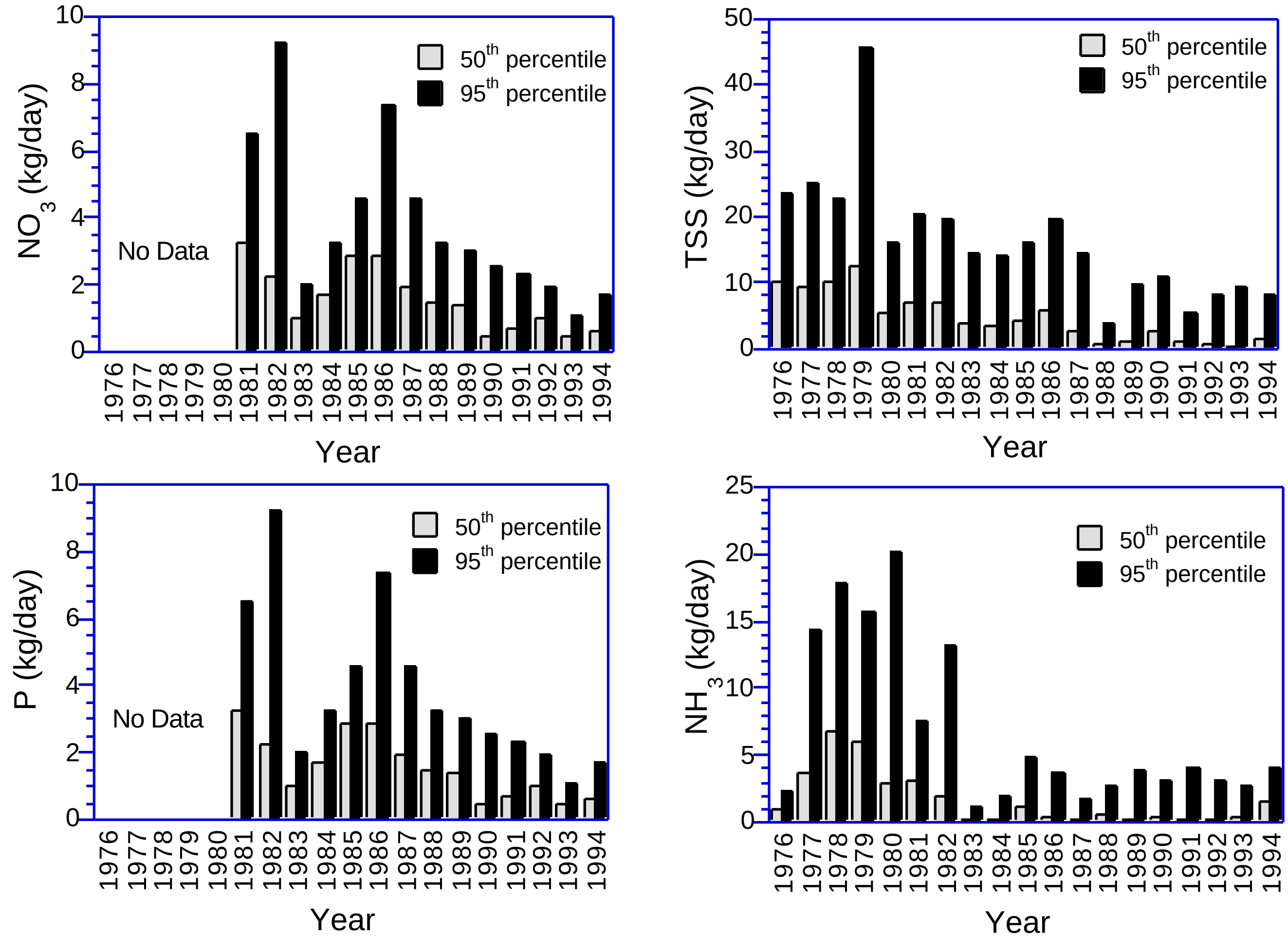
South Side Packers (2IH00027): Formerly Foster Duck Farm, Inc., the facility changed ownership in 1987 and did not resume operations until 1988. Approximately 18,000 ducks are raised and processed for shipping each month by South Side Packers. The facility uses two systems for wastewater treatment: (1) the processing plant sends blood, rinse water and sanitary wastes to a holding tank before it is spray irrigated over the fields; (2) each of the two feedlots (one on the east and one on the west side of S.R. 199) is graded to its own spillway and lagoon treatment system before being discharged to the East Branch Portage River. Currently the feedlot on the east side of S.R. 199 is not being used. The feedlot on the west side of S.R. 199 is in use, but the lagoon system is inadequately treating the waste. By sometime in late 1995, South Side plans to land apply both the liquid and the sludge from this lagoon system and abandon it. A new, larger lagoon system will be constructed. At some future date South Side may put the east side feedlot back into use, at which time the adequacy of that lagoon system will have to be evaluated.

Sugar Creek

Tanks Meats (2IH00084): Tanks Meats processes cattle and hogs by slaughtering, scalding, cleaning, cutting, blending and smoking. Approximately 15 cattle and 60 hogs are processed weekly resulting in about 2000 lbs. of meat products per day. Process wastewater has been sent to the Elmore WWTP sewer system since early 1994. Prior to that connection, treatment consisted of septic tanks and a subsurface sand filter before being discharged to Sugar Creek.

Portage River (including Hyde Run)

Pemberville WWTP (2PB00012): Constructed in 1970, the Pemberville WWTP provides tertiary treatment, consisting of pre-chlorination, oxidation ditches, final settling, tertiary lagoon, chlorination, and sludge drying beds. A 1993 plant upgrade added dechlorination. The WWTP has a design flow is 0.20 MGD and serves a population of 1,321. The final effluent is discharged directly to the Portage River mainstem. The collection system is 65% combined storm and sanitary sewer with four overflow locations (outfalls 003-006). The village currently has a compliance schedule in the NPDES permit aimed at resolving any CSO problems.



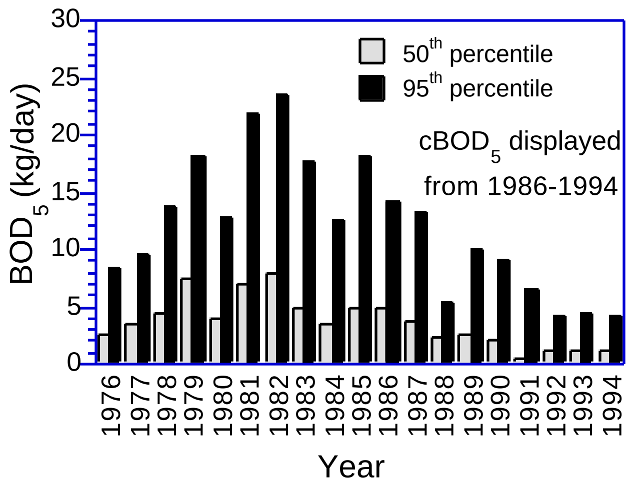


Figure 8. Median and 95th percentile loadings of nitrate-N, total phosphorus, ammonia-N, BOD_5, and total suspended solids discharged by the Pemberville WWTP (outfall 001) during 1976-1994.

The Pemberville WWTP contributed 0.85% of all treated wastewater discharged to the Portage River basin from 1992-1994 (0.76% in 1994 - Figure 3). Average flow through the plant from 1990-1994 was 0.16 MGD. Peak flows through the plant appear to have marginally decreased since 1990. The decreasing mean annual loads of total phosphorus from the Pemberville WWTP can probably be attributed in part to the ban on phosphorus detergents passed into State law in 1988. However, the Pemberville WWTP is still contributing a significant amount of phosphorus to the Portage River (Figure 19). The average total phosphorus load for the period 1990-1994 was 0.95 kg/day. The plant contributed 2.63% of reported phosphorus discharged to the Portage River Basin from 1992-1994 (2.49% in 1994).

The average NH_3-N load for 1990-1994 was 1.10 kg/day. The plant contributed 0.59% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (0.98% in 1994) or 1.05% of the ammonia-N (1.46% in 1994) when the Brush Wellman loads are excluded (Figures 17 and 18).

Plant data indicates loadings of total suspended solids (TSS), total phosphorus, $cBOD_5$, and nitrate-N (NO_3-N) have been decreasing since 1987 (Figure 8), which may be due in part to a slight decrease in plant flows. The average annual TSS load for the period 1990-1994 was 2.44 kg/day. The Pemberville WWTP contributed 0.44% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (0.40% in 1994). The average $cBOD_5$ load for the period 1990-1994 was 1.93 kg/day. The plant contributed 0.57% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (0.55% in 1994).

Woodville WWTP (2PB00052): Constructed in 1971, the Woodville WWTP provides secondary treatment, consisting of a two cell aerated stabilization lagoon with chlorination. The plant is in the process of adding dechlorination to the treatment process. The plant has a design flow of 0.30 MGD and an hydraulic capacity of 0.80 MGD, serving a population of approximately 2,080. The final effluent is discharged to the Portage River. The collection system is 85% combined sewers, with 18 overflows (Outfalls 002-019) and 15% separate sewers. In 1994, larger pumps were installed to enable a larger volume of stormwater to be routed to the plant during storm events, and flap gates were installed to prevent river water from backing up into the plant during high river flow. However, the CSOs may still be impacting the Portage River. Wet weather sampling of the CSO discharges is recommended.

The Woodville WWTP contributed 2.08% of all treated wastewater discharged to the Portage River Basin from 1992-1994 (2.23% in 1994 - Figure 3). Average flow through the plant from 1990-1994 was 0.336 MGD, which indicates the plant is frequently treating more wastewater than it was designed to handle.

The average NH_3-N load for 1990-1994 was 6.00 kg/day. The plant contributed 3.51% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (2.91% in 1994) or 6.73% of the ammonia-N (4.34% in 1994) when the Brush Wellman loads are excluded (Figures 17 and 18).

Mean annual loads of total phosphorus from the Woodville WWTP have declined since 1987, due in part to the phosphorus detergent ban passed into State law in 1988. However, the Woodville WWTP is still contributing a significant amount of phosphorus to the Portage River (Figure 19). The average total phosphorus load for the period 1990-1994 was 1.81 kg/day. The plant contributed 4.25% of reported phosphorus discharged to the Portage River Basin from 1992-1994 (4.51% in 1994).

Plant data showed no apparent trend in total suspended solids (TSS) , ammonia-N (NH_3-N), nitrate-N (NO_3-N), or $cBOD_5$ loadings to the Portage River from 1976-1994 (Figure 9). The average annual TSS load for the period 1990-1994 was 21.08 kg/day. The Woodville WWTP contributed 4.79% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (2.89% in 1994). The average $cBOD_5$ load for the period 1990-1994 was 11.63 kg/day. The plant contributed 3.75% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (3.14% in 1994).

Elmore WWTP (2PB00051): Constructed in 1969, the Elmore WWTP is a secondary treatment facility, consisting of a grit chamber, settling tanks, a spiragester, trickling filters, secondary settling, chlorination/dechlorination, and sludge drying beds. The plant has design flow of 0.18 MGD and an hydraulic capacity of 1.44 MGD, serving a population of 1350. The final effluent is discharged to the Portage River. The collection system is 80% combined sewers, with 5 overflows (Outfalls 003, 005, 006, 007, 008), and 20% separate sewers. The Village of Elmore is currently on a compliance schedule (in current NPDES Permit) to address CSO problems.

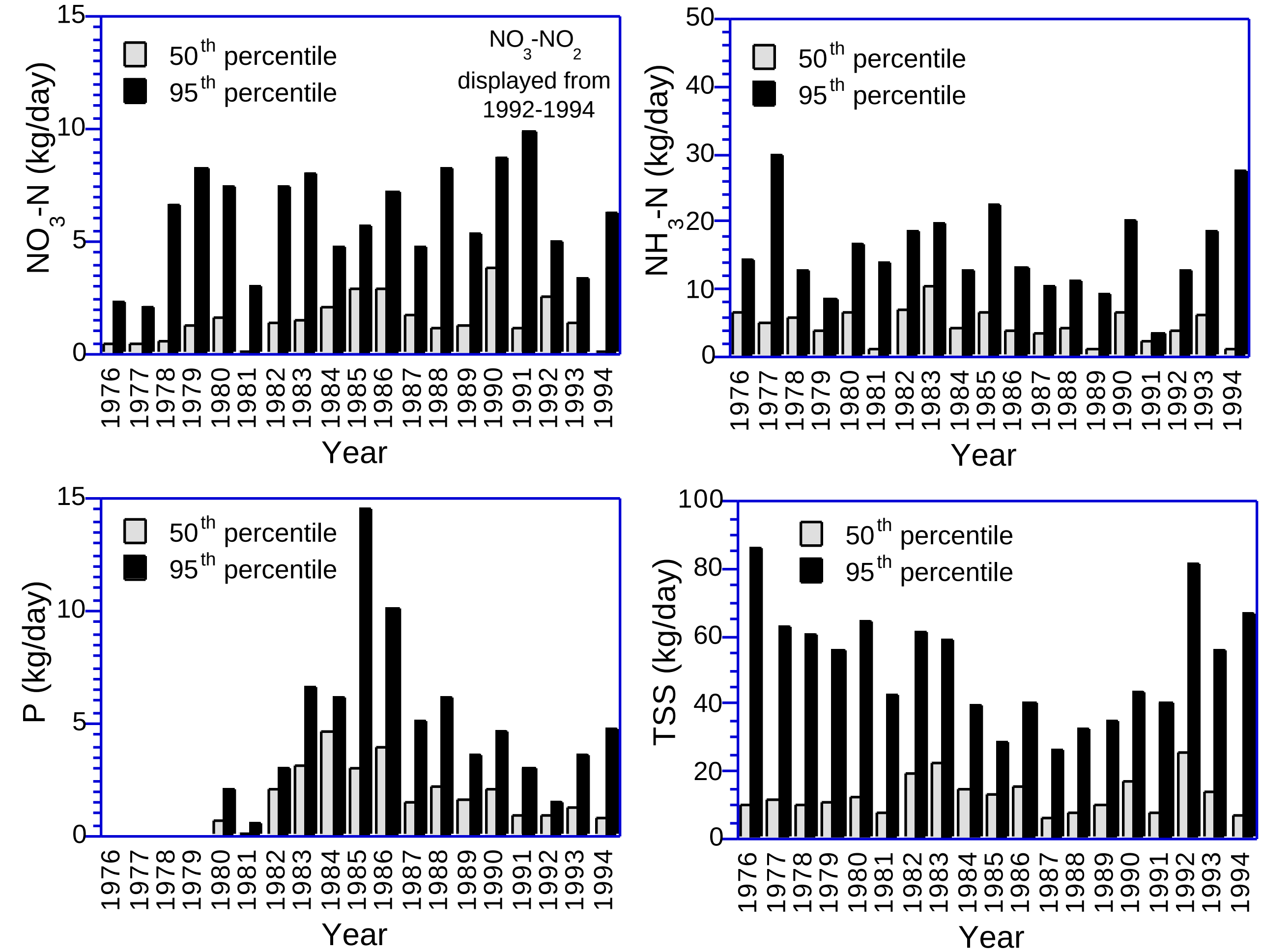
The Elmore WWTP contributed 1.06% of all treated wastewater discharged to the Portage River Basin from 1992-1994 (1.14% in 1994 - Figure 3). The average flow from 1990-1994 was 0.18 MGD. The plant is often treating more wastewater than it was designed to handle.

The mean annual NH_3-N load for 1990-1994 was 0.73 kg/day (Figure 10). The plant contributed 0.31% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (0.50% in 1994) or 0.55% of the ammonia-N (0.75% in 1994) when the Brush Wellman loads are excluded (Figures 17 and 18).

The Elmore WWTP's average phosphorus load for the period 1990-1994 was 1.28 kg/day (Figure 10). The plant contributed 3.92% of the reported phosphorus discharged to the Portage River Basin from 1992-1994 (4.48% in 1994 - Figure 19).

There were no apparent trends in loadings of total suspended solids (TSS) or phosphorus. Loadings of $cBOD_5$ and ammonia-N (NH_3-N) to the Portage River have slightly decreased since 1986, with a corresponding increase in nitrate-N (NO_3-N), indicating that more nitrification is occurring prior to discharge (Figure 10). The mean annual TSS load for the period 1990-1994 was 8.632 kg/day. The Elmore WWTP contributed 1.73% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (1.38% in 1994). The mean annual $cBOD_5$ load for the period 1990-1994 was 5.51 kg/day. The plant contributed 1.75% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (1.64% in 1994).

Brush Wellman, Inc. (2IE00000): Brush Wellman is an industrial facility located along the Portage River downstream from Elmore. Brush Wellman is the only fully integrated supplier of beryllium, beryllium oxide, beryllium and copper alloys, and beryllium ceramics in the U.S. The raw materials used include scrap copper and other metallic sources. Processes include: pickling, plating, melting, casting, forming, extruding, annealing, and heat treating. Process wastewater, sanitary wastewater and stormwater is discharged to Hyde Run (aka Brush Creek), which is a



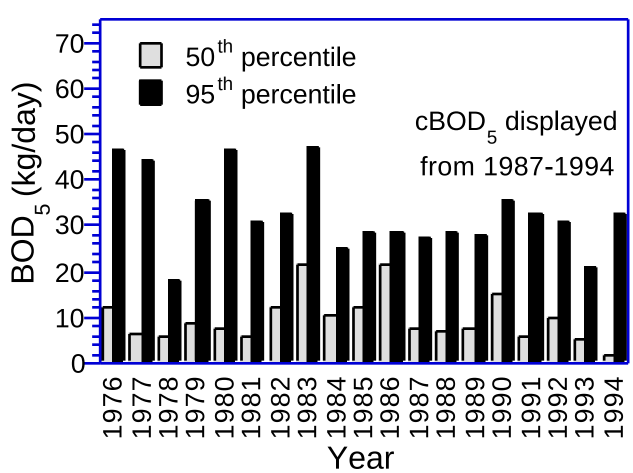
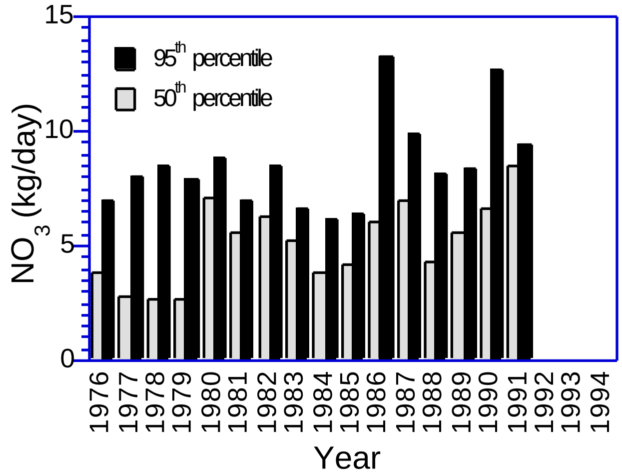
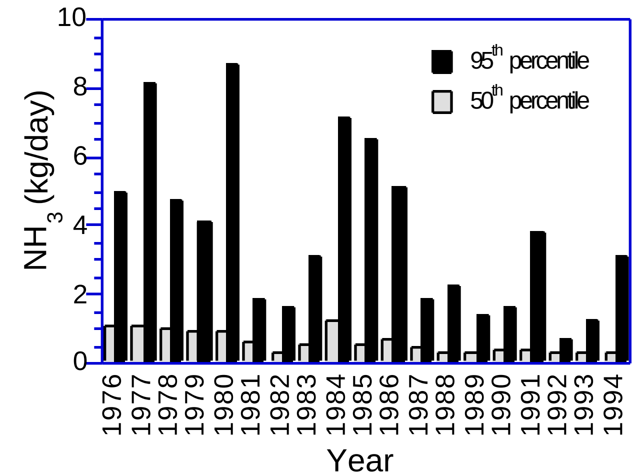
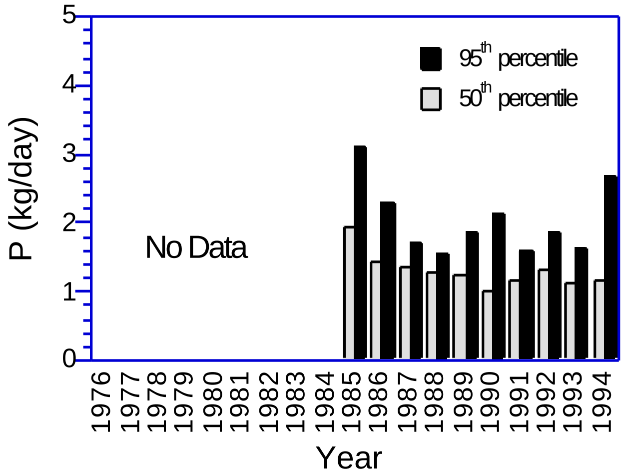
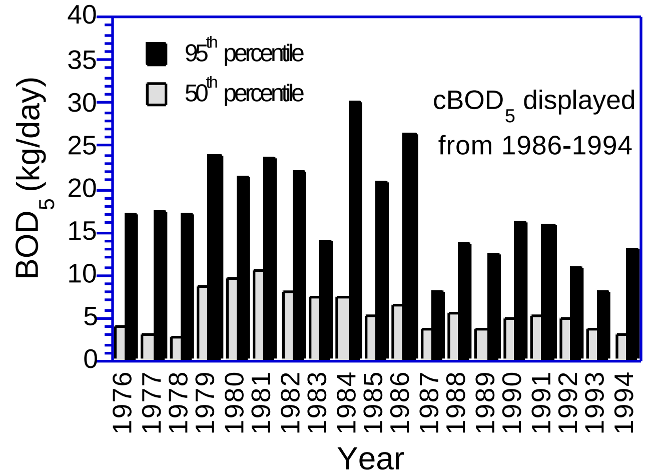


Figure 9. Median and 95th percentile loadings of nitrate-N, total phosphorus, ammonia-N, BOD_5, and total suspended solids discharged by the Woodville WWTP (outfall 001) during 1976-1994.









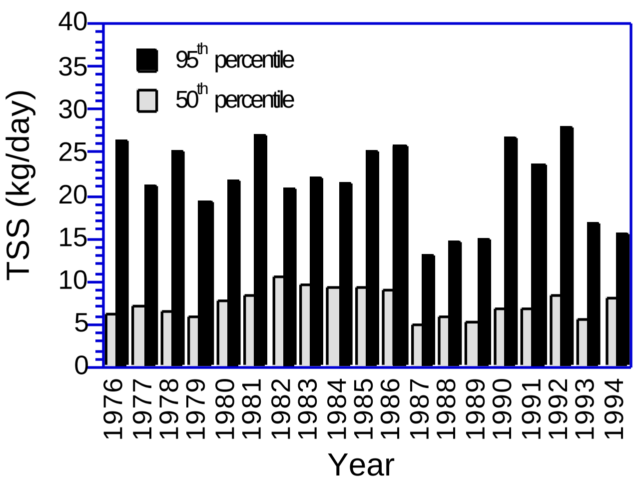


Figure 10. Median and 95th percentile loadings of nitrate-N, total phosphorus, ammonia-N, BOD_5, and total suspended solids discharged by the Elmore WWTP (outfall 001) during 1976-1994.

tributary to the Portage River at river mile 16.54. Hyde Run originates at the Brush Wellman facility and is essentially 100% effluent, except during heavy rain events, when flow in Hyde Run may include some runoff from Brush Wellman's property upstream of their outfalls. A description of the Brush Wellman facility outfalls or stations follows (Mike Schack, Environmental Supervisor for Brush Wellman, pers. comm.):

Outfall 001 - discharges to Hyde Run from #6 lagoon; **this outfall no longer exists**. When in service, process wastewater from an industrial wastewater treatment plant (IWWTP) was pumped to a holding basin, then to the #6 lagoon before being discharged to Hyde Run. Brush Wellman has completed a RCRA approved closure of the #6 lagoon.

Outfall 002 - discharge to Hyde Run from #5 lagoon. Process wastewater from the Beryllium Metal Plant is sent to #5 lagoon following ammonia removal by aeration. Calcium chloride and chlorine may be added for the removal of fluoride and cyanide, respectively, if levels warrant. Wastewater from the #5 lagoon is reused in the plant, so it is infrequently discharged to Hyde Run. Brush Wellman has not reported a discharge from outfall 002 since April 1994. Wastewater intended for reuse is pumped to a holding tank until needed. Wastewater from the holding tank may also be discharged to Hyde Run if necessary (see Outfall 014), but usually is not. Brush Wellman's NPDES Permit prohibits any discharge from this outfall when the Portage River flow is below 15 cfs (see station 801).

Outfall 003 - internal outfall which discharges sanitary sewage to the IWWTP. Sanitary wastewater is treated in a 23,000 gpd extended aeration plant, including final rapid sand filtration, before being discharged to the IWWTP.

Outfalls 004, 005, 007, 008 - stormwater outfalls draining roofs and roads on the beryllium metal side of the Brush Wellman facility. Discharges from these outfalls are pumped to the IWWTP except during heavy rainfall (the sumps capture at least the first flush). Runoff not pumped to the IWWTP is discharged to Hyde Run.

Outfall 006 - a stormwater outfall draining a relatively small area which includes roads on the copper alloy side of the Brush Wellman facility, Portage River South Road, access roads and ditches along Portage River South Road, and the parking lot. Most of the runoff from these areas is diverted to Brush Wellman's make-up pond, which is used for process water, so flow from Outfall 006 should be low. Runoff that is not diverted to the make-up pond is discharged directly to the Portage River upstream of Hyde Run.

Outfall 009 - stormwater outfall draining an area west of SR 590, fields around the facility on the west side, and one stormwater tile on the copper alloy side of the Brush Wellman facility. Most of the runoff from these areas is pumped to Brush Wellman's make-up pond, which is used for process water, so flow from Outfall 009 should be low and it should not discharge at all during the summer. Runoff that is not diverted to the make-up pond is discharged directly to the Portage River upstream of Outfall 006.

Outfall 010 - discharge to Hyde Run from nickel plating line; **this outfall no longer exists**. The nickel plating line was taken out of service, the process and discharge were eliminated, and all equipment and tanks have been removed.

Outfall 011 - The industrial wastewater treatment plant (IWWTP) discharges to Hyde Run (aka Brush Creek). Wastewater from the beryllium alloy and beryllium oxide processes is treated by chemical precipitation, flocculation, mixing and neutralization. Lime is added to raise the pH of the wastewater to 9-10 S.U., causing metal hydroxides to settle out. Calcium chloride is used for fluoride removal and a Nalco flocculent is added before the waste is sent to the parallel plate clarifier. Sludge from the clarifier is sent to a thickener, then is disposed of off-site. Effluent from the clarifier is neutralized and sent to a holding tank before release to Hyde Run. The IWWTP is a continuous discharge, but can be held back if necessary for up to approximately 2 months. Brush Wellman's NPDES Permit prohibits any discharge from this outfall when the Portage River flow is below 15 cfs (see station 801).

Outfall 013 - stormwater runoff from 2 storage pads. In-process material is stored on one of the storage pads. The smaller storage pad is used as a staging area (temporary holding) for containerized material prior to placement in Brush Wellman's landfill. Stormwater runoff from the storage pads is pumped to the IWWTP except during heavy rainfall events.

Outfall 014 - discharges to Hyde Run from a holding tank. Following treatment in #5 lagoon (see Outfall 002), process wastewater is pumped to this holding tank for reuse in the plant. Wastewater may be discharged to Hyde Run if necessary, but Brush Wellman has never reported a discharge from Outfall 014. Brush Wellman's NPDES Permit prohibits any discharge from this outfall when the Portage River flow is below 15 cfs (see station 801).

Location 801 - USGS gaging station on the Portage River at Woodville (04195500). Brush Wellman obtains instantaneous gage height information daily from this station and converts it to river flow in order to determine daily discharge limitations for outfalls 002, 011, and 014.

Brush Wellman is currently operating under an NPDES permit which contains loading limits for the three process discharges (Outfalls 002, 011, and 014) that are graduated based on the daily flow of the Portage River (see Station 801 above). Process wastewater discharges are permitted only when flow in the Portage River exceeds 15 cfs. Only one of the these three outfalls may discharge on any given day, and load limits that maintain the water quality criteria at various flows have been calculated for each outfall.

Brush Wellman was the largest contributor of inorganic nitrogen to the Portage River, accounting for approximately 34% of the total load (Figure 17). Loadings of nitrogen were reported as ammonia-nitrogen; however, nitrification during the treatment and holding process resulted in nitrate-nitrogen in the effluent. Reported ammonia loading rates decreased since 1987 (Figure 11), but nitrate concentrations measured in the Portage river downstream of Brush Wellman in 1985 and 1994 were nearly identical, suggesting that loadings are effectively unchanged.

Reported loadings of copper and beryllium by outfall number from 1989 to 1994 reflect the tiered permitted discharge based on river flows (Figures 12 and 13). The tiered discharge is also evident in total effluent discharged (Figure 14). The 50th percentile loadings have decreased since 1989, while the 95th percentile loadings have increased, especially in 1994. It should be noted that loadings data for beryllium and copper may not always be representative of the actual loads to the

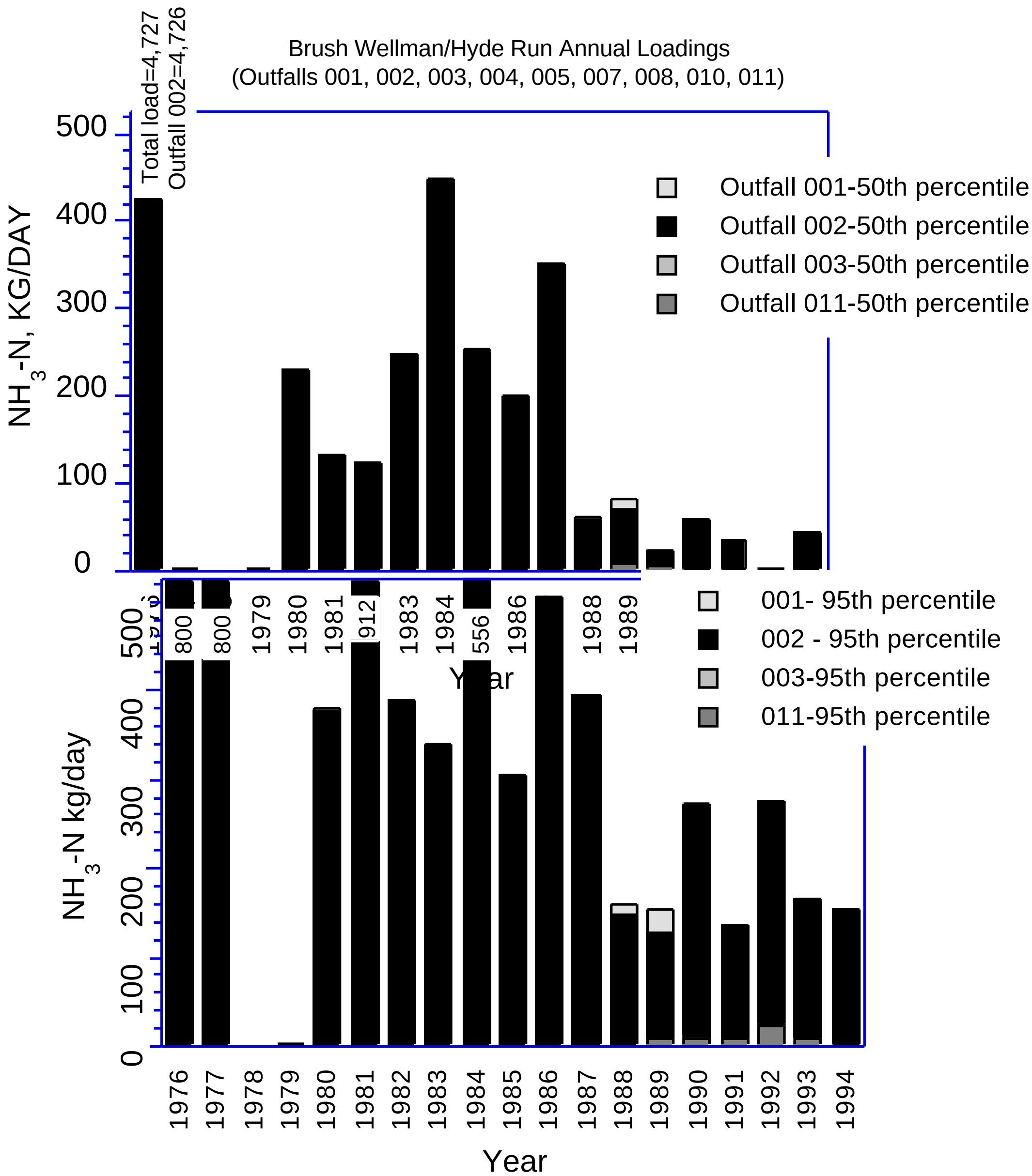
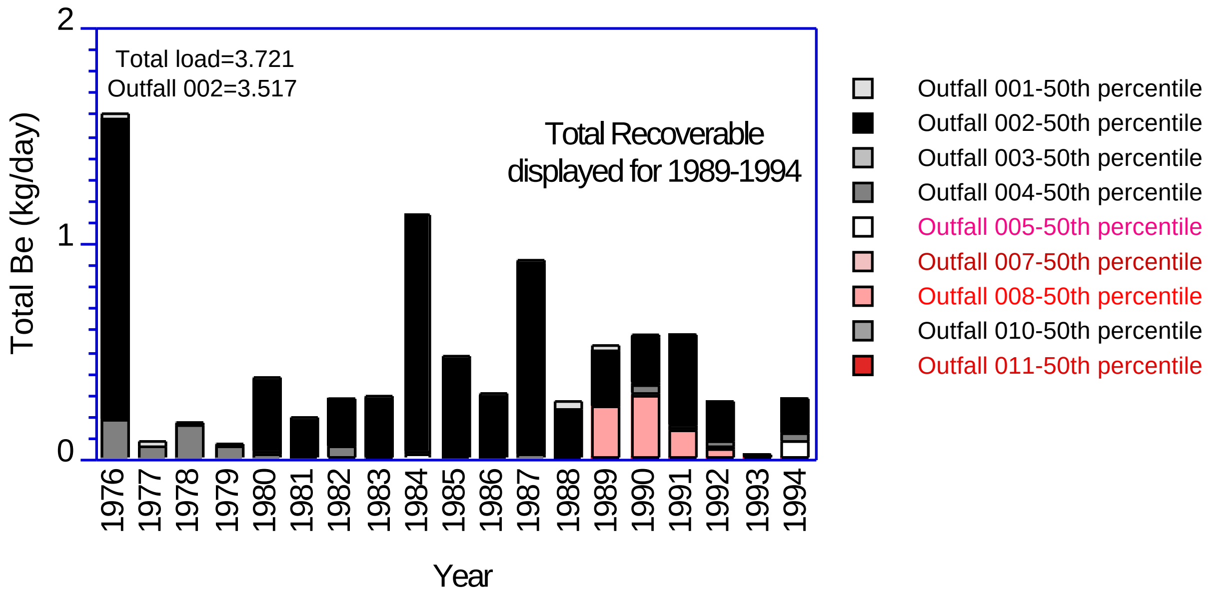


Figure 11. Annual 50th percentile (top) and 95th percentile (bottom) loadings of ammonia-N discharged to the Portage River by Brush Wellman during 1976-1994.



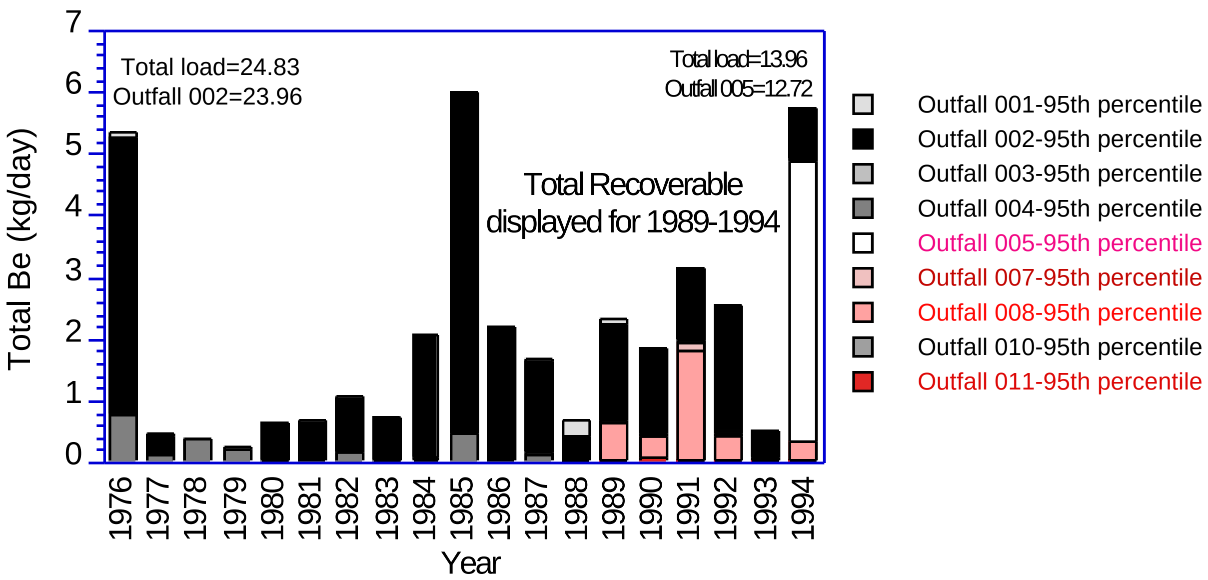


Figure 12. Annual 50th percentile (top) and 95th percentile (bottom) laodings of beryllium to the Portage River for Brush Wellman, 1976-1994.

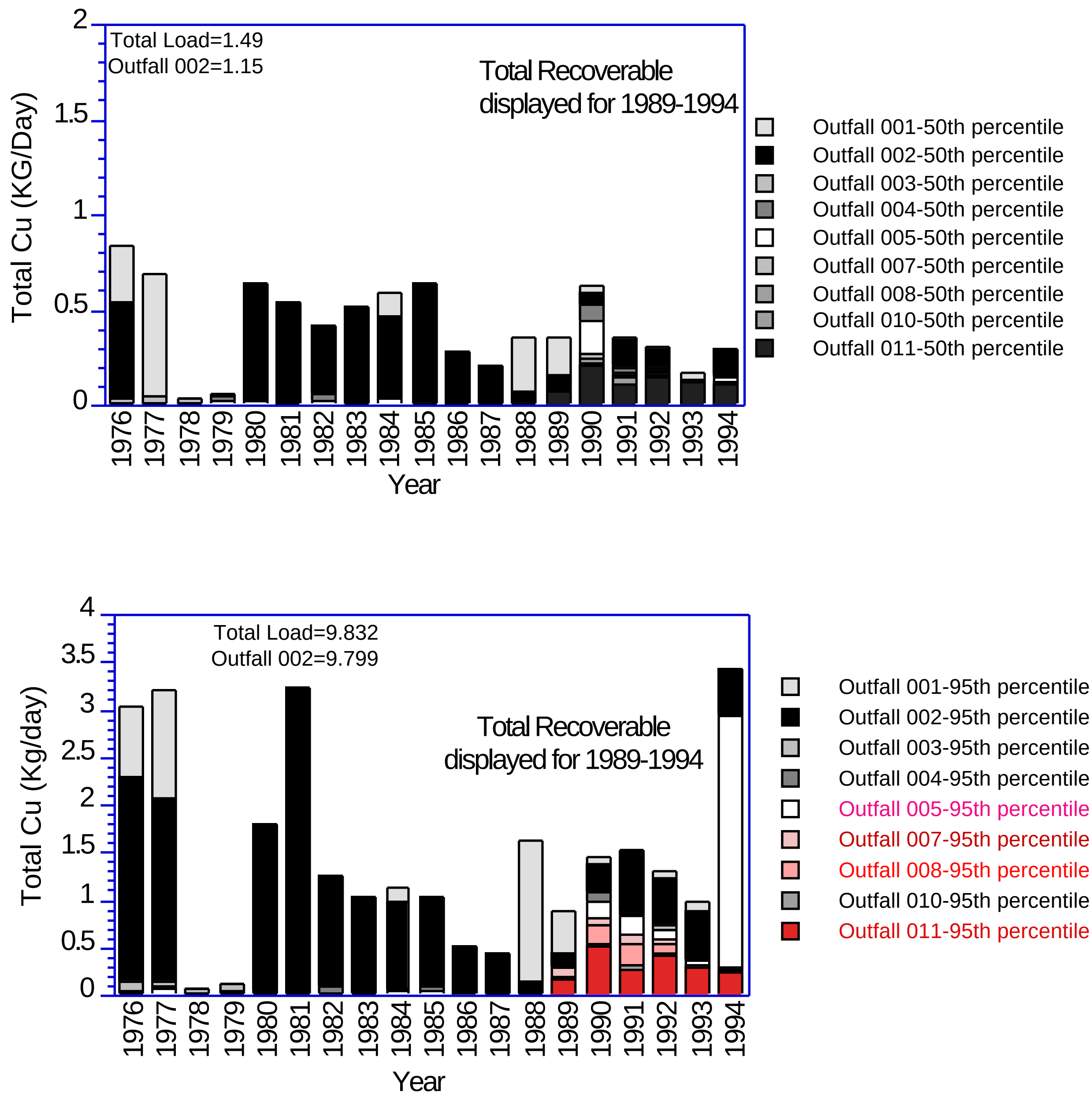
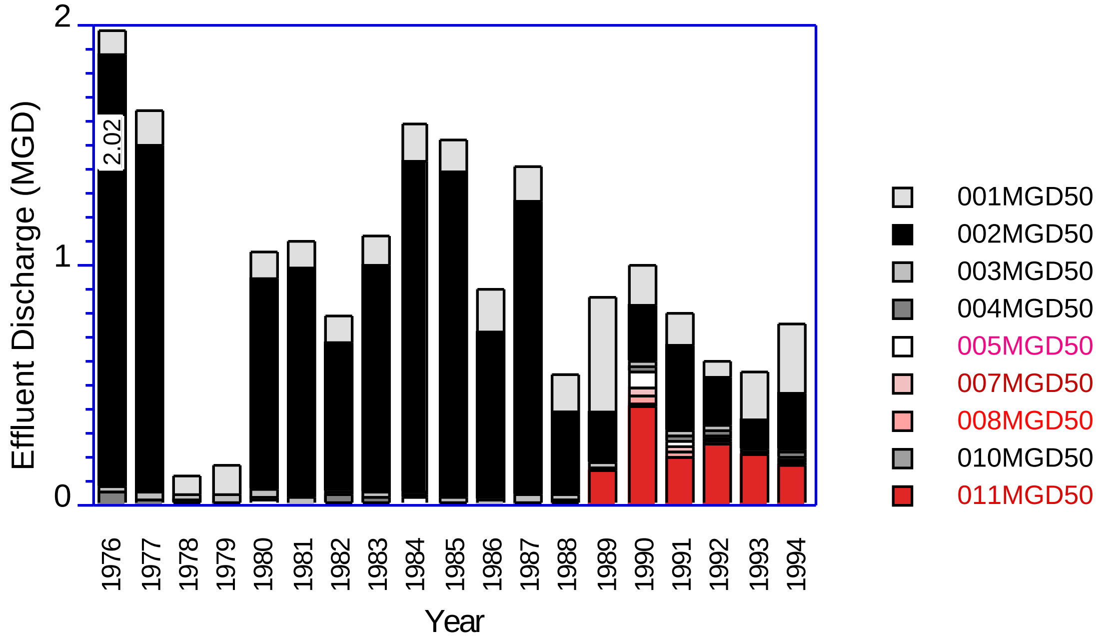


Figure 13. Annual 50th percentil (top) and 95th percentile (bottom) loadings of copper to the Portage River for Brush Wellman, 1976-1994.



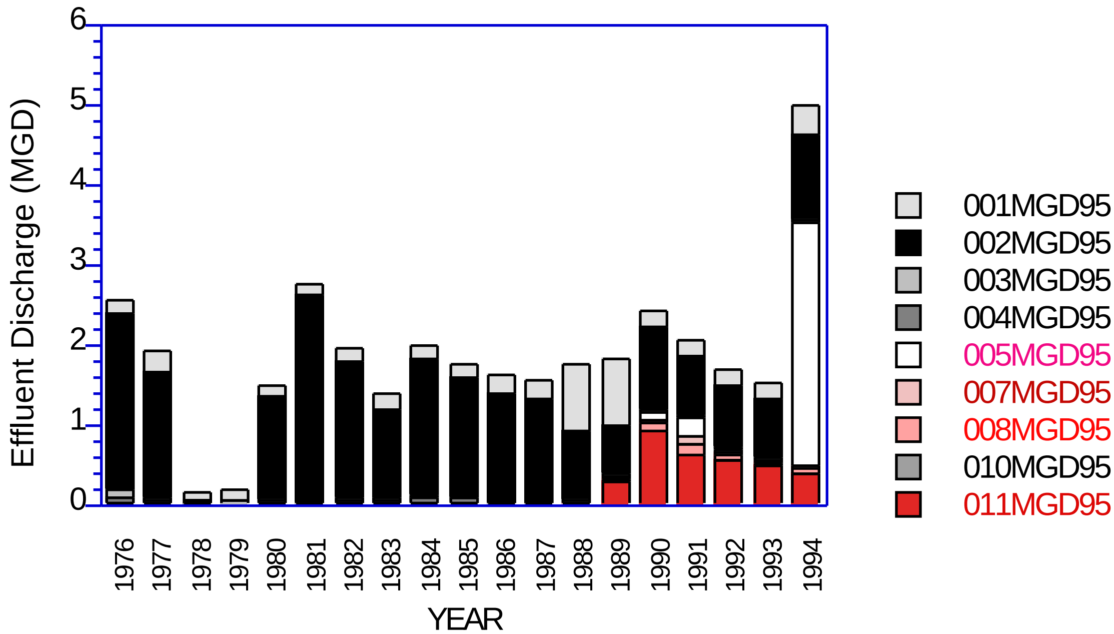


Figure 14. Annual 50th percentile (top) and 95th percentile (bottom) total effluent discharge to the Portage River by Brush Wellman, 1976-1994.

river. The stormwater outfalls (004, 005, 007, 008) do not have concentration or loading limits in the NPDES Permit; Brush Wellman is required to monitor and report concentration and loading of beryllium and copper from these outfalls only once per month. Although the loadings from these outfalls usually appear low due to low flow, the concentrations are frequently quite high. More frequent monitoring of stormwater discharges would be necessary to accurately estimate loads of these parameters to the Portage River and to determine the impact that stormwater discharges during rainfall events may be having on water quality.Oak Harbor WWTP (2PB00032): The Oak Harbor WWTP was constructed in 1958, chlorination facilities were added in 1975, and the plant was upgraded in 1990. The plant is a secondary treatment facility consisting of a grit chamber, preaeration, primary settling, trickling filters, final settling, chlorination and sludge digestion tanks. The plant has a design flow of 0.74 MGD and hydraulic capacities of 4.33 MGD for primary facilities and 2.15 MGD for secondary facilities. Final effluent is discharged to the Portage River. The system was designed to serve a population of approximately 3000, but is essentially serving 5430. Oak Harbor's collection system has 80% combined sewers, with 9 overflows (Outfalls 002, 003, 004, 005, 006, 007, 008, 009, 010), 10% separate sewers and 10% is unsewered. When Oak Harbor WWTP's NPDES Permit is renewed in 1995, the permit will include a compliance schedule for addressing CSO problems.

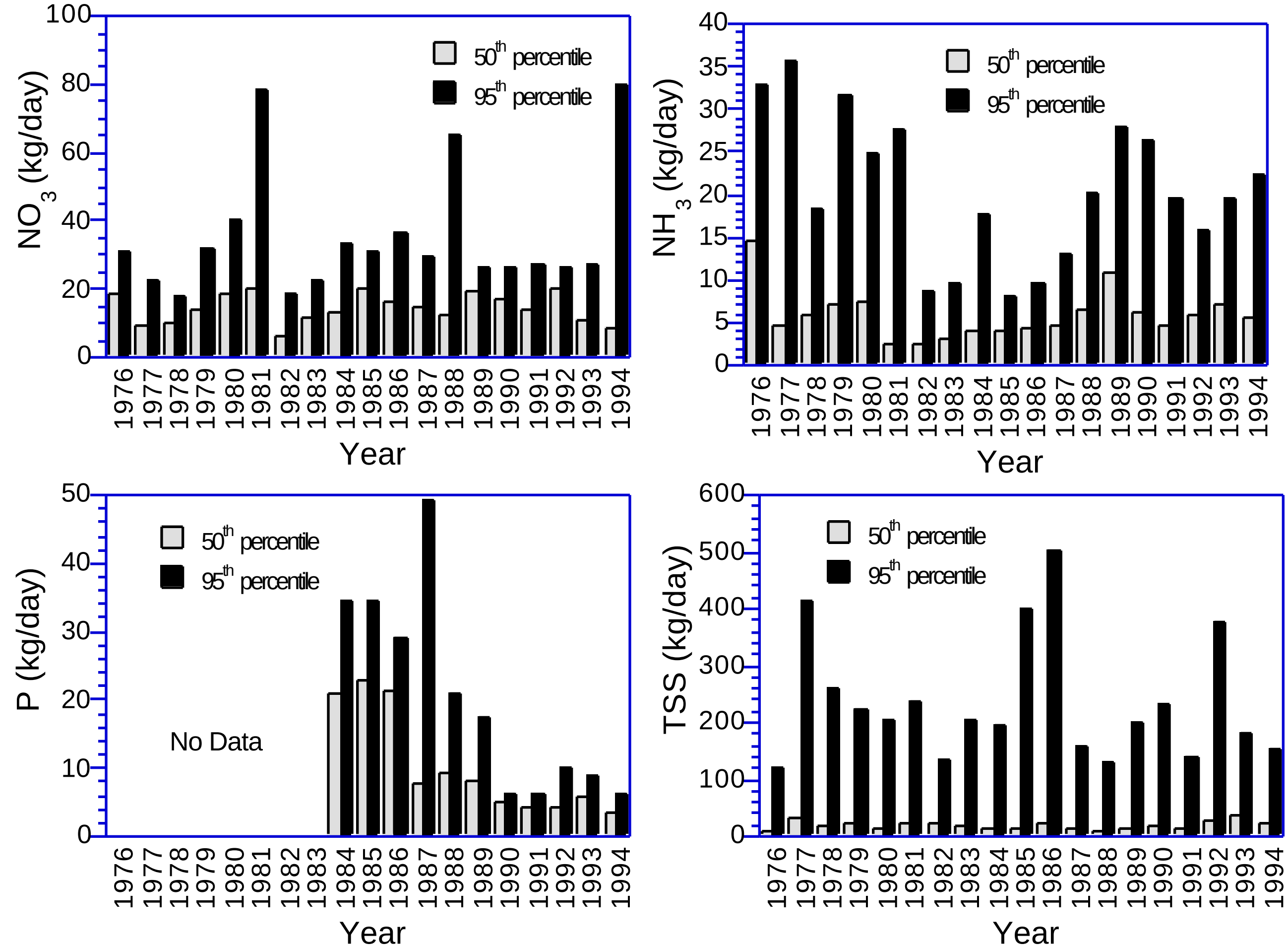
The Oak Harbor WWTP contributed 5.84% of all treated wastewater discharged to the Portage River Basin from 1992-1994 (4.95% in 1994 - Figure 3). Mean annual flow through the plant exceeded design capacity 4 out of 5 years: the average flow from 1990-1994 was 0.95 MGD, indicating the plant is frequently treating more wastewater than it was designed to handle.

The mean annual NH_3-N load for 1990-1994 was 9.10 kg/day. The plant contributed 5.00% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (4.12% in 1994) or 9.62% of the ammonia-N (6.15% in 1994) when the Brush Wellman data is excluded (Figures 17 and 18).

Although mean annual loads of total phosphorus declined during 1990-1994, the Oak Harbor WWTP is still one of the 3 highest contributors of phosphorus to the Portage River Basin (Figure 19). The plant's average phosphorus load for the period 1990-1994 was 26.36 kg/day. The plant contributed 15.87% of the reported phosphorus discharged to the Portage River Basin from 1992-1994 (10.8% in 1994). The decline in phosphorus loadings may be related to the plant upgrade in 1990, but could also be attributed to a phosphorus detergent ban for the Lake Erie drainage basin passed into State law in 1988.

There were no apparent trends in loadings of total suspended solids (TSS), $cBOD_5$ or ammonia-N (NH_3-N) to the Portage River from 1976-1994 (Figure 15). However, the Oak Harbor WWTP loads for these parameters are comparatively high when considered on a "per flow" basis (compared to the other WWTPs in the Portage River Basin). Higher loads are probably the result of consistently exceeding design flow, which likely compromises the quality of treatment.
The mean annual TSS load for the period 1990-1994 was 59.62 kg/day. The Oak Harbor WWTP contributed 12.16% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (6.17% in 1994). The mean annual $cBOD_5$ load for the period 1990-1994 was 31.64 kg/day. The plant contributed 12.09% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (9.88% in 1994).

<u>Port Clinton WWTP (2PD00014)</u>: The Port Clinton WWTP was constructed in 1955 and



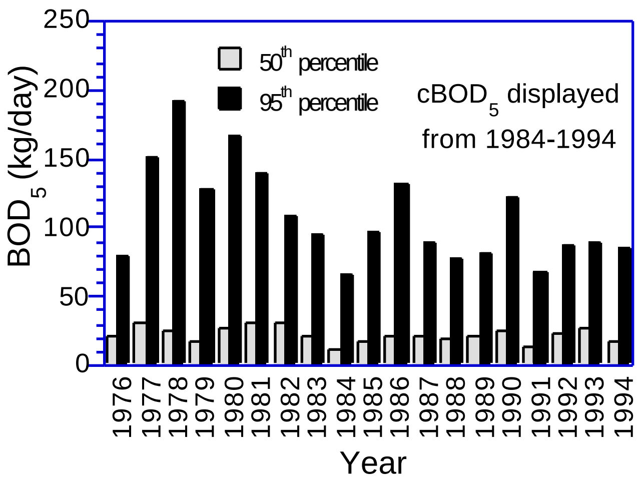


Figure 15. Median and 95th percentile loadings of nitrate-N, total phosphorus, ammonia-N, BOD_5, and total suspended solids discharged by the Oak Harbor WWTP (outfall 001) during 1976-1994.

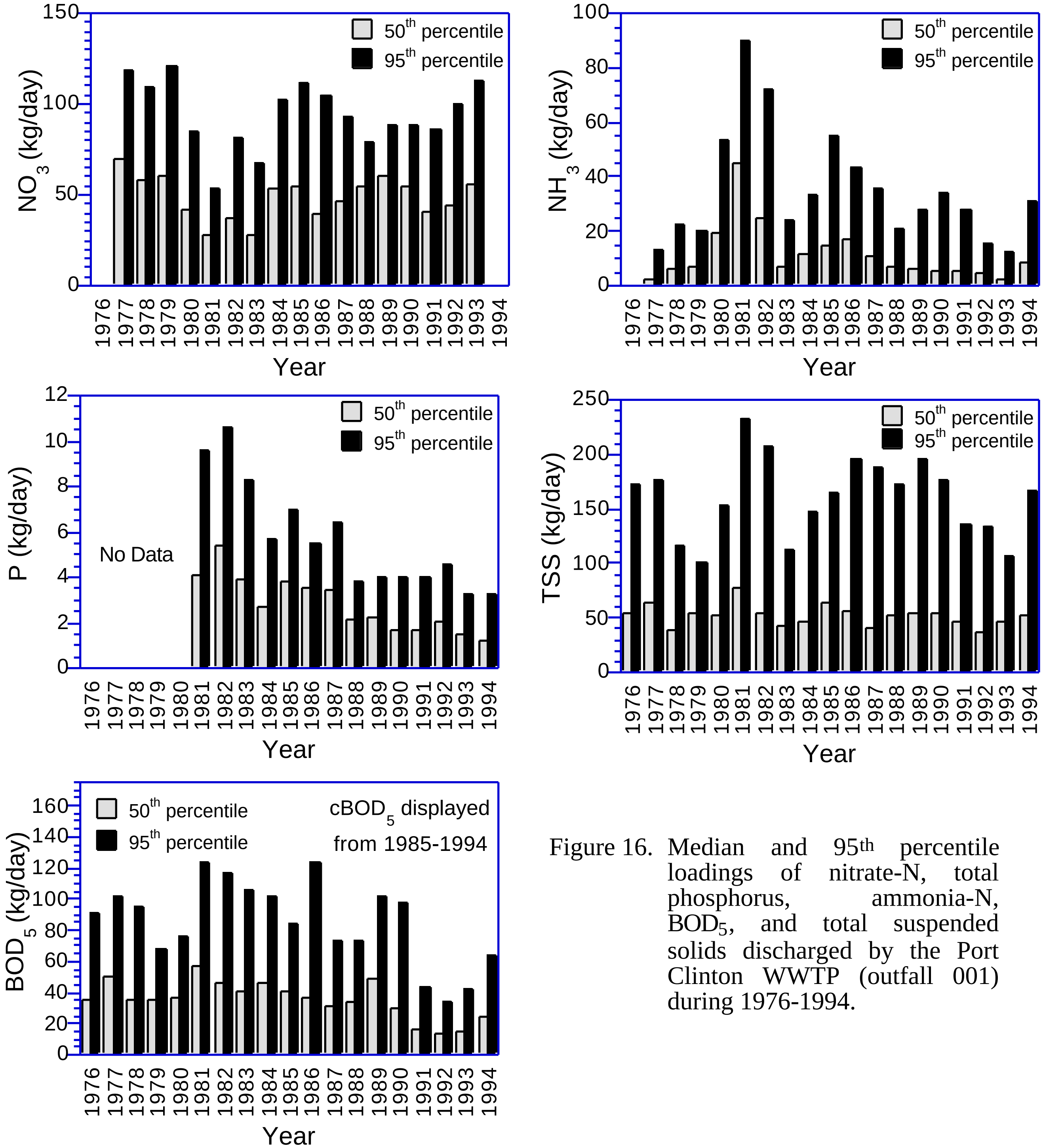


Figure 16. Median and 95th percentile loadings of nitrate-N, total phosphorus, ammonia-N, BOD_5, and total suspended solids discharged by the Port Clinton WWTP (outfall 001) during 1976-1994.

upgraded to secondary treatment with phosphate removal in 1970. Treatment consists of a pumping station, grit chamber, pre-aeration tanks, primary settling tanks, phosphate removal, final aeration tanks, blowers, chlorine contact tanks, an anaerobic digester and sludge drying beds. To facilitate wastewater treatment during the canning season, lime and alum can be added to the raw sewage prior to pre-aeration. The plant has a design flow of 1.50 MGD and an hydraulic capacity of 3.10 MGD, serving a population of 7106. The final effluent is discharged to the Portage River. The collection system is 70% combined sewers with 1 bypass (Outfall 002) and 4 overflows (Outfalls 003-006) and 25% separate sewers. Five percent of the City of Port Clinton is unsewered.

The Port Clinton WWTP contributed 10.67% of all treated wastewater discharged to the Portage River Basin from 1992-1994 (10.5% in 1994 - Figure 3). Average flow through the plant from 1990-1994 was 1.80 MGD, which indicates the plant is frequently treating more wastewater than it was designed to handle. In addition, the influent bypass was observed to be active on at least 3 of the 6 sampling dates in 1994. Wastewater that bypasses the plant is discharged directly to the Portage River with no treatment. The amount of influent being bypassed is not included in the plant flow. Frequent bypassing may be contributing to even higher levels of pollutants (particularly those associated with raw sewage, such as fecal coliform bacteria and ammonia-N) being discharged to the Portage River than indicated by the loadings data. Because the plant is located near the mouth, inflow from Lake Erie dilutes the effects of sewage bypasses.

Average annual loadings of ammonia-nitrogen (NH_3-N) and $cBOD_5$ from the Port Clinton WWTP appear to have declined slightly over the last 4-6 years (Figure 16). The average $cBOD_5$ load for the period 1990-1994 was 24.10 kg/day. The plant contributed 7.58% of the $cBOD_5$ loads from point source discharges to the Portage River Basin from 1992-1994 (9.78% in 1994). The average NH_3-N load for 1990-1994 was 8.56 kg/day. The plant contributed 4.24% of the ammonia-N discharged to the Portage River Basin from 1992-1994 (5.98% in 1994) or 7.84% of the ammonia-N (8.93% in 1994) when the Brush Wellman loads are excluded.

Mean annual loads of total phosphorus from the Port Clinton WWTP have declined since 1988 (Figure 16), due in part to the ban on phosphorus detergents since 1988. The average total phosphorus load for the period 1990-1994 was 1.87 kg/day. The plant contributed 5.41% of reported phosphorus discharged to the Portage River Basin from 1992-1994 (4.69% in 1994 - Figure 19).

Plant data showed no apparent trend in total suspended solids (TSS) or nitrate-N (NO_3-N) loadings to the Portage River from 1976-1994 (Figure 16). The average annual TSS load for the period 1990-1994 was 59.36 kg/day. The Port Clinton WWTP contributed 10.83% of the TSS loads from point source discharges to the Portage River Basin from 1992-1994 (10.6% in 1994).

Chemical Spills

Sixty-six (66) chemical spills have been documented in the Portage River and its tributaries between 1989 and 1994 (see Appendix Table A-1). Petroleum products (diesel fuel, gasoline, oils, and other fuels), and sewage were the first and second most common substances spilled, respectively. Most of the spills were of unknown quantity. Brush Wellman was the single leading contributor of spilled substances (fifteen spills), mostly waste water and one large spill involving 7,000 gallons of nickel solution. Gasoline stations and fuel distributors, as a group, accounted for the second highest number of spills (ten). Spills by municipal sewage treatment plants have occasionally lead to fish kills (see Appendix Table A-2). Other spills were diverse in their locations and sources. The number of spills is likely under-reported, which suggests that a significant load of oxygen demanding pollutants is added to the river annually by these episodes.

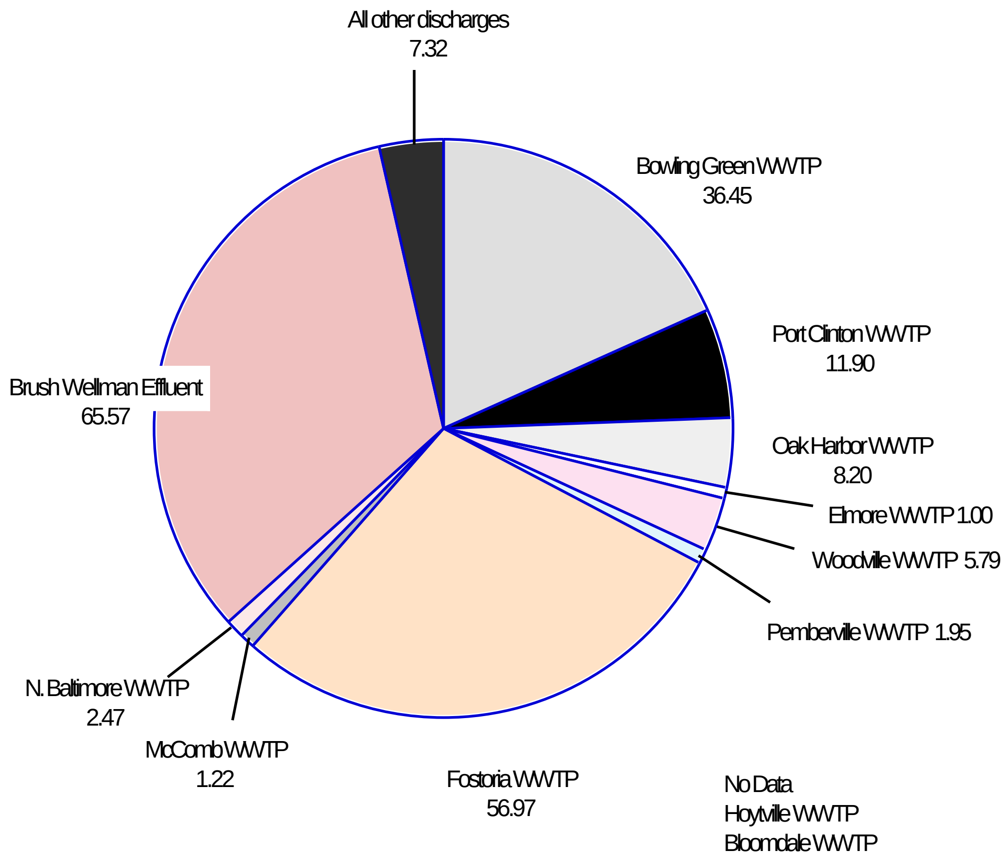


Figure 17. Mean daily loadings of ammonia-nitrogen (kg/day) from major point source discharges in the Portage River basin for 1994 in relation to the total load of 199.51 kg/day.

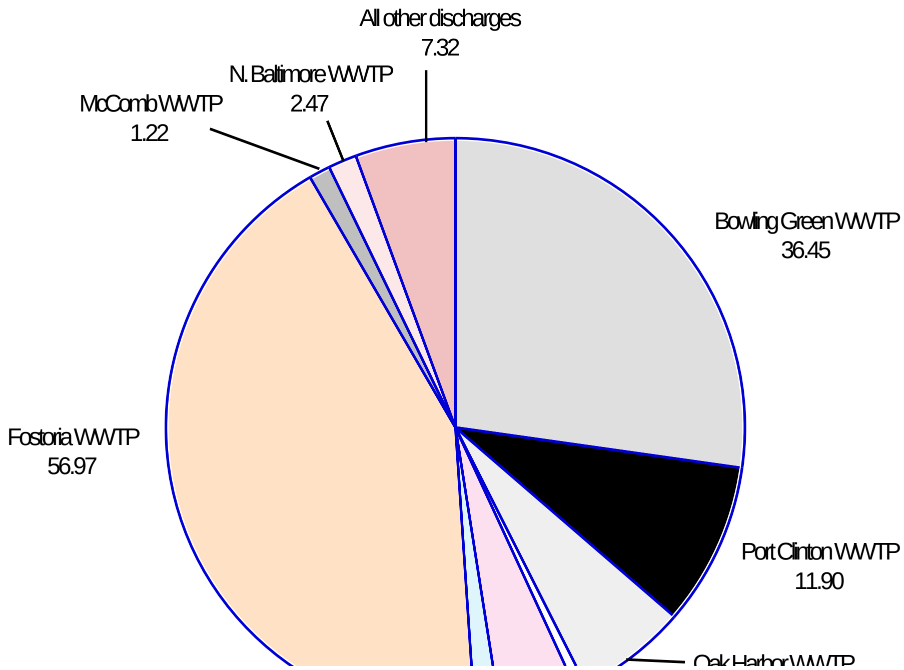


Figure 18.Mean daily loadings (kg/day) of ammonia nitrogen from major point source discharges in the Portage River basin during 1994, in relation to the total load (133.94 kg/day) excluding Brush Wellman.

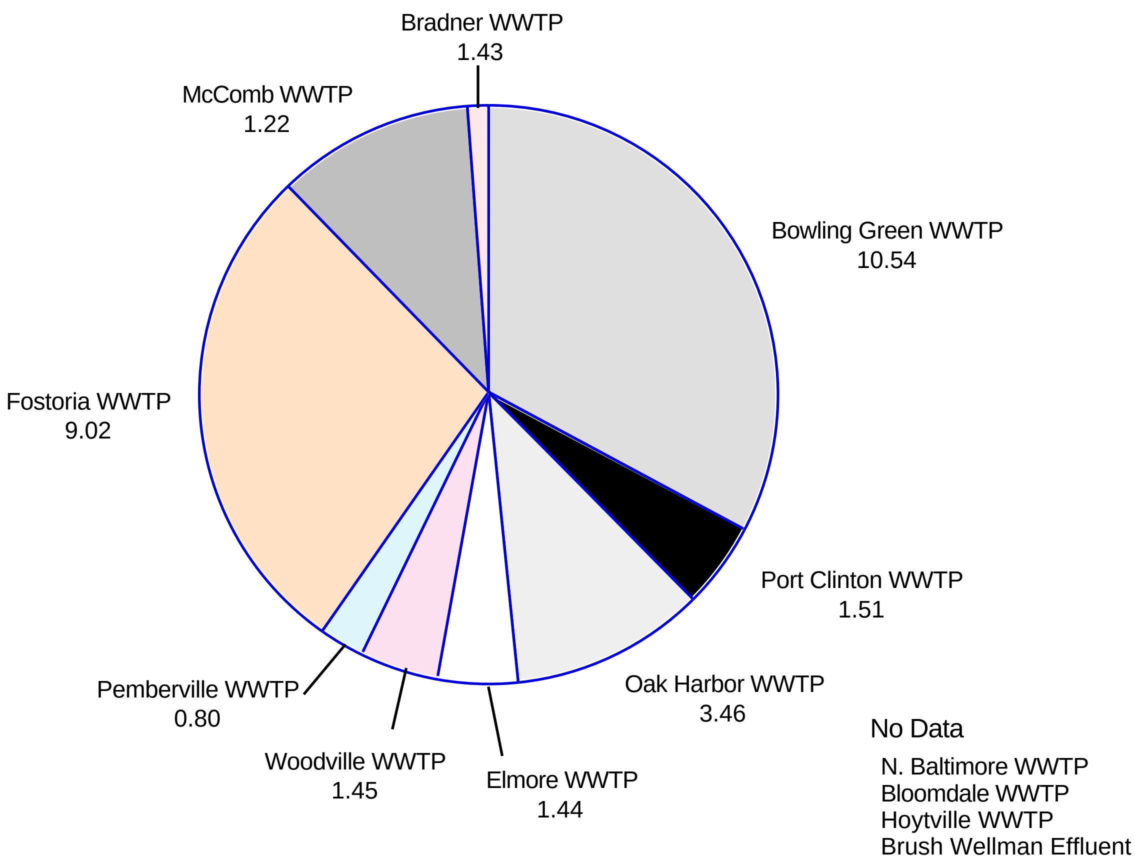


Figure 19. Mean daily loadings of phosphorus (kg/day) from major point source discharges in the Portage River basin during 1994, in relation to the total load of 33.22 kg/day.

Surace Water Quality

Low dissolved oxygen (DO) concentrations (< 5.0 mg/l) were recorded in a relatively high percentage (48 of 276) of water quality grab samples in the Portage River Basin (Tables 4-A and 4-B). Low DO concentrations were distributed throughout the basin, reflecting the pervasiveness of nutrient enrichment from nonpoint sources and habitat modifications, and underscoring the need to restore riparian habitat throughout the basin. Concentrations in violation of the 4.0 mg/l minimum at any time Water Quality Standard were observed in 25 samples, and were most frequent in the East Branch Portage River and Rocky Ford owing to grossly polluted conditions from CSO inputs.

Table 4-A. Exceedences of Ohio EPA water quality criteria (OAC 3745-1; Ohio EPA 1994) for water quality parameters measured in grab samples taken from the Portage River study area during 1994. Units are µg/l for metals and organics, number of colonies/100 ml for fecal coliform, and mg/l for all other parameters. Mixing zone samples appear in italics.

Stream	River Mile	Parameter (value)
Instream Samples		
Portage River	*27.38*	*NH_3-N (13.0*, 12.2*)* [a] *Total P (2.20, 2.61)* †
	24.10	Fecal Coliform (2400◊◊)
	22.54	Fecal Coliform (2100◊◊)
	22.13	*Total P (1.95)* †
	16.50	*Cu (78*, 37*)* [a]
	12.55	Fecal Coliform (2600◊◊)
	12.00	*TDS (1620**)* [a]
	0.60	D.O. (4.5‡)
	0.50	*Cu (38*)* [a]
	0.40	Fecal Coliform (4400◊◊)
	0.05	D.O. (4.5‡)

Table 4-A. Continued.

Stream	River Mile	Parameter (value)
East Branch - Portage River	12.47	D.O. (4.0‡, 4.2‡) Fecal Coliform (2100◊◊) Sulfates (274#) TDS (1560**)
	10.40	D.O. (3.8‡‡, 4.2‡, 2.3‡‡, 1.5‡‡‡, 2.5‡‡, 2.8‡‡) Fecal Coliform (7600◊)
	10.19	*Fecal Coliform (3800◊)* [a]
	9.00	D.O. (1.7‡‡‡, 3.2‡‡, 3.4‡‡, 3.5‡‡, 3.8‡‡,4.4‡) Fecal Coliform (4000◊◊) NH_3-N (4.18*)
	6.20	D.O. (3.6‡‡, 3.8‡‡, 4.0‡, 4.3‡, 4.2‡) Fecal Coliform (3400◊)
	0.80	Fecal Coliform (2200◊) Pb (27.00**)
Rocky Ford	15.04	D.O. (3.5‡‡, 3.7‡‡, 4.7‡) Nitrate-N (12.32#)
	10.80	D.O. (3.9‡‡, 4.2‡) DDT (0.010**#)
	9.80	D.O. (2.3‡‡, 0.2‡‡‡, 3.8‡‡, 4.2‡) Fecal Coliform (2700◊) Zn (260***)
Nichols Ditch	0.10	D.O. (3.8‡‡, 4.6‡, 4.7‡) Fecal Coliform (2000◊)
North Branch - Portage River	17.92	D.O. (3.9‡‡,4.8‡) Sulfates (260#, 309#)
	9.73	D.O. (3.8‡‡) Sulfates (425#, 400#, 474#)
	6.55	D.O. (4.1‡)

Table 4-A. Continued.

Stream	River Mile	Parameter (value)
Poe Ditch	*2.40*	*D.O. (2.4‡‡)* *Fecal Coliform (>10000◊◊◊)* [a] *Total P (1.07)* †
Middle Branch - Portage River	8.70	D.O. (4.7‡)
	6.07	D.O. (3.0‡‡, 3.7‡‡)
South Branch - Portage River	8.30	D.O. (4.0‡, 4.9‡) DDT (0.004**#)
Rader Creek	11.70	Fecal Coliform (6200◊, >10000◊, >10000◊) NH_3-N (4.00*, 7.11*) Total P (2.28, 1.23, 2.44, 1.82)†
Algire Creek	*1.00*	*Fecal Coliform (> 10000◊)* *Total P (1.99, 1.31, 3.60, 2.2, 3.16, 3.25)†*
Sugar Creek	8.80	D.O. (4.1‡, 4.6‡)
	5.68	D.O. (4.3‡)
Needles Creek	1.30	D.O. (3.7‡‡, 4.0‡)
Bull Creek	0.64	D.O. (3.8‡‡) Ni (1050**) Sulfates (281#)
Effluent Samples [b]		
Portage River	34.70 (Pemberville)	TDS (1680**, 1990**) Total P (3.07, 2.57, 1.84, 2.76, 2.49, 1.71)†
	27.40 (Woodville)	DDT (0.002**#) Total P (1.43, 2.81, 2.66, 2.52, 2.87, 2.86)†
	22.15 (Elmore)	Fecal Coliform (4800◊◊, 5000◊) TDS (2760**, 2030**, 4490**, 7140**, 2260**, 2540**, 1840**) D.O. (4.7‡)

Table 4-A. Continued.

Stream	River Mile	Parameter (value)
Portage River (continued)	22.15 (Elmore)	Total P (2.40, 3.41, 2.40, 2.25, 2.32, 3.09)†
	12.03 (Oak Harbor)	Total P (1.46, 1.48, 1.00, 1.18, 1.27, 2.05)†
Brush Creek		Be (1020) Cu (928***) DDT (0.026**) Fecal Coliform (3600◊◊) PCB (0.318) TDS (9130**, 1940**, 12100**, 8780**, 11100**, 10500**, 10500**) Total P (2.03)†
East Branch Portage R.	10.20 (Fostoria)	Fecal Coliform (>10000◊,3800◊◊)
Poe Ditch - Bowling Green	2.46	Fecal Coliform (>10000◊◊◊)
Algire Creek	1.05	Fecal Coliform (>10000◊, 2200◊◊)
		NPDES Permit Violations
McComb WWTP effluent		Fecal Coliform (>10000Δ, 2200Δ) TSS (23Δ)
Brush Wellman (002 and 011 limits combined)		Fecal Coliform (3600∂) Cu (928∂ - flow 19 cfs at Woodville gauge) Pb (90∂ - flow 176 cfs at Woodville gauge) Ni (744∂ - flow 19 cfs at Woodville gauge) Be (1020∂ - flow 19 cfs at Woodville gauge)
Fostoria WWTP effluent		Fecal Coliform (>10000Δ, 3800Δ) Ammonia (3.03Δ)
Bowling Green WWTP effluent		Fecal Coliform (>10000Δ, 3800Δ) Phosphorus (1.07ΔΔ)
Pemberville WWTP effluent		Ammonia (2.25ΔΔ, 2.12ΔΔ, 3.03Δ) TSS (22Δ, 14ΔΔ, 15ΔΔ, 20Δ, 23Δ)

Table 4-A. Continued.

Stream	River Mile	Parameter (value)
Elmore WWTP effluent		Fecal Coliform (4800◊◊)

a outside mixing zone criteria are applied to mixing zone samples to gauge potential for localized impacts to receiving waters.
b water quality standards do not apply to effluent samples, but are shown to gauge the relative quality of the effluent in comparison to the standards.
† all phosphorus values listed exceed the WQS guideline of 1.0 mg/l.
* exceedence of numerical criterion for prevention of chronic toxicity (CAC).
** exceedence of numerical criterion for prevention of acute toxicity (AAC).
*** exceedence of numerical criterion for prevention of lethality (FAV).
# exceedes numerical criterion for human health 30 day average for Public Water Supplies.
◊ exceedence of average primary contact recreation criterion (fecal coliform 1000/100ml).
◊◊ exceedence of maximum primary contact recreation criterion (fecal coliform 2000/100ml).
◊◊◊ exceedence of maximum secondary contact recreation criterion (fecal coliform 5000/100ml).
‡ exceedence of average warmwater habitat dissolved oxygen concentration (5.0 mg/l).
‡‡ exceedence of minimum warmwater habitat dissolved oxygen concentration (4.0 mg/l).
‡‡‡ exceedence of the the nuisance prevention minimum criterion (2 mg/l).
∂ violation of NPDES permit daily maximum concentration limit.
Δ exceedence of NPDES permit 7 day average concentration limit.
ΔΔ exceedence of NPDES permit 30 day average concentration limit.

Table 4-B. Number of dissolved oxygen (DO) concentrations less than 5.0 mg/l detected in surface water grab samples collected from the Portage River basin, 1994. Effluent and mixing zone grabs are excluded.

Stream	Samples w/ DO < 5.0 mg/l	Tot. Number of Samples	Percent of Samples
Portage River	2	102	1.96
East Branch	19	36	52.78
Rocky Ford	9	24	37.50
Nichols Ditch	3	6	50.00
North Branch	4	30	13.33
Middle Branch	3	12	25.00
South Branch	2	6	33.33
Sugar Creek	3	18	16.67
Needles Creek	2	6	33.33
Bull Creek	1	6	16.67
Portage Basin[1]	48	276	17.39

[1]Includes locations not listed above.

Portage River

Water quality samples were collected from 29 locations in the Portage River mainstem from RM 35.28 to RM 0.1 (Table 3). Results for each measured parameter at all sampling locations appear in Appendix Table A-3. Flow data from the USGS gaging station in Woodville (Figure 20) reveals that the first set of surface water samples were collected following a period of elevated flow. Subsequent samples were collected at near normal or slightly elevated flows.

Significant inputs of phosphorus were detected in each of the WWTP mixing zone samples (Figures 22 and 24). Nutrient levels (total P and NO_3-N) were highest in the Woodville WWTP mixing zone along with elevated levels of ammonia-N (Figures 21 and 22) where concentrations exceeded the maximum water quality criterion in two samples. The high concentrations of nitrogen and phosphorus fluctuated about the Redfield Ratio (Figure 24), an indication that favorable conditions for the formation of algal blooms exist (Hecky and Kilham 1988). The Redfield Ratio is the average ratio of nitrogen to phosphosphorus found in phytoplankton, and reprepresents the relative concentrations at which each nutrient becomes limiting with respect to the other. Thus, as the concentration of phosphorus increases (as in WWTP discharges) in relation to elevated levels of nitrogen, phytoplankton productivity can increase dramatically. Levels of nitrate-N were extremely elevated in the Brush Wellman mixing zone and resulted in elevated nitrate-N concentrations extending four miles downstream. Nitrate-N levels in Hyde Run (aka Brush Creek) were >400 mg/l in all but one sample. Nitrate-N analyses for two of the earlier sampling dates are not available because the laboratory discarded the samples after laboratory equipment was damaged by the extremely high levels of nitrate-N. Once it was determined that the levels of nitrate-N in the samples were indeed real, subsequent samples were diluted in order to allow analyses without damaging the analytical equipment.

Five-day biochemical oxygen demand (BOD_5) increased in and downstream from Woodville in response to CSO and nutrient loadings (Figure 23). Mean D.O. concentrations declined in the free flowing portion of the mainstem in response to the organic enrichment (Figure 23). D.O. and BOD_5 both generally increased in the Lake Erie influenced portion of the mainstem reflecting the transition to a phytoplankton based food chain bolstered by elevated nutrient levels.

The magnitude of diffuse nonpoint source nutrient inputs to the Portage River is illustrated by the high levels of nitrate-N in samples collected in the first sampling pass (Figure 21; Table A-1). Also, the generally elevated fecal coliform counts at locations upstream of the Woodville and Elmore CSOs (Figure 23) suggest unsewered discharges are another source of organic enrichment. Fecal coliform counts exceeded the Primary Contact Recreation (PCR) criterion downstream of all CSOs sampled in at least one of the three sampling events. Elevated fecal coliform counts were also detected in each of the WWTP mixing zones, indicating bypasses of raw, or poorly treated sewage.

Flow in the Portage River as measured by the USGS gage at Woodville was normal during the survey period as rainfall amounts averaged normal in June and July. The hydrograph reveals the influence of periodic rainfall and runoff events with a high peak flow in late June and lesser peaks in August (Figure 20). September and October rainfall was well below normal and resulted in lower river flows. Flows below the 80% duration value (10 cfs) occurred twice during the survey, but were above the $Q_{7,10}$ critical low flow of 3.4 cfs.

East Branch Portage River

Surface water quality in the East Branch Portage River was heavily degraded by inputs of raw and poorly treated sewage from the Fostoria area. This included sources such as CSOs, and, to a lesser extent, raw and poorly treated sewage from the WWTP. D.O. concentrations were well below the average and minimum water quality criteria in and downstream of Fostoria (Figure 25). Fecal coliform counts also exceeded the Primary Contact Recreation (PCR) criterion in the same reach. However, BOD_5 levels were not elevated nor consistent with the high level of organic enrichment, suggesting that toxic conditions hamper the microbial breakdown of the organic material. The CSOs and WWTP were also significant sources of ammonia-N, total phosphorus, and nitrate-N.

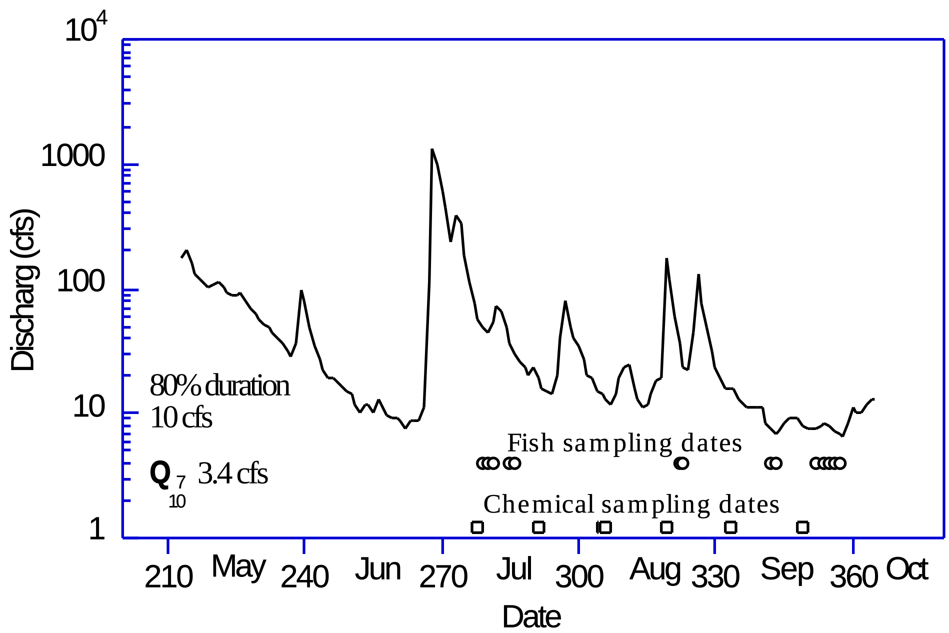


Figure 20. Flow hydrograph for the Portage River measured by the USGS gage at Woodville near US Route 20 between May 1 and October 6, 1994. The fish and chemical sampling dates are indicated with symbols; artificial substrates were set between July 25-26 and September 7-8. The numbers on the x-axis are Julian days.

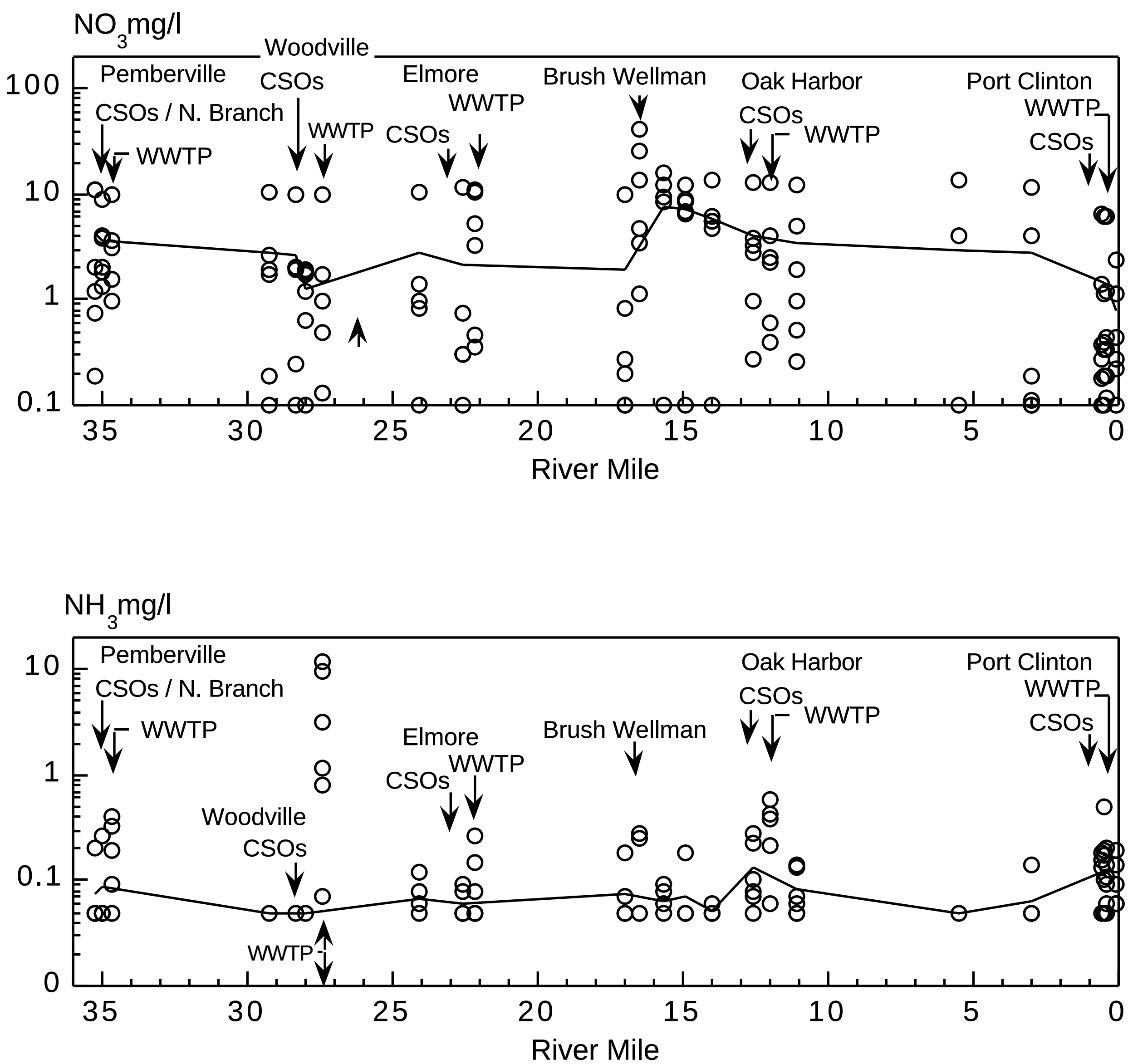


Figure 21. Plots of nitrate-nitrogen (NO_3) and ammonia-nitrogen (NH_3) from water quality samples in relation to major point source discharges in the Portage River, 1994. The solid line depicts means at each river mile excluding mixing zone samples.

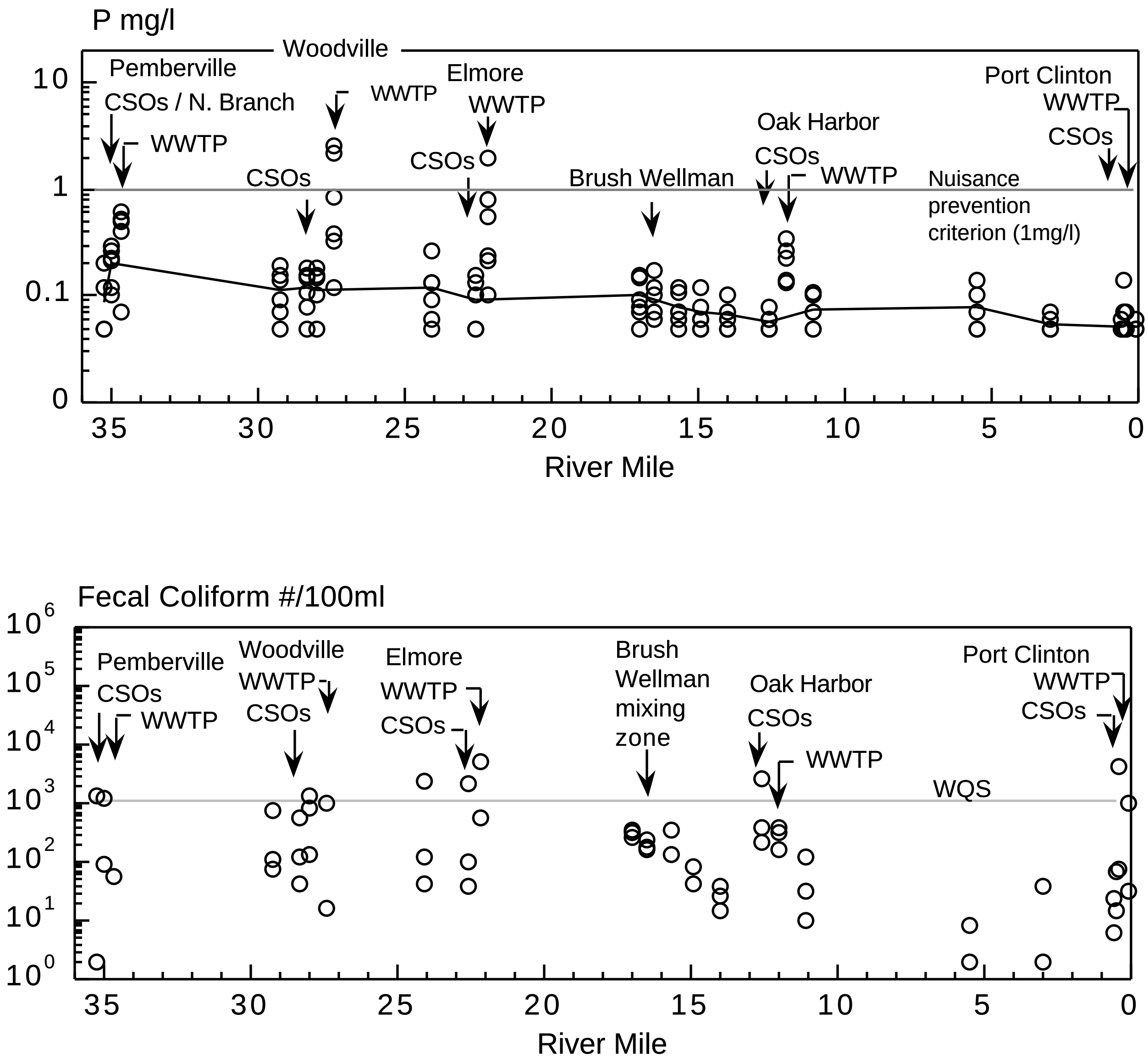


Figure 22. Plots of phosphorus (top) and fecal coliform counts (bottom) from water quality in relation to major point source discharges to the Portage River, 1994. The depicts means at each river mile (for phosphorus) excluding mixing zone samples. The dotted line shows the water quality standard (WQS) for fecal coliform bacteria.

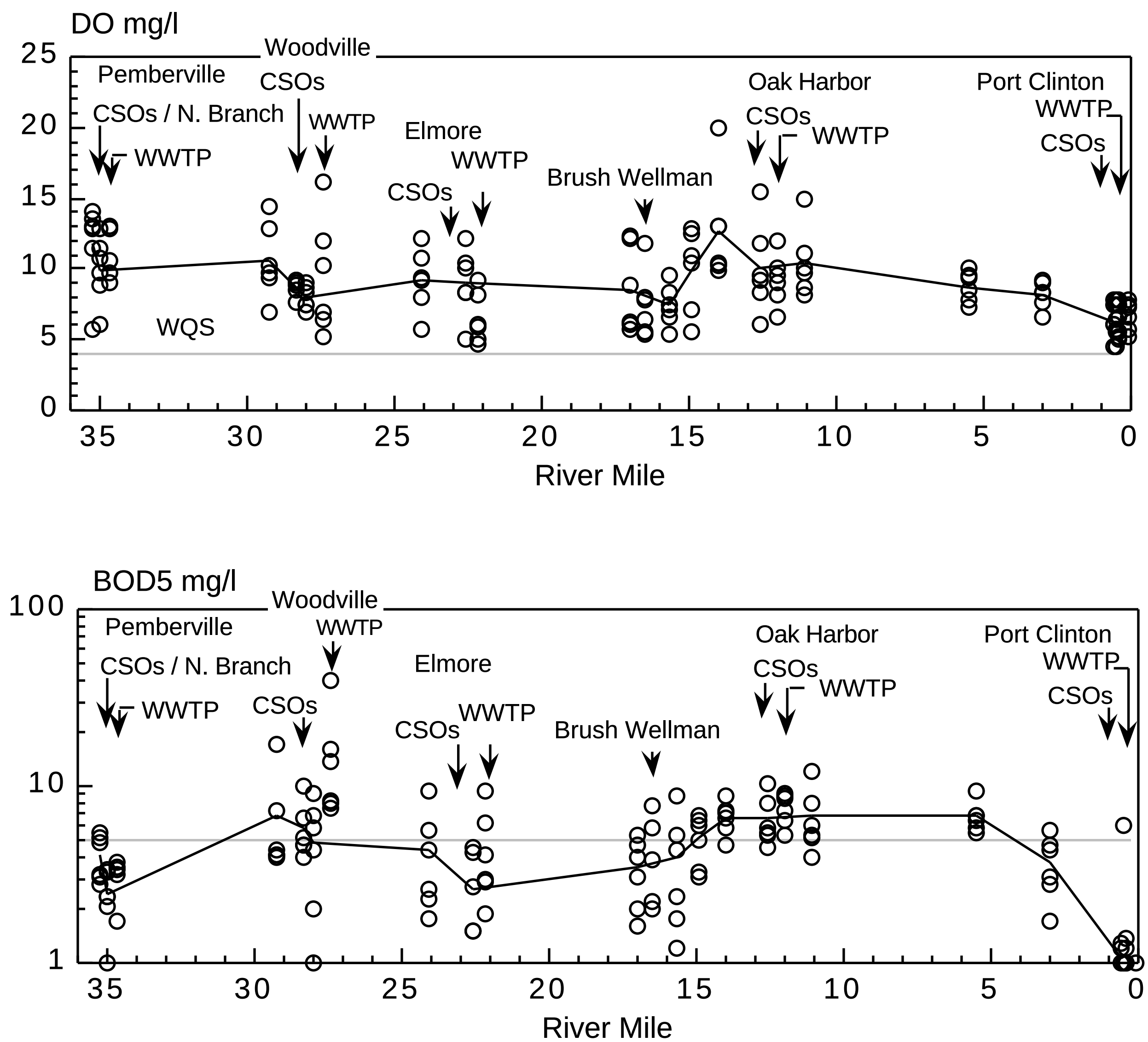


Figure 23. Plots of dissolved oxygen (D.O.) and five-day biochemical oygen demand (BOD5) from water quality samples in relation to point source discharges to the Portage River, 1994. The solid line depicts means at each river mile excluding mixing zone samples. The dotted line depicts water quality standards (WQS) for dissolved oxygen, and for BOD5, elevated levels (Warren 1971).

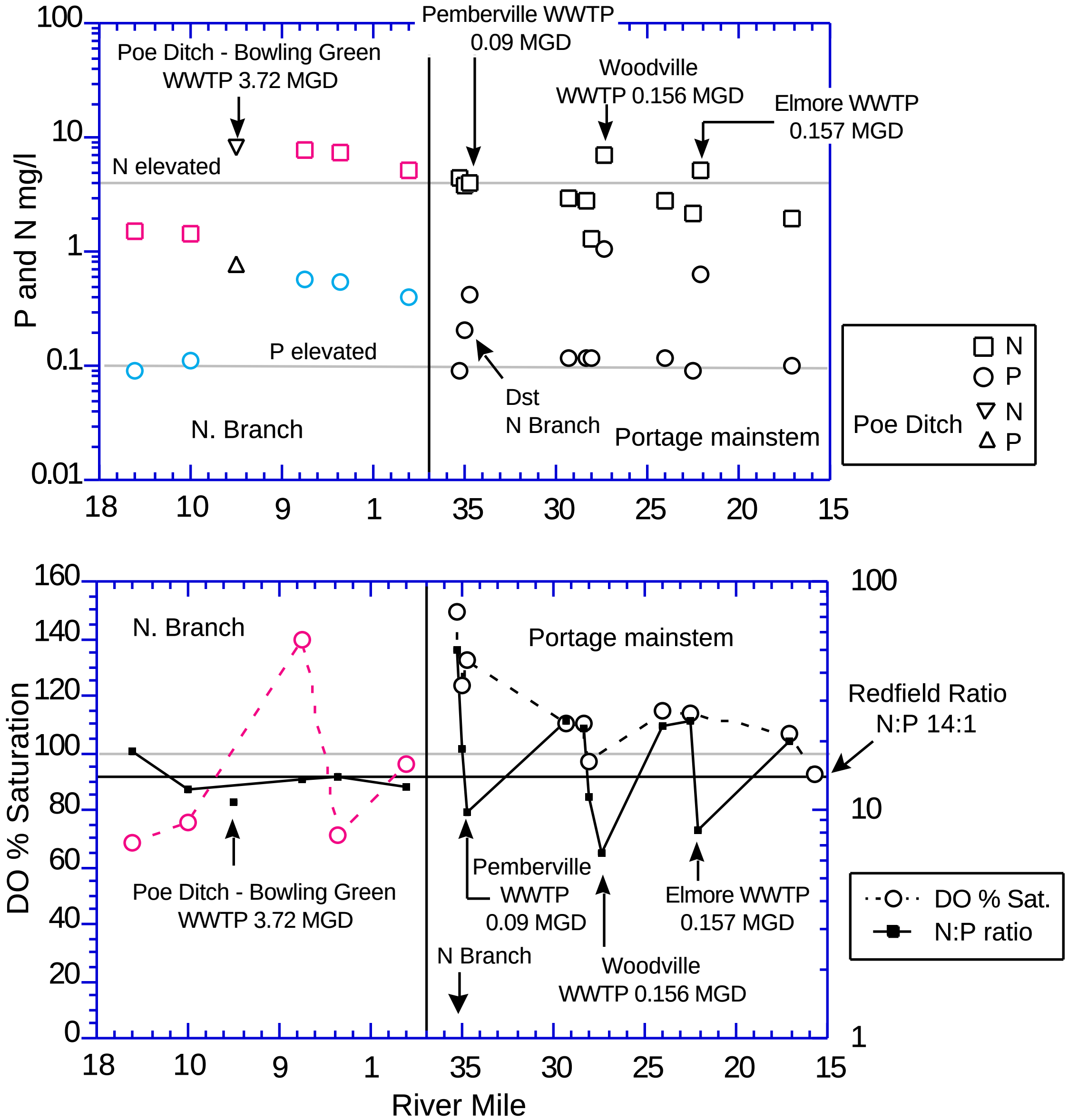


Figure 24. Concentrations of phosphorus and nitrogen in relation to point source discharges to the North Branch Portage River and the Portage River mainstem (top). Poe Ditch (Bowling Green WWTP) is treated as a point source to the North Branch. Notice that nutrient loads from the Bowling Green WWTP are conserved and delivered to the Portage mainstem. The relative response of algal productivity to the nutrient inputs is inferred from the percent saturation of dissolved oxygen (lower figure). Super saturation (*i.e.*, > 100%) is indicative of high algal productivity. Concentrations of nitrogen and phosphorus are high, and fluctuate about the Redfield ratio indicating conditions are favorable for the production of algal blooms.

Rocky Ford

The North Baltimore CSOs impaired surface water quality. D.O. concentrations and fecal coliform counts in several samples collected downstream of the CSOs did not meet water quality standards (Figure 26). The presence of black sludge deposits below the Water Street CSO suggest that dry weather overflows are occurring and further indicate the limited ability of the North Baltimore WWTP to handle existing. loads Also, total phosphorus levels were elevated in three samples collected below the CSOs. Unlike the East Branch Portage River, BOD_5 levels increased in response to the organic loadings indicating that the scope of the water quality problems do not include a significant toxic component.

Other Tributaries

High levels of nutrients (NO_3-N, NH_3-N, and total P) were detected in surface water samples collected in Algire Creek downstream from the McComb WWTP and in Rader Creek downstream of the confluence with Algire Creek (Figure 27 and 28). Ammonia-N levels exceeded water quality criteria in Rader Creek. Total phosphorus concentrations in both streams were two orders of magnitude higher than those measured at reference sites in the HELP ecoregion. Fecal coliform counts were in excess of the PCR criteria, suggesting the presence of raw or poorly treated sewage resulting from bypasses and/or the McComb WWTP (Figure 27). A hog farm at the confluence of Algire and Rader Creek may also have added to the water quality problems. High BOD_5 levels reflected the input of organic materials.

High concentrations of nitrogen (both ammonia-N and nitrate-N) and total phosphorus were detected in Poe Ditch samples collected downstream of a CSO and in the Bowling Green WWTP mixing zone. Fecal coliform counts were elevated in the Bowling Green WWTP mixing zone, indicating inputs of poorly treated or raw sewage. Total phosphorus from the WWTP was exported to the Portage River mainstem (Figure 24), and contributed, in part, to the enriched conditions observed. The WWTP also appears to contribute to foaming in the North Branch as far downstream as Pemberville. However, the specific foaming agent was not indentified.

The Middle Branch and Sugar Creek samples represent sites in the Portage River basin that are relatively unimpacted by point sources. Nutrient levels were generally lower in these streams than in those impacted by point sources. However, nutrient concentrations, compared to least impacted reference sites, were one order of magnitude higher, demonstrating the significance of nonpoint source nutrients in the Portage River basin.

Organics

Detections of priority volatile organic compounds (VOCs) occurred almost exclusively in samples collected near or downstream of CSOs and WWTP effluents (Table 6). VOCs are widely used in industry and common household products, thus their occurrence is not surprising. Trichloroethene (TCE), a common industrial solvent and probable carcinogen was detected in Bush Wellman effluent samples (Table 7). All detections of VOCs, however, were well below the established outside mixing zone (OMZ) 30-day average for WWH Aquatic Life Use designations. Halomethanes were the most commonly detected VOCs.

Non-priority volatile and semi-volatile organic compounds were detected in all samples (Table 6). Atrazine, a widely employed herbicide, was the most commonly detected (15 of 27 samples) herbicide.

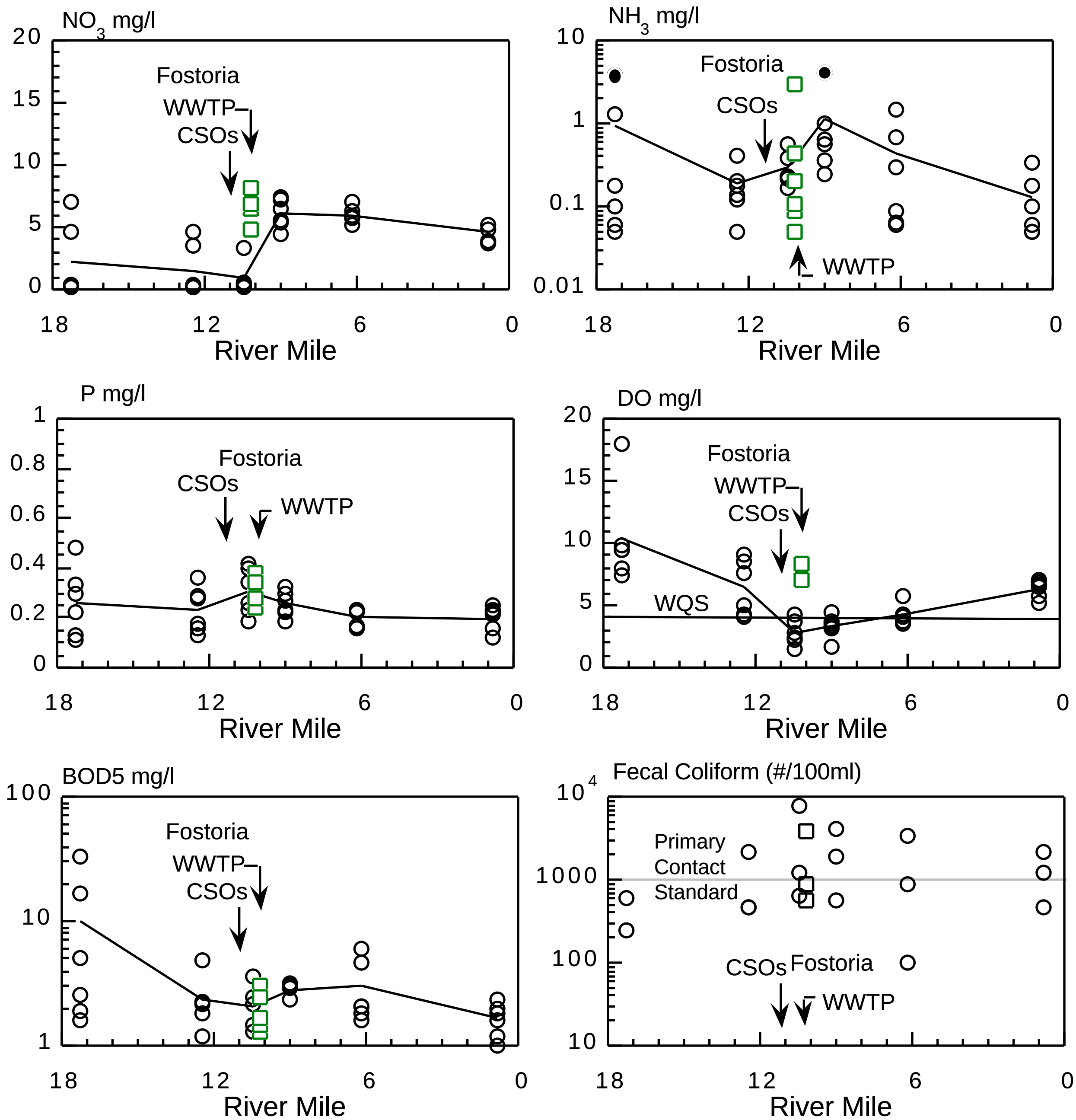


Figure 25. Longitudinal plots of important water quality parameters for the East Branch Portage River Portage River. The solid line connecting the data points depicts the mean of the six samples for each river mile. The Outside mixing zone water quality standards (WQS) are shown where applicable. Solid dots in the NH_3 plot represent violations of WQS.

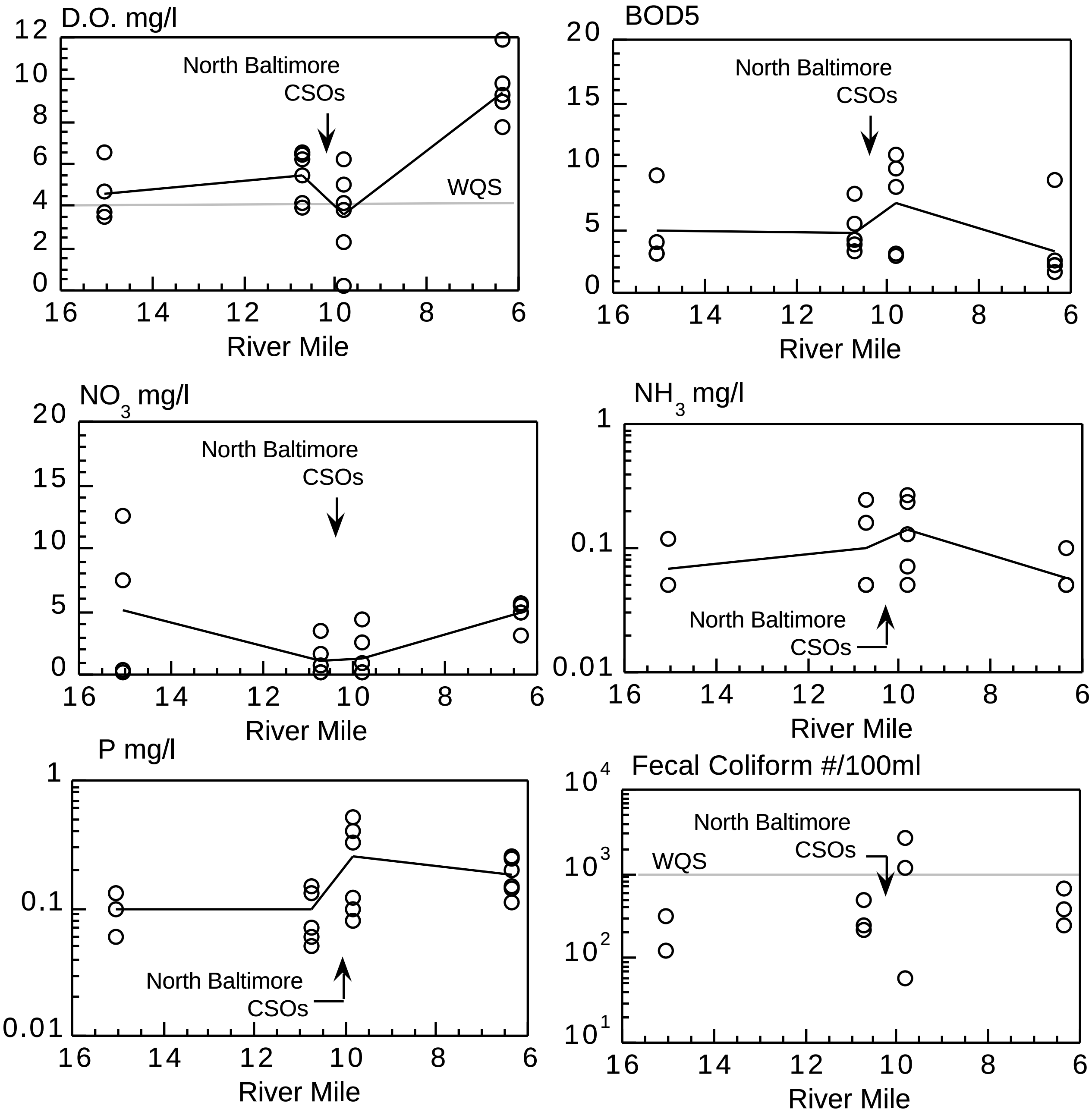


Figure 26. Longitudinal plots of important water quality parameters for Rock Ford in relation to North Baltimore CSOs. Means for each river mile are represented by the solid line. Water quality standards are depicted where applicable.

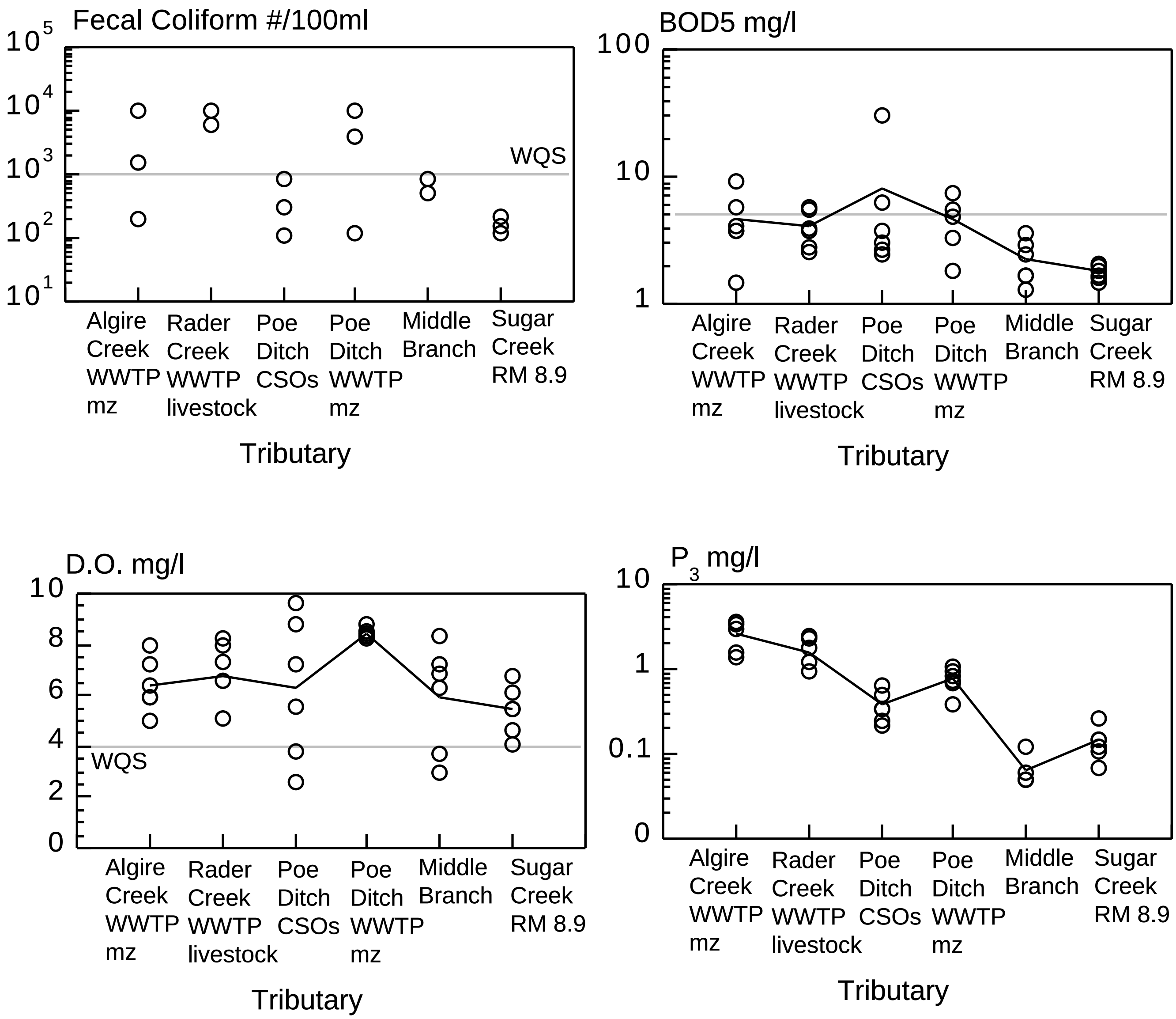


Figure 27. Plots of important water quality parameters sampled in tributaries to the Portage River, 1994. The solid line shows means at each location. Algire Creek, Rader Creek and Poe Ditch are effluent dominated. Dotted lines show either water quality standards (WQS), or levels that can be considered elevated. Factors influencing water quality (*i.e.*, WWTP) are listed under the stream name.

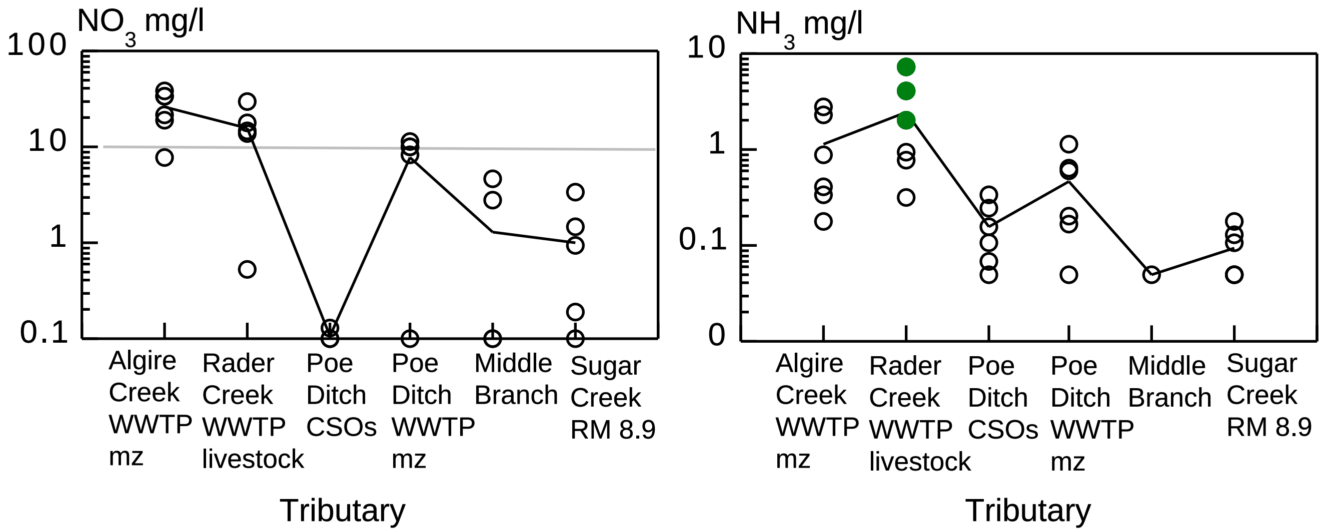


Figure 28. Plots of nitrate (NO_3) and ammonia (NH_3) nitrogen sampled in tributaries to the Portage River, 1994. The solid line shows means at each location. Algire Creek, Rader Creek and Poe Ditch are effluent dominated.The dotted line in the nitrate plot shows elevated levels. Solid dots in the NH_3 plot show concentrations in violation of water qualiy standards.Factors influencing water quality (*i.e.*, WWTP) are listed under the stream name.

Organochlorine pesticides were detected in virtually all surface water grab samples (including the tributaries). Lindane and endosulfans, which are commonly used agricultural inseciticides, and heptachlor, an insecticide approved only for termite control, were detected most frequently. Residues of environmentally persistant pesticides (*i.e.*, aldirn, DDT, endrin) no longer in general commercial use, or thier metabolites (*e.g.*, DDE, dieldrin) were also detected frequently. Detections were most numerous in samples collected from the Woodville WWTP effluent and mixing zone. The frequency of detections reflects the lack of retaining mechinisms, particularly riparian buffers, throughout the watershed. Pesticides were not detected at RM 0.4 of the Portage River owing to dilution by Lake Erie, and RM 17.92 in the North Branch (Table 7). The lack of detection of any pesticide in the North Branch (essentially a modified stream channel predominated by agricultural land use) was surprising given that many of the pesticides analyzed for are persistent in the environment and the analytical detection limits are sensitive to concentrations as low as 0.001$\mu g \cdot l^{-1}$ (*i.e.*, 1 part per trillion). DDT and/or DDE were detected in samples from the South Branch, Rocky Ford, Woodville WWTP effluent and mixing zone, and the Brush Wellman effluent. Any detection of DDT or DDE (*i.e.*, $\geq$ 0.001$\mu g \cdot l^{-1}$) constitutes violation of water quality standards for 30-day OMZ average or 30 day Human Health 30-day average. The aquatic life, human health 30-day average, and public water supply criteria for DDT is 0.00024 $\mu g \cdot l^{-1}$, which represents the level at which DDT poses a significant bioaccumulation risk (including human consumption of fish), or to public water supplies. The villages of North Baltimore and Van Buren both use the Rocky Ford as a public water supply. Because DDT is rapidly degraded to more stable and persistent metabolites (*e.g.*, DDE) DDT detections are more likely the result of atmospheric deposition or possibly deliberate releases of recently discovered material. DDE, however, is persistent in the environment, and is likely the residue, in part, of historical domestic DDT use. The number of pesticides detected generally increased in the Portage River mainstem compared to its tributaries, and were highest in the Woodville WWTP effluent (including DDT). No PCBs were detected in any water sample except the Brush Wellman effluent in Hyde Run (Table 8).

Sediment Chemistry
Analysis of sediment samples revealed two locations with grossly polluted sediments. The East Branch Portage River Portage River downstream of Fostoria (RM 10.4 through 9.0), and the Portage River in the Brush Wellman mixing Zone (Table 9). Sediments downstream of Fostoria's CSOs were grossly contaminated with polycyclic aromatic hydrocarbons (PAHs), had elevated levels of polychlorinated biphenyls (PCBs), and detectable concentrations of organochlorine pesticide residues (Table 9). PAHs originate in coal tar or as the by product of industrial processes, suggesting untreated industrial effluents are entering the East Branch Portage River via CSOs. The levels of PAHs found can be expected to impact the abundance and diversity of benthic life forms in the East Branch Portage River (Persaud et al. 1993, Long and Morgan 1991). Additionally, high levels of the DDT metabolite, 4,4'-DDD, were detected upstream of Fostoria at RM 12.47 (Tiffin Street). RM 12.47 is downstream of the Norfolk and Western railroad and the associated grain elevators and agricultural supply stores serviced by the railroad, suggesting the residues originated from the rail yard as DDT prior to the ban. The city of Fostoria fills its water supply reservoirs directly from the East Branch Portage River, including Lake Lamberjack and Lake Mottram which are downstream of RM 12.47. Organochlorine pesticides were not analyzed near Fostoria, but trace amounts of DDT metabolites may occur given the level found in the sediments. Detectable levels of DDT (or its metabolites) constitute an exceedence of the PWS water quality criterion. Given the risk posed by these detections, the sediments and surface waters of the East Branch Portage River should be analyzed for DDT and metabolites.

Table 6. Summary of organic priority and nonpriority pollutants detected in surface water samples collected in the Portage River Basin study area in July 1994. All results are reported in ug/l.

	ROCKY FORD		MIDDLE BRANCH PORTAGE RIVER	
PARAMETER*	RM 10.74	RM 6.34	RM 8.64	RM 6.08
Priority Volatile Organic Compounds (VOCs)				
Bromodichloromethane	--	--	--	--
Chloroform	--	--	--	--
Chloromethane	1.1	1.2	--	--
Dibromochloromethane	--	--	--	--
Naphthalene	--	--	--	--
Tetrachloroethene	--	--	--	--
Toluene	--	--	--	--
Trichloroethene	--	--	--	--
Priority Semi-Volatile Organics (Base Neutral/Acid Extractable)				
NONE DETECTED				
Non-priority Volatile and Semi-Volatile Organics				
Number Detected**	13	11	9	4
Including (in ug/l)†:				
Atrazine	2.1	4.3	2.3	2.2
Bentazon	--	--	--	--
Cyanazine	--	--	--	--
Metolachlor	1.9	--	--	--

* Only pollutants that were detected at least once are listed.

** Only the total number of non-priority pollutants identified is presented here.

-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.

† These pesticides are not included as part of the standard pesticide scan (Table 8), but have been tentatively identified in the non-priority pollutant scan.

Table 6. Continued.

PARAMETER*	EAST BRANCH PORTAGE RIVER RM 12.47	RM 10.42	RM 10.20 Fostoria WWTP effluent	RM 10.19 mix zone	RM 9.00	RM 6.18	RM 0.80
Priority Volatile Organic Compounds (VOCs)							
Bromodichloromethane	--	--	--	--	--	--	--
Chloroform	--	3.1	0.6	0.6	1.0	--	--
Chloromethane	--	--	--	--	--	--	1.2
Dibromochloromethane	--	--	--	--	--	--	--
Naphthalene	--	--	--	--	--	--	0.6
Tetrachloroethene	--	--	--	--	--	--	--
Toluene	--	--	1.9	--	--	3.4	--
Trichloroethene	--	--	0.5	--	--	--	--
Priority Semi-Volatile Organics (Base Neutral/Acid Extractable)							
NONE DETECTED							
Non-priority Volatile and Semi-Volatile Organics							
Number Detected**	6	8	9	9	12	7	4
Including (in ug/l)†:							
Atrazine	1.3	--	--	--	--	--	--
Bentazon	--	--	--	--	--	--	--
Cyanazine	--	--	--	--	--	--	--
Metolachlor	--	1.6	--	--	--	--	--

* Only pollutants that were detected at least once are listed.

** Only the total number of non-priority pollutants identified is presented here.

-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.

† These pesticides are not included as part of the standard pesticide scan (Table 8), but have been tentatively identified in the non-priority pollutant scan.

Table 6. Continued.

PARAMETER*	PORTAGE RIVER RM 29.26	RM 28.30	RM 28.04	RM 27.40 Woodville WWTP effluent	RM 27.38 Woodville WWTP mix zone	RM 17.03	HYDE RUN RM 0.02†† Brush Wellman effluent
Priority Volatile Organic Compounds (VOCs)							
Bromodichloromethane	--	--	--	--	--	--	--
Chloroform	--	--	--	--	--	--	--
Chloromethane	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--
Naphthalene	--	--	--	--	--	--	--
Tetrachloroethene	--	--	--	--	--	--	--
Toluene	--	--	--	--	0.6	--	--
Trichloroethene	--	--	--	--	--	--	--
Priority Semi-Volatile Organics (Base Neutral/Acid Extractable)							
NONE DETECTED							
Non-priority Volatile and Semi-Volatile Organics							
Number Detected**	7	7	2	15	7	15	16
Including (in ug/l)†:							
Atrazine	4.4	5.4	--	--	2.7	2.8	--
Bentazon	--	--	--	--	--	--	--
Cyanazine	--	--	--	--	--	--	--
Metolachlor	--	1.8	--	--	--	1.6	--

* Only pollutants that were detected at least once are listed.
** Only the total number of non-priority pollutants identified is presented here.
-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.
† These pesticides are not included as part of the standard pesticide scan (Table 8), but have been tentatively identified in the non-priority pollutant scan.

Table 6. Continued.

PARAMETER*	PORTAGE RIVER RM 16.50 Brush Wellman Mix Zone	RM 15.70	RM 14.90	RM 0.58	RM 0.55 Port Clinton WWTP effluent	RM 0.50 Port Clinton WWTP mix zone	RM 0.40
Priority Volatile Organic Compounds (VOCs)							
Bromodichloromethane	--	--	--	--	3.0	--	--
Chloroform	--	--	--	--	4.6	--	--
Chloromethane	--	--	--	0.8	--	0.9	1.4
Dibromochloromethane	--	--	--	--	1.1	--	--
Naphthalene	--	--	--	--	--	--	--
Tetrachloroethene	2.2	--	--	--	--	--	--
Toluene	--	--	--	--	--	--	--
Trichloroethene	--	--	--	--	--	--	--
Priority Semi-Volatile Organics (Base Neutral/Acid Extractable)							
NONE DETECTED							
Non-priority Volatile and Semi-Volatile Organics							
Number Detected**	15	8	16	9	5	11	10
Including (in ug/l)†:							
Atrazine	2.9	5.4	3.6	3.0	--	3.1	3.3
Bentazon	--	--	--	3.8	--	--	2.6
Cyanazine	--	--	--	2.6	--	--	2.3
Metolachlor	1.9	2.0	2.7	--	--	--	1.6

* Only pollutants that were detected at least once are listed.

** Only the total number of non-priority pollutants identified is presented here.

-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.

† These pesticides are not included as part of the standard pesticide scan (Table 8), but have been tentatively identified in the non-priority pollutant scan.

Table 7. Summary of organic priority and nonpriority pollutants detected in surface water samples collected in Hyde Run (Brush Wellman effluent) July - September, 1994. All results are reported in ug/l.

PARAMETER*	HYDE RUN (Brush Wellman effluent) RM 0.02 7/5/94	8/24/94	9/14/94
Priority Volatile Organic Compounds (VOCs)			
Bromodichloromethane	--	--	--
Chloroform	--	--	--
Chloromethane	--	--	--
Dibromochloromethane	--	--	--
Cis-1,2-dichloroethene	--	--	0.6
Naphthalene	--	--	--
Tetrachloroethene	--	2.5	50.1
Toluene	--	--	--
1,1,2-Trichloroethane	--	--	1.5
Trichloroethene	--	--	1.2
Priority Semi-Volatile Organics (Base Neutral/Acid Extractable)			
NONE DETECTED			
Non-priority Volatile and Semi-Volatile Organics			
Number Detected**	16	20	14
Including (in ug/l)†:			
Atrazine	--	--	--
Bentazon	--	--	--
Cyanazine	--	--	--
Metolachlor	--	--	--

* Only pollutants that were detected at least once are listed.
** Only the total number of non-priority pollutants identified is presented here.
-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.
† These pesticides are not included as part of the standard pesticide scan (Table 8), but have been tentatively identified in the non-priority pollutant scan.

Table 8. Summary of pesticides and PCBs detected in surface water samples collected in the Portage River Basin study area in August, 1994. All results are reported in ug/l.

PARAMETER*	NEEDLES CREEK RM 1.25	NORTH BRANCH RM 17.92	SOUTH BRANCH RM 8.35	EAST BRANCH RM 0.80	SUGAR CREEK RM 13.38	SUGAR CREEK RM 8.90
PESTICIDES						
Aldrin	--	--	--	--	--	--
a-BHC	--	--	0.003	--	0.003	0.006
b-BHC	--	--	--	--	--	--
d-BHC	0.003	--	0.004	--	--	0.005
y-BHC	0.002	--	0.006	0.014	--	--
4,4'-DDE	--	--	0.004	--	--	--
4,4'-DDT	--	--	--	--	--	--
Dieldrin	--	--	0.005	0.003	--	--
Endosulfan I	0.003	--	--	--	0.002	0.002
Endosulfan II	--	--	0.007	0.007	0.003	0.007
Endosulfan sulfate	--	--	--	--	--	--
Endrin	--	--	--	0.004	--	0.004
Endrin aldehyde	--	--	--	--	--	--
Heptachlor	0.003	--	--	--	--	--
Heptachlor epoxide	--	--	0.008	--	0.003	0.003
Hexachlorobenzene	--	--	--	--	--	0.003
PCBs						
NONE DETECTED						

* Only pollutants that were detected at least once are listed.
-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.

Table 8. Continued.

PARAMETER*	ROCKY FORD RM 10.74	ROCKY FORD RM 6.34	BULL CREEK RM 0.64	MIDDLE BRANCH PORTAGE RIVER RM 8.64	MIDDLE BRANCH PORTAGE RIVER RM 6.08
PESTICIDES					
Aldrin	--	--	--	--	--
a-BHC	--	0.007	--	--	--
b-BHC	--	--	--	--	0.004
d-BHC	0.002	0.017	0.002	0.003	0.003
y-BHC	--	0.004	--	0.003	0.005
4,4'-DDE	0.003	--	--	--	--
4,4'-DDT	0.007	--	--	--	--
Dieldrin	0.004	--	--	--	0.003
Endosulfan I	0.002	--	0.002	--	0.005
Endosulfan II	--	0.006	0.003	--	--
Endosulfan sulfate	--	--	--	--	--
Endrin	--	--	--	--	--
Endrin aldehyde	--	--	--	--	--
Heptachlor	--	--	--	0.003	--
Heptachlor epoxide	0.005	--	0.002	0.003	0.002
Hexachlorobenzene	--	0.005	--	--	--
PCBs					
NONE DETECTED					

* Only pollutants that were detected at least once are listed.

-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.

Table 8. Continued.

PARAMETER*	PORTAGE RIVER RM 29.26	RM 28.30	RM 28.04	RM 27.40	RM 27.38	RM 17.03	HYDE RUN RM 0.02	
				Woodville WWTP effluent	Woodville WWTP mix zone		Brush Wellman effluent 8/2	Brush Wellman effluent 9/14**
PESTICIDES								
Aldrin	--	--	--	0.024	0.004	--	--	0.008
a-BHC	0.004	0.004	0.004	0.010	0.006	--	0.036	--
b-BHC	--	--	0.002	0.036	0.002	0.003	0.092	MI
d-BHC	0.006	--	--	0.005	0.006	0.003	0.109	MI
y-BHC	--	0.004	0.004	0.003	0.010	0.003	--	MI
4,4'-DDE	--	--	--	0.004	0.002	--	0.026	--
4,4'-DDT	--	--	--	0.006	--	--	--	--
Dieldrin	0.003	0.003	0.004	0.007	0.003	0.004	--	0.003
Endosulfan I	0.004	0.002	0.003	0.005	--	--	--	--
Endosulfan II	--	--	--	--	--	--	--	--
Endosulfan sulfate	--	--	--	--	--	--	0.024	--
Endrin	0.004	0.009	0.005	0.002	0.005	--	--	--
Endrin aldehyde	--	--	--	0.019	--	--	0.011	--
Heptachlor	0.002	--	--	0.015	0.008	--	0.023	0.003
Heptachlor epoxide	0.003	0.002	0.002	0.003	0.002	0.004	0.017	--
Hexachlorobenzene	0.003	0.003	0.003	--	0.009	--	0.036	--
PCBs								
PCB-1248	--	--	--	--	--	--	--	0.318

* Only pollutants that were detected at least once are listed.
** Results of an additional unscheduled sample of the Brush Wellman effluent collected on 9/14/94.
-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.
MI Indicates matrix interference during analysis; no information possible.

Table 8. Continued.

PARAMETER*	PORTAGE RIVER RM 16.50 Brush Wellman Mix Zone	RM 15.70	RM 14.90	RM 0.58	RM 0.55 Port Clinton WWTP effluent	RM 0.50 mix zone	RM 0.40
PESTICIDES							
Aldrin	--	--	--	--	0.009	--	--
a-BHC	0.013	0.004	--	--	0.008	--	--
b-BHC	0.003	0.003	0.003	--	--	--	--
d-BHC	0.017	0.005	--	--	0.005	--	--
y-BHC	0.009	0.005	0.005	--	0.049	--	--
4,4'-DDE	--	--	--	--	--	--	--
4,4'-DDT	--	--	--	--	--	--	--
Dieldrin	--	0.007	0.005	--	0.004	--	--
Endosulfan I	0.007	0.004	0.004	--	0.007	0.002	--
Endosulfan II	0.004	--	--	0.002	--	--	--
Endosulfan sulfate	--	--	--	--	--	--	--
Endrin	--	0.011	--	--	0.009	--	--
Endrin aldehyde	0.013	--	--	--	--	--	--
Heptachlor	--	--	--	--	0.009	--	--
Heptachlor epoxide	0.003	0.005	0.006	0.003	0.011	--	--
Hexachlorobenzene	0.008	0.003	--	--	--	--	--
PCBs							
NONE DETECTED							

* Only pollutants that were detected at least once are listed.
** Results of an additional unscheduled sample of the Brush Wellman effluent collected on 9/14/94.
-- Indicates that the pollutant was not detected (i.e. not present or below the method detection limit) at this site.
MI Indicates matrix interference during analysis; no information possible.

Table 9. Dry weight concentrations of priority organic pollutants detected in sediments collected from the Portage River Basin, 1994. Concentrations preceded by an (*) exceed the Effects Range-Median (ER-M) value for the specific polutant or the the class total (*i.e.*, total PAHs) described by Long and Morgan (1990). Selected parameter concentrations were ranked (see foot notes) based on classifications described by Kelly and Hite (1984).

PARAMETER	EAST BRANCH RM 12.47	PORTAGE RIVER RM 10.42	PORTAGE RIVER RM 9.00
VOLATILE ORGANIC COMPOUNDS (mg/kg or ppm)			
Tetrachloroethene	NA	NA	NA
Toluene	NA	NA	NA
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg or ppm)			
Acenaphthene	--	*** 12.4**	--
Anthracene	--	*** 17.4**	--
Benzo[B&K]Fluoranthene	--	*** 38.0**	7.7
Benzo[A]Pyrene	--	*** 8.2**	*** 3.4**
Benzo[GHI]Perylene	--	5.1	4.5
Benz[A]Anthracene	--	*** 22.7**	*** 5.1**
Chrysene	--	*** 22.5**	*** 4.7**
Dibenzofuran	--	11.4	--
Dibenz[A,H]Anthracene	--	*** 2.2**	--
Fluoranthene	--	*** 59.7**	*** 11.5**
Fluorene	--	*** 15.2**	--
Indeno[1,2,3-CD]Pyrene	--	6.4	4.7
2-Methylnaphthalene	--	*** 11.7**	--
Naphthalene	--	*** 10.5**	--
Phenanthrene	--	*** 61.7**	*** 4.3**
Pyrene	--	*** 40.9**	*** 10.2**
Total PAHs	--	*** 346.0**	*** 56.1**
(NOTE: ER-M for total PAHs is 35 ppm)			
PHTHALATES (mg/kg or ppm)			
Bis(2-Ethylhexyl)Phthalate	--	0.8	10.2
Di-N-Butyl Phthalate	--	--	--

[a] non-elevated; [b] slightly elevated; [c] elevated; [d] **highly elevated;** [e] **extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

Table 9. Continued.

PARAMETER	EAST BRANCH PORTAGE RIVER RM 12.47	RM 10.42	RM 9.00	
ORGANOCHLORINE PESTICIDES AND PCBs (µg/kg or ppb)				
Aldrin	--	--	NA	
d-BHC	--	--	NA	
4,4'-DDD	* **42.50**	2.95	NA	
4,4'-DDE	2.64	1.45	NA	
4,4'-DDT	--	--	NA	
Dieldrin	--	3.69[b]	NA	
Endosulfan I	--	4.95	NA	
Endosulfan II	--	2.73	NA	
Endosulfan sulfate	--	20.17	NA	
Endrin	--	7.41	NA	
Heptachlor epoxide	--	--	NA	
Mirex	--	--	NA	
Total DDT	**45.14**[d]	4.30[a]	NA	
PCB-1248	--	89.45	NA	
PCB-1260	--	41.46	NA	
Total PCBs	--	120.91c	NA	
VOLATILE ORGANIC COMPOUNDS (mg/kg or ppm)				
Tetrachloroethene	NA	NA	NA	NA
Toluene	NA	NA	NA	NA
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg or ppm)				
Acenaphthene	NA	--	--	--
Anthracene	NA	--	--	--
Benzo[B&K]Fluoranthene	NA	--	--	--
Benzo[A]Pyrene	NA	--	--	--
Benzo[GHI]Perylene	NA	--	--	--
Benz[A]Anthracene	NA	--	--	--
Chrysene	NA	--	--	--
Dibenzofuran	NA	--	--	--
Dibenz[A,H]Anthracene	NA	--	--	--

[a] non-elevated; [b] slightly elevated; [c] elevated; [d] **highly elevated;** [e] **extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

Table 9. Continued.

PARAMETER	ROCKY FORD RM 10.74	ROCKY FORD RM 6.34	MIDDLE BRANCH RM 8.60	MIDDLE BRANCH RM 6.07
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg or ppm)				
Fluoranthene	NA	--	--	--
Fluorene	NA	--	--	--
Indeno[1,2,3-CD]Pyrene	NA	--	--	--
2-Methylnaphthalene	NA	--	--	--
Naphthalene	NA	--	--	--
Phenanthrene	NA	--	--	--
Pyrene	NA	--	--	--
Total PAHs	NA	--	--	--
PHTHALATES (mg/kg or ppm)				
Bis(2-Ethylhexyl)Phthalate	NA	--	--	--
Di-N-Butyl Phthalate	NA	--	--	--
ORGANOCHLORINE PESTICIDES AND PCBs (µg/kg or ppb)				
Aldrin	--	--	--	--
d-BHC	--	--	2.68	2.68
4,4'-DDD	--	--	--	--
4,4'-DDE	5.00	--	--	--
4,4'-DDT	--	--	--	--
Dieldrin	--	--	--	0.77 [a]
Endosulfan I	--	--	--	--
Endosulfan II	--	--	--	--
Endosulfan sulfate	--	--	--	--
Endrin	--	--	--	--
Heptachlor epoxide	--	--	1.00 [b]	--
Mirex	--	--	--	--
Total DDT	5.00 [a]	--	--	--
PCB-1248	--	--	--	--
PCB-1260	--	--	--	--
Total PCBs	--	--	--	--

[a] non-elevated; [b] slightly elevated; [c] elevated; **[d] highly elevated; [e] extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

Table 9. Continued.

PARAMETER	PORTAGE RIVER RM 29.26	RM 28.30	RM 28.05	RM 22.54	Brush Wellman mix zone RM 16.50
VOLATILE ORGANIC COMPOUNDS (mg/kg or ppm)					
Tetrachloroethene	--	--	--	--	0.1
Toluene	--	--	0.33	0.4	--
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg or ppm)					
Acenaphthene	--	--	--	--	--
Anthracene	--	--	--	--	--
Benzo[B&K]Fluoranthene	--	--	--	--	7.5
Benzo[A]Pyrene	--	--	--	--	*** 3.2**
Benzo[GHI]Perylene	--	--	--	--	2.3
Benz[A]Anthracene	--	--	--	--	*** 3.1**
Chrysene	--	--	--	--	*** 4.9**
Dibenzofuran	--	--	--	--	--
Dibenz[A,H]Anthracene	--	--	--	--	*** 1.0**
Fluoranthene	--	--	1.3	--	*** 9.1**
Fluorene	--	--	--	--	--
Indeno[1,2,3-CD]Pyrene	--	--	--	--	3.0
2-Methylnaphthalene	--	--	--	--	--
Naphthalene	--	--	--	--	0.6
Phenanthrene	--	--	--	--	*** 5.4**
Pyrene	--	--	--	--	*** 7.0**
Total PAHs	--	--	1.3	--	*** 47.1**
PHTHALATES (mg/kg or ppm)					
Bis(2-Ethylhexyl)Phthalate	1.0	--	1.9	0.5	2.0
Di-N-Butyl Phthalate	--	--	2.4	--	--

[a] non-elevated; [b] slightly elevated; [c] elevated; [d] **highly elevated**; [e] **extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

Table 9. Continued.

PARAMETER	RM 29.26	PORTAGE RIVER RM 28.30	RM 28.05	RM 22.54	Bush Wellman mix zone RM 16.50
ORGANOCHLORINE PESTICIDES AND PCBs (µg/kg or ppb)					
Aldrin	--	NA	NA	--	21.79
d-BHC	--	NA	NA	--	--
4,4'-DDD	--	NA	NA	--	--
4,4'-DDE	--	NA	NA	1.22	13.86
4,4'-DDT	--	NA	NA	1.70	--
Dieldrin	--	NA	NA	--	--
Endosulfan I	--	NA	NA	--	--
Endosulfan II	--	NA	NA	--	--
Endosulfan sulfate	--	NA	NA	--	--
Endrin	--	NA	NA	--	--
Heptachlor epoxide	--	NA	NA	--	--
Mirex	--	NA	NA	--	4.33
Total DDT	--	NA	NA	2.92[a]	13.86[c]
PCB-1248	--	NA	NA	--	*** 1485.72**
PCB-1260	--	NA	NA	--	158.98
Total PCBs	--	NA	NA	--	*** 1644.70**[e]

(NOTE: ER-M for Total PCBs is 400 ppb)

[a] non-elevated; [b] slightly elevated; [c] elevated; [d] **highly elevated;** [e] **extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

Table 9. Continued.

PARAMETER	PORTAGE RIVER RM 15.70	RM 14.00	RM 12.55	RM 0.60	RM 0.10
VOLATILE ORGANIC COMPOUNDS (mg/kg or ppm)					
Tetrachloroethene	--	NA	NA	--	--
Toluene	--	NA	NA	--	--
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg or ppm)					
Acenaphthene	--	NA	NA	--	--
Anthracene	--	NA	NA	--	--
Benzo[B&K]Fluoranthene	--	NA	NA	--	--
Benzo[A]Pyrene	--	NA	NA	--	--
Benzo[GHI]Perylene	--	NA	NA	--	--
Benz[A]Anthracene	--	NA	NA	--	--
Chrysene	--	NA	NA	--	--
Dibenzofuran	--	NA	NA	--	--
Dibenz[A,H]Anthracene	--	NA	NA	--	--
Fluoranthene	--	NA	NA	--	0.7
Fluorene	--	NA	NA	--	--
Indeno[1,2,3-CD]Pyrene	--	NA	NA	--	--
2-Methylnaphthalene	--	NA	NA	--	--
Naphthalene	--	NA	NA	--	--
Phenanthrene	--	NA	NA	--	--
Pyrene	--	NA	NA	--	0.6
Total PAHs	--	NA	NA	--	1.3
PHTHALATES (mg/kg or ppm)					
Bis(2-Ethylhexyl)Phthalate	--	NA	NA	--	--
Di-N-Butyl Phthalate	--	NA	NA	--	--

[a] non-elevated; [b] slightly elevated; [c] elevated; **[d] highly elevated; [e] extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

Table 9. Continued.

PARAMETER	PORTAGE RIVER RM 15.70	RM 14.00	RM 12.55	RM 0.60	RM 0.10
ORGANOCHLORINE PESTICIDES AND PCBs (µg/kg or ppb)					
Aldrin	--	--	--	NA	NA
d-BHC	--	--	--	NA	NA
4,4'-DDD	--	--	--	NA	NA
4,4'-DDE	--	--	--	NA	NA
4,4'-DDT	--	--	--	NA	NA
Dieldrin	--	--	--	NA	NA
Endosulfan I	--	--	--	NA	NA
Endosulfan II	--	--	--	NA	NA
Endosulfan sulfate	--	--	--	NA	NA
Endrin	--	--	--	NA	NA
Heptachlor epoxide	--	--	--	NA	NA
Mirex	--	--	--	NA	NA
Total DDT	--	--	--	NA	NA
PCB-1248	54.62	46.18	44.84	NA	NA
PCB-1260	--	--	--	NA	NA
Total PCBs	54.62[c]	46.18[b]	44.84[b]	NA	NA

[a] non-elevated; [b] slightly elevated; [c] elevated; **[d] highly elevated; [e] extremely elevated**, after Kelly and Hite (1984).

† Exceeds severe effect level based on 5% TOC in sediments by weight, after Persaud et al. (1993).

-- indicates parameter was below the method detection limit.

NA indicates parameter was not analyzed.

High levels of PCBs were detected in the Brush Wellman mixing zone (RM 16.5 of the Portage River), and downstream of Brush Wellman at RMs 15.7, 14.0 and 12.6. PCBs were below detection levels upstream of Brush Wellman at RM 22.5 and 29.3, implying the PCBs originated at Brush Wellman. The level of PCBs detected in the mixing zone sample were extremely elevated (Kelly and Hite 1984) and can be expected to have a moderate to severe effect on the benthic fauna (Persaud et al. 1993, Long and Morgan 1991). The levels detected in the three samples downstream of the mixing zone, although elevated, are likely to only affect the most sensitive components of the benthic fauna (Persaud et al. 1993). Additionally, PCBs were detected in water column samples only in Hyde Run (Table 8). Concentrations of PAHs in sediments from the Brush Wellman mixing zone were also high (Table 9), and may be expected to have some effect on the benthic community (Persaud et al. 1993, Long and Morgan 1991). PAHs were not detected in samples collected downstream of the Brush Wellman mixing zone.

Sediment Metals
Concentrations of metals in sediment samples collected throughout the Portage River basin were highest in areas affected by urban run-off, CSOs and in the Brush Wellman mixing zone (Table 10, Figure 29). Copper concentrations in Brush Wellman mixing zone sediments exceeded the Effects Range - Median (ER-M) level for expected toxicity to benthic organisms (Long and Morgan 1991). Beryllium levels were two orders of magnitude higher in Brush Wellman mixing zone sediments than in sediments collected upstream in other tributaries (Table 10). Standards for beryllium have not been established, however, beryllium is extremely toxic to humans and is reasonably expected to be carcinogenic.

Although all metals tended to increase with proximity to urban areas, chromium, copper, lead and zinc, metals associated with automobiles and auto emissions, were the most elevated. Concentrations of metals derived from urban runoff and CSOs were comparable to that found downstream from Brush Wellman (Figure 29). Poe Ditch sediments upstream of the Bowling Green WWTP had elevated levels of metals because of a CSO discharge.

Sediments collected from the East Branch Portage River in and downstream of Fostoria had the highest level of metal contamination due, in part, to urban/industrial sources. However, the levels found were comparable to those which occur in the heavily industrialized and grossly contaminated lower Cuyahoga River, suggesting that untreated industrial effluents are being discharged directly into Fostoria's sewers. Arsenic levels were slighly elevated in sediments throughout the basin, possibly as a residue from agricultural chemicals (*i.e.*, herbicides and fungicides).

Fish Tissue
Bioaccumulation of some of the contaminants which were found in the water column and sediments, were also found in fish tissue samples collected in the Portage River (Table 10A). DDT detections were primarily of the metabolite DDE, reflecting a strong persistence in the environment. Elevated levels of PCBs were detected in all fish samples collected at RM 16.5 in the immediate vicinity of the Brush Wellman facility. This coincides with the elevated levels, which were the highest in the study area, found in sediments. Total PCB levels in fish tissue tended to decrease or were not detected in some samples collected farther downstream. PCBs have caused cognitive impairment in children via in utero exposure through mothers who have consumed even occasional meals of contaminated fish prior to conception (Jacobson et al. 1990).

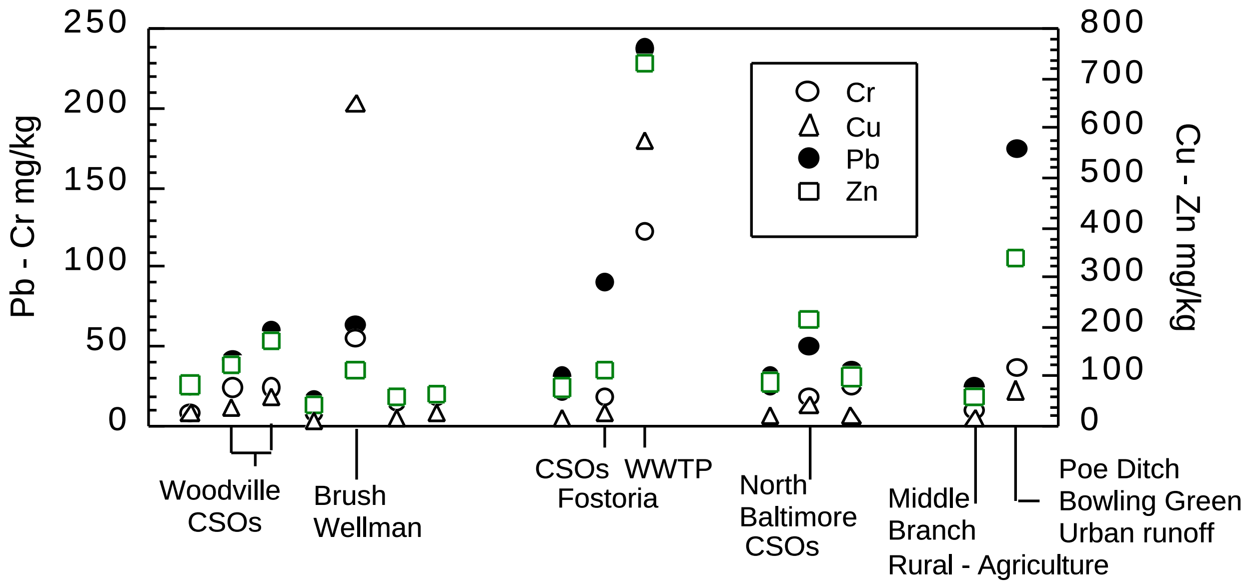


Figure 29. Sediment metal concentrations from areas affected by urban runoff compared to adjacent rural sites. The metals plotted, Cr, Cu, Pb and Zn, are commonly derived from urban sources (automobiles, automobile emissions, and industrial processes).

Table 10. Dry weight concentrations (mg·kg^{-1} or ppm) of metals in sediment samples from the Portage River basin, 1994. Metal concentrations were compared to published accounts of toxicity thresholds (Long and Morgan 1991, Persaud and Hayton 1994) and background levels (Kelly and Hite 1984) and ranked accordingly (see footnotes).

Stream RM	As	Cd	Cr	Cu	Fe	Pb	Ni	Zn	Al	Be
Portage River										
29.26	5.00	0.368	8.04	26.8[†]	17200	26.0	25.9	82.4	12000	0.569
28.30	7.36[†]	0.619	24.70[a]	38.0[†]	20400	42.3[a†]	36.2[†]	122.0[a†]	18600	0.885
27.70	7.43[†]	0.771	23.60[a]	60.0[a†]	21400	61.0[b†]	35.9[†]	171.0[b†]	13900	0.785
22.54	3.98	0.166	7.88	13.6	14400	17.1	19.9	42.7	5450	0.244
16.50	9.23[†]	0.573	55.00[b†]	**649.0**[c*‡]	30900[a]	63.5[b†]	47.2[†]	111.0[a]	14900	133.0
15.70	7.65[†]	0.179	16.20	14.2	25900[a]	14.2	25.5	64.1	8360	3.400
14.00	10.00[†]	0.385	18.80	27.7[†]	31700[a]	20.8	26.0	68.4	15300	3.100
12.55	9.60[†]	0.361	24.10[a]	26.6[†]	46100[b]	22.6	34.4[†]	99.9[a]	17300	2.740
0.60	11.90[a†]	0.408	25.60[a]	26.2[†]	35500[b]	26.9	37.4[†]	75.9	24500	1.540
0.10	11.20[a†]	0.436	15.60	19.5	25000[a]	20.1	27.7	50.7	12100	1.170
East Branch Portage River										
12.47	5.58	0.370	23.00[a]	18.7	20300	30.6	23.6	79.0	1450	0.589
10.40	5.13	0.419	19.60	**262.0**[c*‡]	10300	90.2[b†]	17.7	112.0[a]	3810	0.218
9.00	9.57[†]	1.350[a†]	**124.00**[c‡]	**578.0**[c*‡]	25400[a]	238.0[c*†]	41.8[†]	732.0[c†]	15300	0.486
Rocky Ford										
10.80	8.75[†]	0.421	25.80[a]	23.7	27500[a]	30.7	33.0[†]	87.9	18300	0.931
9.80	5.15	0.443	18.40	43.5[†]	15500	50.3[a†]	17.7	218.0[b†]	8930	0.362
6.34	7.88[†]	0.426	25.60[a]	24.4	27200[a]	35.4[a†]	30.4	102.0[a]	18000	0.323
Middle Branch										
8.70	12.70[a†]	0.169	11.10	14.4	16700	24.6	19.1	60.4	8060	0.391
6.07	10.40[†]	0.174	11.60	15.5	16300	22.2	19.1	44.0	7410	0.398
Poe Ditch										
3.00	20.70[b†]	1.590[a†]	36.90[a†]	74.6[a†]	24100[a]	175.0[c*†]	33.3[†]	338.0[c†]	15400	0.649
2.40	5.39	0.584	19.70	34.1[†]	22100	62.2[b†]	25.8	183.0[b†]	10100	0.659

[a]Elevated, [b]Highly Elevated, [c]Extreamly Elevated; rankings based on Kelly and Hite (1984).
*Exceeds ER-M value described by Long and Morgan (1990).
[†]Exceeds Lowest Effect Level described in Persaud and Hayton (1994).
[‡]Exceeds Severe Effect Level described in Persaud and Hayton (1994).

Table 10-A. Portage River fish tissue results, 1994. Metals results are presented in mg/kg, organics are presented in µg/kg. Consumption advisory rankings for total PCBs are based on recommendations from the Great Lakes Sport Fish Advisory Task Force (Ohio EPA 1994), and are listed here for comparative purposes only[a]. Sample types and contaminants are indicated by the following abbreviations: WBC = Whole Body Composite, SOFC = Skin-on Fillet Composite, SFFC = Skin-off Fillet Composite, S = total, Cd = cadmium, Hg = mercury, Pb = lead, PCBs = Polychlorinated biphenyls, NA = not analyzed, ND = not detected.

River Mile	Species (Sample)	Size Range (mm)	ΣCd mg/kg	ΣPb mg/kg	ΣHg mg/kg	ΣPCBs µg/kg	ΣDDT µg/kg
16.5	Carp* (WBC)	431-474	0.173	0.482	0.080	840[3]	60.2
16.5	SM Bass (SOFC)	292-304	ND	NA	0.166	340[3]	ND
16.5	SM Bass (SOFC)	198	ND	0.088	0.141	210[2]	ND
16.5	Rock Bass (SOFC)	207-229	ND	0.088	0.160	100[2]	ND
11.0	W. Crappie (SOFC)	255-282	0.010	0.424	0.041	ND	ND
11.0	LM Bass (SOFC)	318-342	ND	0.132	0.065	150[2]	17.0
11.0	Channel Catfish (SFFC)	410	ND	ND	0.158	470[3]	49.0
6.0	LM Bass (SOFC)	342	ND	0.072	0.051	ND	ND
6.0	W. Crappie (SOFC)	210-234	ND	0.116	0.029	ND	ND
6.0	Carp (WBC)	471-515	ND	0.100	0.076	490[3]	12.0
3.0	W.Crappie (SOFC)	305	ND	ND	0.051	ND	10.0
3.0	Channel Catfish (SFFC)	371	0.011	0.402	0.075	750[3]	106.0
3.0	LM Bass (SOFC)	345-378	ND	ND	0.055	ND	17.0
3.0	LM Bass (SOFC)	414-442	ND	0.119	0.134	170[2]	41.0
0.6	Rock Bass (SOFC)	217-220	ND	0.118	0.088	ND	10.0
0.6	W. Crappie (SOFC)	235-256	0.009	0.284	0.033	ND	16.0
0.6	Brown Bullhead (SFFC)	263-266	ND	ND	0.067	63[2]	ND
0.6	LM Bass (SOFC)	378-403	ND	0.103	0.088	89[2]	17.0
0.0	FW Drum (SOFC)	411-413	0.012	0.078	0.154	64[2]	ND
0.0	SM Bass (SOFC)	326	ND	0.016	0.043	87[2]	20.0
0.0	LM Bass (SOFC)	369	ND	0.106	0.113	93[2]	14.0

Advisory Group	PCB Concentration Range in Fish Tissue	Consumption Advisory
0	0 - 50 µg/kg	Unrestricted Consumption
1	51 - 300 µg/kg	1 meal per week, 52 meals per year
2	301 - 1000 µg/kg	1 meal per month, 12 meals per year
3	1001 - 1900 µg/kg	6 meals per year
4	> 1900 µg/kg	*Do not consume!*

a Actual consumption advisories for Ohio sport fishes are issued by the Ohio Department of Health.

* Chlordane, aldrin and dieldrin were also detected in the carp sample at RM 16.5.

Physical Habitat for Aquatic Life

Portage River

The quality of the physical habitat at the 19 fish sampling stations in the Portage River mainstem were evaluated using the Qualitative Habitat Evaluation Index (QHEI; Table 11). The mean score for the free-flowing mainstem (excluding the estuarine segment) was 63.1. A mean QHEI score greater than 60.0 generally indicates that near and instream physical habitats are of sufficient quality to support an instream fauna consistent with the WWH use designation. However, in the Huron/Erie Lake Plain (HELP) ecoregion QHEIs less than this value may be expected to support the WWH use designation given the lower biological performance expectations in the HELP. The physical habitat of the mainstem was characterized by an inherently low gradient and extensive areas of bedrock substrate. Additionally, the ability of the habitat to support aquatic life was consistently limited by several factors associated with nonpoint source pollution, intensive agricultural land use practices, and extensive channelization of the tributaries in the upper watershed. Silt cover was moderate, substrates in pools and riffles were moderately embedded by silt and sand, and riparian widths were narrow at most of the mainstem sites sampled. Site specific habitat impairment was evident in one reach. The riffle-pool-run development was altered at two sites (RMs 22.2 and 22.0) by an accumulation of silt and sand due to partial impoundment by a low head dam at RM 20.1. The respective QHEI scores (43.5 and 58.5) were the lowest and third lowest recorded for the portion of the mainstem not influenced by the level of Lake Erie.

The mean QHEI score in the lake influenced portion was 54.9, and there was little variation between sites. The QHEI scores indicate the habitat is suitable to support assemblages of aquatic life consistent with the interim Lake Erie estuarine criteria. Instream cover, being extensive to moderate at all locations, was the single most influential positive habitat attribute in the estuarine segment. Silt and muck substrates negatively influenced the habitat potential at RMs 12.3 and 5.9.

East Branch Portage River Portage River

Physical habitats in the East Branch Portage River were limited by historical habitat modifications, and by both point source and nonpoint source pollution. All of the sampling locations showed evidence of past channelization and substrates were heavily embedded by either silt and sand or sewage sludge. Consequently, sinuosity was low, channel development was poor, and cover was sparse at most locations. The mean QHEI score for all locations sampled was 46.9. QHEI scores less than 45.0 are generally indicative of habitats that are not capable of supporting aquatic assemblages consistent with the WWH use designation, implying the biological potential of the East Branch Portage River is limited by subpar habitat quality. However, sewage sludge deposits contributed significantly to the habitat impairment (even though it was not factored into the QHEI scores), and if abated, the instream habitat would improve. Natural recovery processes, if permitted to work, should result in habitat redevelopment which would be capable of supporting the relaxed biological criteria for the Huron/Erie Lake Plain ecoregion, even with QHEI scores less than 60.

Rocky Ford

The physical habitats at four locations were evaluated in Rocky Ford (Table 11). Overall habitat quality was poor, as reflected by a mean QHEI score of 43.1, which would be expected to limit the performance of the biological community. Recent channelization, a non-existent or narrow riparian buffer strip, and intensive agricultural land use practices have resulted in degraded instream habitat. The characteristics of modified habitats evident at most locations were siltation and substrate embeddedness, little or no sinuosity, poor channel development, and sparse instream cover. Only the most upstream location (RM 15.2) no longer exhibited evidence of previous channelization and

Table 11. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the Portage River study area, July-September 1994.

Table 11. Continued.

exhibited positive habitat attributes. However, extensive portions of the stream bed at this site were dry due to a lack flow releases from Van Buren Reservoir.

North Branch Portage River and Sugar Creek
A channelized and an unchannelized segment in the North Branch were evaluated for physical habitat quality. The physical habitat at the channelized site, RM 6.6, was severely degraded as indicated by a QHEI of 29.0. The QHEI at the unchannelized location, RM 1.3, scored 59.5, reflecting good habitat for the HELP ecoregion. The high proportion of modified habitat attributes (*i.e.*, siltation and substrate embeddedness) at the unchannelized downstream site reflects the increased bedload and other variations from the extensively channelized upper watershed.

Channelized and unchannelized sites in Sugar Creek were also evaluated. Sugar Creek was analogous to the North Branch in that the habitat quality of the unchannelized downstream site was similarly limited by channelization and land use practices in the upper watershed.

Other tributaries
QHEI values for eight locations in various Portage River basin tributaries averaged 32.9, demonstrating the overall degradation of habitat within the watershed (Table 11). All eight locations were either recently or previously channelized and as a result carry heavy bed loads of silt and sand for eventual export to the Portage River mainstem.

Biological Assessment: Macroinvertebrate Community

Portage River Mainstem
Quantitative and qualitative data were collected from 13 Portage River mainstem stations between RMs 35.8 and 16.5 (Table 12). The quantitative artificial substrate samplers were set on July 25-26. Current velocity ranged from 0.5-1.2 $ft \cdot sec^{-1}$ in the free flowing portion of the river upstream from Brush Wellman. At Brush Wellman, current velocity declined to 0.3-0.4 $ft \cdot sec^{-1}$. Samplers were collected on September 7-8 when current velocities ranged from <0.05-0.60 $ft \cdot sec^{-1}$. Community performance was consistent with the WWH or EWH ICI criteria except for the site downstream from Woodville (RM 24.0), where the ICI (28) scored in the fair range of performance (Table 12, Figure 30).

The ICI upstream from Pemberville (RM 35.8) reflected exceptional community performance (48). Moderate to extensive riffle development allowed for a high diversity and percentage of mayflies in the quantitative totals (*i.e.*, 58% of the organisms collected). Caddisflies were the predominant organisms in the riffle-run areas, but were not present on the artificial substrates due to slow current. Also, a diverse dipteran community with numerous sensitive species was also present in the sample.

Downstream from the Pemberville CSOs (RM 34.9), an increased abundance of oligochaetes and midges indicated a response to organic enrichment. Though mayflies were common, the macroinvertebrate community was less diverse as some sensitive species (*e.g.*, *Chimarra*, *Leucrocuta*, *Isonychia*, *Corynoneura lobata* and *Hexagenia*) decreased or were absent**.** Qualitative sampling indicated elmid beetles and midges became predominant in the riffle-run habitat. The percentage of tolerant organisms collected from the artificial substrates increased to approximately 12% from 1% upstream. Four pollution tolerant midge species were present or were more abundant on the substrates (*e.g.*, *Polypedilum (P.) fallax* , *P. (P.) illinoense*, *Chironomus (C.) decorus* group, and *Dicrotendipes sp.*), suggesting a slight toxic or nutrient impact (Simpson and Bode

1977); however, the ICI score (36) indicated community performance consistent with the WWH criterion for the HELP ecoregion.

Several of the sensitive species lost below the CSOs were collected downstream from the Pemberville WWTP at RM 34.6, and three of the tolerant midges collected upstream were not collected at this site. However, the tolerant midge taxon *Chironomus (C.) decorus* was present and is an indicator of sewage pollution (Simpson and Bode 1977). The ICI score of 38 reflected good community performance and little or no localized impact attributable to the Pemberville WWTP.

An ICI of 40 (good) upstream from Woodville at RM 29.3 indicated good community performance. The deposition of silt on the artificial substrates indicates that this reach is impacted by nonpoint source pollution. Correspondingly, a macroinvertebrate community response to nutrient enrichment was evident, with riffle beetles, baetid mayflies, and hydropsychid caddisflies predominant in the well-defined riffle and run habitats. The percentage of tolerant organisms, however, decreased to less than 1% compared to 12% downstream from the Pemberville CSOs. Slow flow likely precluded the presence of *Isonychia* and *Chimarra* in the riffles.

ICI scores at RMs 27.3 and 27.1 (upstream and downstream from the Woodville WWTP) were in the exceptional range of community performance (50 and 46, respectively). Communities at both sites had high proportions of mayflies and caddisflies in the quantitative totals, although caddisfly numbers declined downstream from the WWTP. Similarly, two sensitive mayfly genera, *Acerpenna* and *Isonychia*, collected from artificial substrates at RM 27.3, were not collected downstream from the WWTP, whereas flatworms were more abundant. The unionized ammonia concentration, as calculated from total ammonia concentrations in the Woodville WWTP effluent was 0.3-0.4 $mg \cdot l^{-1}$, which is in the potentially toxic range of 0.2-2.0 $mg \cdot l^{-1}$ (U.S. EPA 1976). This may have affected the composition of the downstream community as reflected in the lower ICI score.

The effects of organic enrichment from the Woodville WWTP, combined with the high nutrient loads from sources upstream, were evident in the performance of the macroinvertebrate community upstream from Elmore at RM 24.0 where the ICI (28) failed to meet WWH criterion. Density increased on the artificial substrates to $4562 \cdot ft^{-2}$ (Figure 31), and total taxa declined from 42 to 23. Mayfly diversity in the quantitative sample declined from seven to two taxa. Combined percent mayflies and caddisflies in quantitative totals decreased from approximately 70 and 58% upstream at RMs 27.3 and 27.1, respectively, to less than 10% at RM 24.0. Flatworms, Elmid beetles, scuds and midges (*Rheotanytarsus*) predominated the riffle-run habitat. Large numbers of parasites infested the mayflies, caddisflies, and flatworms that were collected. The abundance of attached algae noted at the site reflected the high degree of nutrient enrichment and likely contributed to increased diel fluctuations in D.O. which could adversely impact macroinvertebrate community performance.

Downstream from St. Rt. 51 in Elmore (RM 22.7), an abundance of the aquatic macrophyte *Myriophyllum sp.* and filamentous algae indicated enriched conditions. Macroinvertebrate density decreased to approximately $800 \cdot ft^{-2}$, and flatworms predominated in the riffles, runs, and pools and comprised approximately 25% of organisms on the artificial substrates. Numbers of qualitative EPT taxa increased to 14, but the total percentage of mayflies and caddisflies declined because of the large increase of flatworms, oligochaetes, and bryozoans (*Lophopodella carteri*). The ICI score of 32 marginally met the WWH criterion.

Table 12. Summary of macroinvertebrate results based on data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Portage River study area, July-October 1994.

			Quantitative Evaluation			
Stream River Mile	Organism Density$\cdot$ft^{-2}	Quant. Taxa	Qual. Taxa	Qual. EPT[a]	ICI	Narrative Evaluation
Portage River						
35.8	537	46	55	20	48	Exceptional
34.9	890	46	57	22	36	Good
34.6	839	37	48	13	38	Good
29.3	803	37	56	15	40	Good
27.3	1301	39	57	20	50	Exceptional
27.1	777	42	48	15	46	Exceptional
24.0	4562	23	42	10	28*	Fair
22.7	805	38	48	14	32[ns]	Marginally Good
22.0	1231	38	49	21	50	Exceptional
17.7	928	36	47	20	48	Exceptional
17.0	1254	52	42	23	52	Exceptional
16.5-south	494	38	37	12	34	Good
16.5-north	498	41	29	10	30[ns]	Marginally Good
East Branch Portage River						
17.8	159	25	28	4	12*	Poor
12.5	1029	45	46	6	34	Good
10.2	7137	10	10		0*	Very Poor
9.0	925	8	14	0	2*	Poor
6.2	542	19	20	1	2*	Poor
0.7	264	25	29	6	32[ns]	Marginally Good
North Branch Portage River						
5.0	240	29	45	11	44	Very Good
Rocky Ford						
9.8	366	18	18	0	4*	Poor
9.5	238	32	25	2	14*	Fair
7.5	534	44	40	8	42	Very Good
5.1	429	30	25	4	16*	Fair

Table 12. Continued.

Stream River Mile	No. Qual. Taxa	QCTV[b]	Qual. EPT[a]	Relative Density	Predominant Organisms	Narrative Evaluation[c]
			Qualitative Evaluation			
Rocky Ford						
15.1	21	31.3	2	Low	Mayflies, isopods, worms, snails	Fair
10.2	17	30.3	2	Low	Mayflies,flatworms, limpet snails	Fair
2.9	43	34.2	5	Moderate	Caddisflies, mayflies, riffle beetles	Marginally Good
East Branch Portage River						
10.4	23	19.3	0	Low	Midges, pond snails, isopods, leeches	Poor
North Branch						
17.9	24	22.8	0	Mod.-Low	scuds, water boatmen	Poor
0.7	38	35.5	8	Moderate	riffle beetles	Marginally Good
Sugar Creek						
13.4	43	38.9	9	Mod.-High	Riffle beetles, mayflies	Very Good
8.8	51	35.6	8	Mod.-High	Caddisflies,fingernail clams, red midges	Good
South Branch						
8.4	16	38.2	3	Mod.-High	Mayflies, red midges	Marginally Good
Middle Branch						
8.9	38	36.3	8	Moderate	Caddisflies, mayflies, riffle beetles, flatworms	Good
Bull Creek						
0.6	35	33.0	6	Mod.-Low	Mayflies, scuds, riffle beetles, red midges	Marginally Good
Needles Creek						
1.3	35	34.2	6	Low	mayflies, clams, non-red midges	Marginally Good

See footnotes on the next page.

Table 12. Continued.

[a] EPT - total Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa richness.
[b] Qualitative Community Tolerance Value (QCTV) derived as the median of the tolerance values calculated for each qualitative taxon present; see discussion in text.
[c] The qualitative narrative evaluation is based on best professional judgement utilizing sample attributes such as taxa richness, EPT richness and QCTV score, and is used when quantitative data is not available to calculate an Invertebrate Community Index (ICI) score.
[d] Modified Warmwater Habitat for channel modified areas.
[ns] Non-significant departure from ecoregional biocriteria (≤ 4 ICI units).
* Significant departure from ecoregional biocriteria; poor and very poor results are underlined.

Ecoregion Biocriteria: Huron-Erie Lake Plain (HELP)

Index	WWH	EWH	MWH[d]
ICI	34	46	22

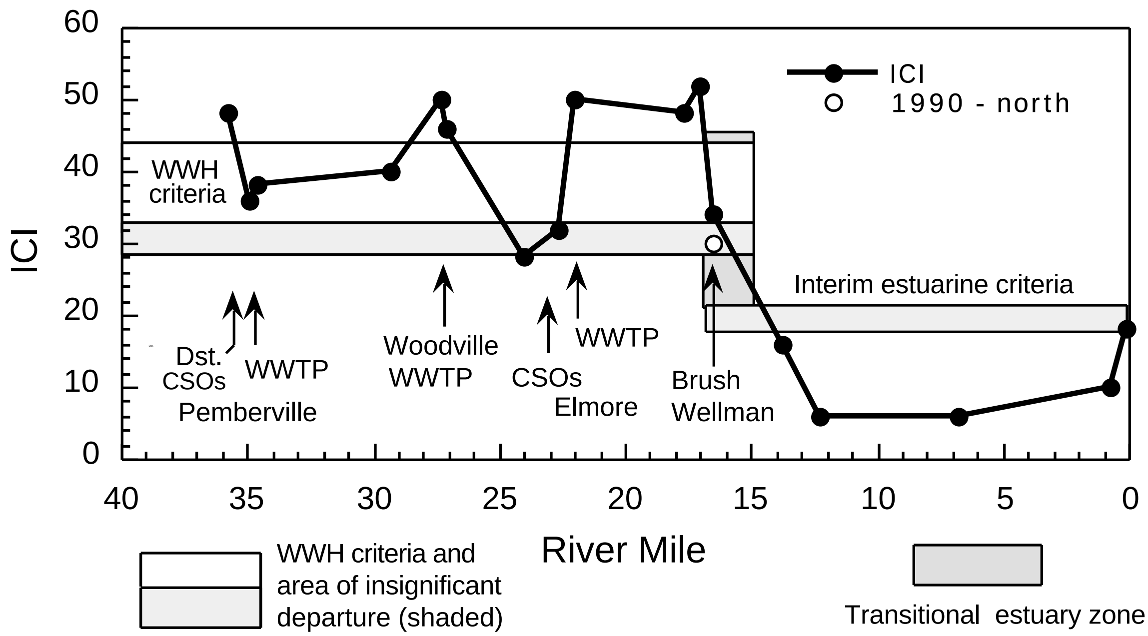


Figure 30. Longitudinal trend of the Invertebrate Community Index (ICI) in relationto major point source disc iver, 1994.

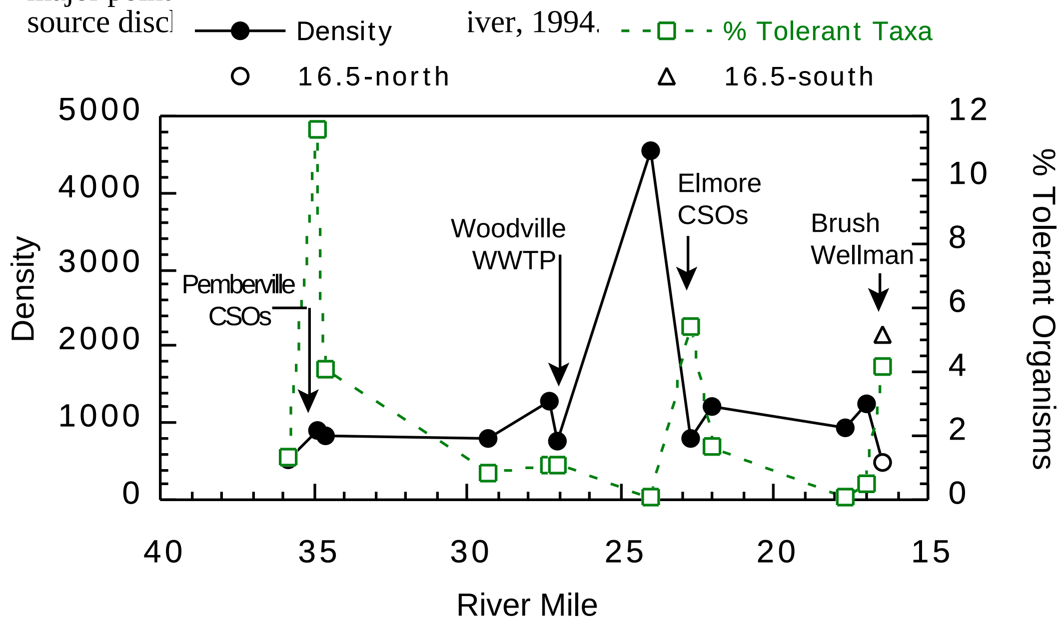


Figure 31. Influence of point source discharges on relative abundance (density) of macroinvertebrates and percentage of tolerant organisms collected from artificial substrates.

The ICI (50) at the site downstream from the Elmore WWTP (RM 22.0) scored in the exceptional range. The riffle-run habitat at this location was well developed. There were 19 EPT taxa collected from natural substrates and 16 EPT taxa collected from the artificial substrates. Mayflies and caddisflies comprised 50% of the total number of organisms collected. Six different species of bivalve mollusks, including the deertoe (*Truncilla truncata*), mapleleaf (*Quadrula quadrula*) and plain pocketbook (*Lampsilis ventricosa*) mussels , were collected at this site. A small percentage of caddisflies had burned gills, possibly the result of exposure to toxic chemicals.

Exceptional macroinvertebrate communities were present both upstream (RM 17.7) and downstream (RM 17.0) from Sugar Creek (ICI= 50 and 52, respectively). Mayfly and caddisfly taxa comprised 87% and 77% of the total organisms at each respective site, and pollution tolerant organisms made up only 0.1% of the quantitative sample. The genera *Chimarra*, *Anthopotamus*, *Leucrocuta*, and *Isonychia* , all pollution sensitive taxa, were collected at RM 17.0.

Quantitative samples collected on the north and south banks of the mainstem at RM 16.5 evaluated the Brush Wellman discharge. These sites were in the portion of the river influenced by Lake Erie where current slows and increased deposition of sediment occurs. The closest riffle was less than 0.4 miles upstream. The south site, located downstream from the Brush Wellman discharge, met the WWH criterion with an ICI score of 34 (good). The two caddisfly species collected on the artificial substrates, *Polycentropus* sp. and *Cyrnellus fraternus*, frequently inhabit low-flow habitats (Wiggins 1977), and the bryozoan population increased markedly in the more lentic, estuarine environment. Pollution tolerant flatworms and oligochaetes also increased in abundance, implying that not all community changes were solely habitat related. The north site had a similar community (ICI = 30) with a slightly higher density and higher percentage of pollution sensitive mayflies and caddisflies (31% of the organisms collected). However, midges associated with lotic environments (those in the tribe *Tanytarsini*) decreased in abundance, while those midges associated with lentic environments, *i.e.*, *Dicrotendipes lucifer*, increased, thus reflecting habitat differences between the north and south bank.

East Branch Portage River

The East Branch Portage River Portage River was quantitatively sampled at six locations. The artificial substrates were lost at the site upstream from the Fostoria WWTP (RM 10.2), thus the evaluation was based on the qualitative sample. The artificial substrates were set July 25 and the current velocities ranged from 0.2 ft·sec^{-1} (upstream) to 1.0 ft·sec^{-1}. Artificial substrates were retrieved and qualitative sampling was completed on September 7 and 8. Current velocities during retrieval ranged from 0.0 ft·sec^{-1} at the upstream site to 0.2-0.8 ft·sec^{-1} at sites in and downstream from Fostoria.

At the upstream site (RM 17.8), the community composition reflected nutrient enrichment and intermittent flows, and did not meet the WWH criterion (ICI = 12; Figure 32). Taxa collected included oligochaetes, two leech taxa, planorbid and pouch snails (*Planorbella* and *Physella),* and the four midge taxa *Dicrotendipes simpsoni* , *Chironomus (C.) decorus* group, *Polypedilum (P.) illinoense* , and *Glyptotendipes (Phytotendipes) ;* the community was evaluated as poor.

Upstream from Fostoria at Tiffin Road (RM 12.5) there was adequate flow when the artificial substrates were collected (0.2 fps). Abundant algae in the riffle and on the artificial substrates was evidence of serious nutrient enrichment, and was reflected by the macroinvertebrate community performance. However, the six EPT taxa collected enabled the community to meet the WWH criterion (ICI = 34). Degraded water quality was indicated in the East Branch Portage River from Fostoria downstream to RM 6.2. No EPT taxa were collected at RM 10.4 below the Fostoria CSO discharges, and midges, leeches, and pouch snails predominated. The narrative community assessment upstream from the WWTP based on the qualitative sample was poor.

The Fostoria WWTP mixing zone ICI was 0 (very poor). Sewage fungus (*Sphaerotillus)* was present in the mixing zone and on the artificial substrates. The East Branch downstream from the WWTP was effluent dominated and the macroinvertebrate community was composed of pollution tolerant oligochaetes, pouch snails, and the tolerant midge *Polypedilum (P.) illinoense*. At RM 9.0, the stream community was still impacted by the Fostoria WWTP and CSOs. A septic odor was present, and oil in the blackish-gray sediments was observed. *Polypedilum (P.) illinoense*, *Physella*, and oligochaetes were the predominant taxa. This along with the extremely low diversity (14 qualitative taxa) and an ICI of 2 (poor) indicated a toxic response.

The Eagleville Road site (RM 6.2) had good riffle development, instream habitat, and a mostly closed canopy. Despite the good habitat, the macroinvertebrate community continued to be degraded (ICI = 2) and predominated by *Polypedilum (P.) illinoense*, planorbid snails, limpets (*Ferrissia*), oligochaetes, and pouch snails. At RM 0.7, the ICI increased to 32 (marginally good), despite marginal habitat. The qualitative EPT increased to six taxa (hydropsychid caddisflies predominating), and species indicating improved water quality appeared (*e.g.*, *Corynoneura lobata*, *Polypedilum (P.) convictum*, and the mayfly *Hexagenia*).

Rocky Ford

Rocky Ford was sampled at eight locations, four quantitatively and four qualitatively. Excluding the artificial substrates at RM 9.8, which had negligible current at both set and retrieval (0.01 $ft \cdot sec^{-1}$), the current ranged from 0.3-0.5 $ft \cdot sec^{-1}$ on July 26 when the substrates were set. The current ranged from 0.4-1.0 $ft \cdot sec^{-1}$ on September 8 when the artificial substrates were retrieved and qualitative samples collected. Two qualitative samples were also collected on September 16, one downstream from Van Buren Reservoir (RM 15.1) and one upstream from Bays Road (RM 2.9).

Rocky Ford had long stretches of dry stream bottom downstream from Van Buren Reservoir (RM 15.1) the result of no water being released. Consequently the macroinvertebrate community was fair, reflecting the poor habitat conditions. Because of the loss of the artificial substrates at RM 10.2 (Water Street), only qualitative samples were collected. Organisms abundant in the pool margin were mayflies, flatworms, and limpet snails. Isopods and crayfish were also common. The QCTV was 30.3, and the narrative assessment was fair. At Water Street, the sediments in the vicinity of unsewered discharges and a CSO were black or blackish-gray with a septic odor.

The macroinvertebrate community downstream from the North Baltimore CSOs (RM 9.8) was severely degraded (ICI = 4; Figure 33). The water was gray with a septic odor and the sediments were black and oily. Red midges were present in the pools (low densities), and tolerant pouch snails *(Physella)* predominated in the margins. Several tolerant midges were also present including the taxa *Chironomus (C.) decorus* group, *Dicrotendipes simpsoni*, and *Cricotopus (Isocladius).*

The habitat improved downstream from Eagleville Rd. due to the largely intact riparian corridor upstream and downstream from the WWTP (RM 9.5). There was good flow, and the water was clear. Downstream from the WWTP, no oily sediments or septic odors were observed and a mixed community of midges predominated in the riffle-run habitats. Species indicative of good water

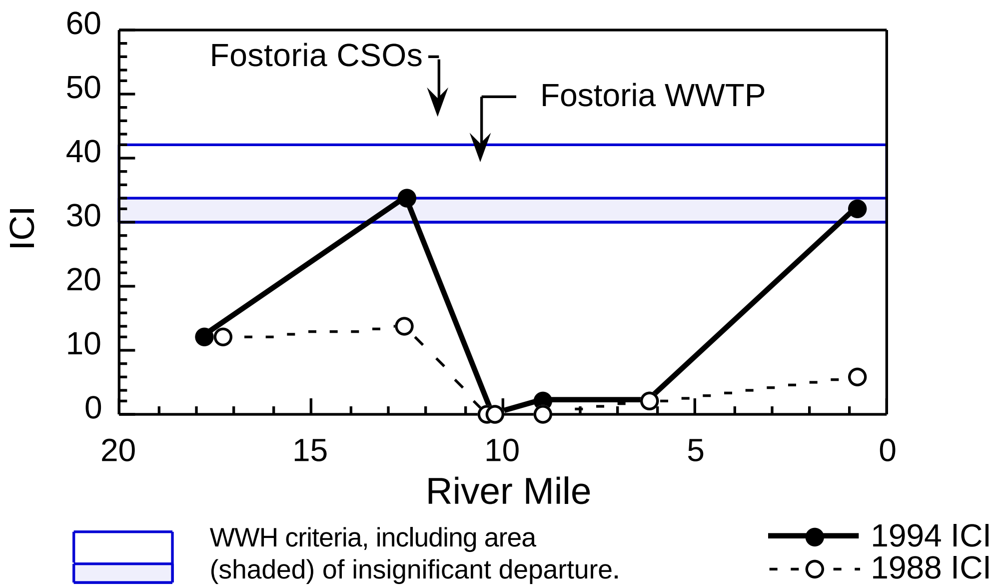


Figure 32. Longitudinal trend in ICI scores for the East Branch Portage River Portage River, 1994 and 1988.

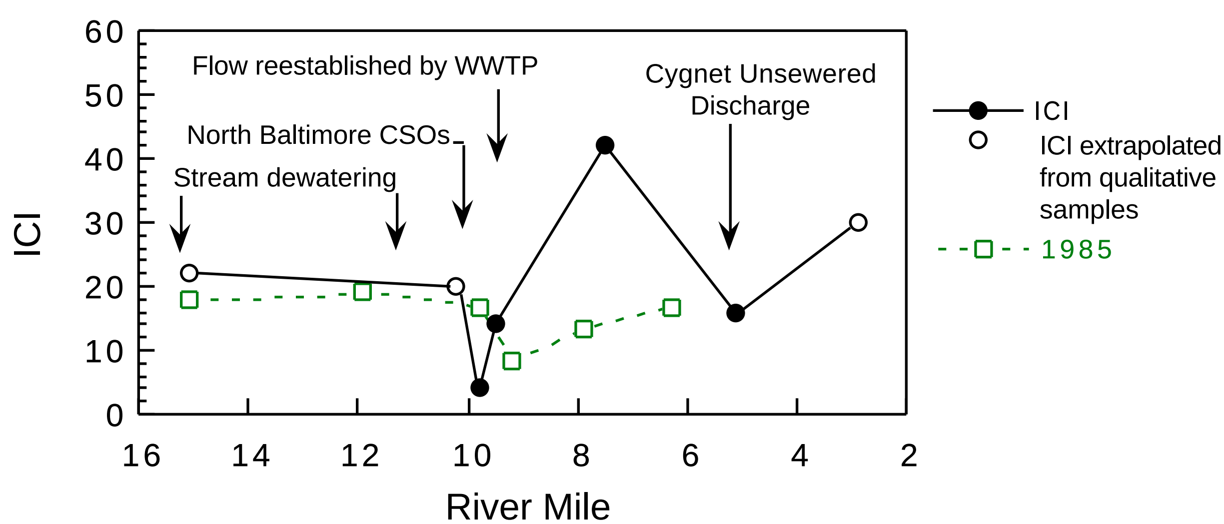


Figure 33. Longitudinal trends in ICI scores in relation to potential pollution impacts for Rocky Ford Creek, 1985 and 1994.

quality appeared (*e.g.*, *Corynoneura lobata*, *Polypedilum (P.) convictum*, and *Tanytarsus glabrescens* group), although the community did not meet the WWH criterion (ICI = 14) and was rated as fair.

At Tank Farm Road (RM 7.5), Rocky Ford met the WWH ICI criterion and scoring a 42 (very good). There were 12 EPT taxa with a relatively large number of hydropsychid caddisflies. Mayflies (*Isonychia* and *Leucrocuta*) were collected along with sensitive midges (*e.g.*, *Corynoneura lobata* and *Polypedilum (P.) convictum)*. However, large numbers of flatworms and isopods were present, possibly the result of unsewered discharges. An 18 to 24-inch pipe with an intermittent gray discharge was discoloring the stream at the sampling site.

The sample at RM 5.1 was collected downstream from an unsewered discharge at Cygnet Rd. The macroinvertebrate community was degraded as evidenced by an ICI of 16 (fair) which did not meet WWH criterion. Sewage fungus *(Sphaerotilus)* was present on the artificial substrates and on the undersides of rocks, dark oily sediments were present in the margins, and a septic odor was present. The highly tolerant midge taxon, *Polypedilum (P.) illinoense*, comprised nearly 27% of the organisms collected.

At Bays Road (RM 2.9) Rocky Ford was channelized and consisted of a deep, wide, and silty ditch with no sinuosity. There was a fairly diverse macroinvertebrate community with moderate numbers of hydropsychid caddisflies, mayflies, and riffle beetles predominating in the riffle-run habitat. Three bivalve mollusks were present: the white heelsplitter, giant floater, and the lilliput mollusc. Despite the habitat limitations the macroinvertebrate community marginally met the WWH criterion.

North Branch Portage River

A quantitative macroinvertebrate sample was collected at RM 5.0, and qualitative samples were collected at RMs 17.9 and RM 0.7. The qualitative sample at RM 17.9 was rated as poor. No EPT taxa were collected and the sample was predominated by scuds and water boatmen (Corixidae). The North Branch Portage River at this location was essentially a channelized ditch with uniformly sloped banks, no riffles, and silt laden substrates.

At RM 5.0 the habitat was limited and runs were formed by woody debris. Substrates were mostly sand, silt, muck, and detritus. Despite the limited habitat, a diverse macroinvertebrate community was collected including 11 taxa of mayflies and caddisflies, and the giant floater bivalve *Anodonta grandis.* Overall community performance was very good (ICI=44). At RM 0.7 the habitat consisted mostly of coarse gravel with boulder and cobble substrates in the riffles and good riparian cover. Despite the good habitat, the community only marginally met the WWH criterion, possibly due to organic enrichment. Riffle beetles predominated in the riffles with heptageniid and caenid mayflies plentiful on the cobbles and in the shallows.

Sugar Creek

Sugar Creek was qualitatively sampled at RMs 13.4 and 8.8. Although the site at RM 13.4 had been channelized there was fairly good riffle development. An abundance of aquatic macrophytes (*i.e.*, *Potamogeton pectinatus* and *P. crispus*) appeared to assimilate the nutrient load and minimize the effects of silt on the macroinvertebrates. There were three different bivalve mollusk species present and nine EPT taxa. The QCTV score was 38.9 which exceeds the 75^{th} percentile for HELP ecoregion reference sites. Macroinvertebrate community performance was very good.

The effects of nonpoint source pollution on the macroinvertebrate community were evident at RM 8.8. Despite improved habitat, community changes in response to increased nutrient enrichment were evident. High densities of caddisflies and fingernail clams were present in the riffle and red midges and fingernail clams predominated in the runs. Also, several tolerant taxa (*e.g.*, leeches, *Ferrissia, Chironomus (C.) riparius* group, and *Polypedilum (P.) illinoense)* were present. The QCTV decreased to 35.6, and the community was rated as good.

South Branch Portage River

The South Branch Portage River was sampled at RM 8.4 (Portage View Rd.). Stream flow intermittent and the artificial substrates were lost. Consequently only a qualitative sample was collected. The narrative assessment was marginally good. Thirty-eight taxa were collected including a fairly low diversity of mayflies and caddisflies (EPT = 3). Three taxa usually associated with good water quality, the midge genus *Cladotanytarsus*, the bryozoan genus Plumatella, and a sponge were collected, indicating low stream flow, as opposed to degraded water quality, probably contributed to the marginal performance of the community.

Middle Branch Portage River

The Middle Branch Portage River was sampled upstream from Solether Road at RM 8.9. The site was channelized with steep (15-20 ft.) grass banks. Despite the limited habitat quality, a diverse community was sampled, including hydropsychid caddisflies, mayflies, riffle beetles, midges, and flatworms. The genus *Isonychia*, a pollution sensitive mayfly, was common in the riffles. The community structure indicates some nutrient enrichment given the relatively high abundance of midges and flatworms. Based on the overall community composition, the presence of 8 mayfly and caddisfly taxa, and a QCTV of 36.3, the community was narratively assessed as good.

Bull Creek

Bull Creek was sampled at RM 0.6. Thirty-five taxa including 6 EPT taxa were collected. *Acerpenna pygmaeus* and *Hexagenia limbata* were among the mayflies collected. The community response indicated nutrient enrichment, as the QCTV was 32 and the narrative assessment was marginally good.

Needles Creek

Needles Creek was sampled at RM 1.3 (Cygnet Road). The sampling site was a channelized, grass banked ditch. Despite the poor habitat this site had a diverse community (35 taxa) with mayflies and fingernail clams abundant in all of the habitats sampled. Six EPT taxa were collected. The QCTV was 34.2 and the narrative assessment was marginally good.

Biological Assessment: Fish Community

Portage River Mainstem

Twenty locations were electrofished over a cumulative distance of 14.8 km in the Portage River mainstem from river mile (RM) 35.8 to 0.2 (Table 13; Figure 34). During the July 6 - September 22 sampling period 29,829 fish comprised of 53 species and 8 hybrids were collected. Species predominating in percent composition by numbers were central stoneroller (32.2%), bluntnose minnow (10.5%), spotfin shiner (7.6%) and greenside darter (6.1%). Excluding the estuarine segment, fish species predominating in percent composition by weight were common carp (23.2%), smallmouth bass (16.4%), golden redhorse (9.6%), and central stoneroller (7.8%).

The abundance of common carp, stonerollers, and bluntnose minnows is indicative of organic enrichment. Also, several metrics of the IBI (*i.e.*, the percent of individuals as simple lithophils, and the number of sucker, darter and intolerant species) were consistently low. Habitat limitations also played a part in the poor performance of these metrics. Because the Portage River has extensive areas of bedrock and a very low gradient, riffles are poorly developed. Consequently, habitat for darters, suckers, and simple lithophils is limited. However, the consistently poor performance of these three metrics at *all* locations suggests overall water quality is degraded. The high relative abundance of smallmouth bass, golden redhorse, and greenside darters, species moderately intolerant of pollution, indicates that the nature of degraded water quality is linked to nonpoint sources of pollution and organic enrichment (*e.g.*, siltation, intensive agriculture throughout the watershed, and poorly treated sewage). This is reflected in the overall performance of the fish community meeting the WWH criteria, as indicated by IBI and MIwb scores (Table 13, Figure 34), and a lack of discernable impairment downstream from point source discharges. Fish kills due to low oxygen were reported from several locations in the basin (Table ?) during the dry weather period of May-June 1994, further indicating high BOD associated with organic enrichment from point and nonpoint sources.

The locations bracketing the Elmore WWTP at RM 22.2 and 22.1 showed a nonsignificant departure from the WWH criteria for one or both indices (Figure 34). Bluntnose minnows and green sunfish, species tolerant of enrichment and low dissolved oxygen, predominated at both locations. The Elmore CSOs did not appear to impact this reach given that levels of ammonia-N, BOD, sediment metals, and fecal coliform bacteria were not elevated compared to unimpacted areas. The nutrient enrichment in this reach, and subsequent marginal performance of the fish and macroinvertebrate communities, was associated with the Woodville WWTP. Phosphorus and ammonia-N levels were 1-2 orders of magnitude higher in samples collected from the Woodville WWTP mixing zone (Figures 21 and 22) than other mainstem sites. The fish community in this reach was limited, in part, by poor habitat. The reach is visibly influenced by a low head dam at RM 20.8. Natural substrates such as bedrock and cobble, though present, were embedded by sand or silt, and the channel was poorly developed. The QHEI scores of 43.5 at RM 22.2 and 58.5 at RM 22.0 were, respectively, the lowest and third lowest recorded for the non-estuarine portion of the Portage River. The impoundment appeared to localize and exacerbate the effect of organic enrichment through stagnation as Eurasian water millfoil was abundant in the reach. Also, these likely reduced D.O. levels at night given the relatively high levels of algal biomass and wide variations in D.O. found in the Portage River mainstem (Figure 23).

Discharges from Brush Wellman appeared to have minimal impact on the fish community of the Portage River mainstem. The IBI score in the mixing zone showed nonsignificant departure from WWH, and MIwb scores in the mixing zone and downstream sample showed significant and nonsignificant departure from the WWH criteria, respectively (Figure 34). However, this reach is in the transitional zone between the lake influenced and free flowing portions of the mainstem. Consequently, components of the IBI metrics were influenced by changes in the species composition associated with the estuarine conditions, specifically the decline in the number of sucker species and increases in the percent omnivores (*i.e.*, gizzard shad) as opposed to changes caused by increases in tolerant species. The effect of the proximity to the estuary is revealed by fluctuations in the IBI scores. Gizzard shad composed a large percentage of the fish fauna at RM 16.3 (dst. Brush Wellman) and RM 17.4 (dst. Sugar Creek) with both locations being deeper and more lentic than adjacent sites. Furthermore, the incidence of DELT anomalies remained constant between the upstream (1.03%), mixing zone (0.93%) and downstream (0.8%) samples.

Table 13. Fish community indices from samples collected in the Portage River study area 1994, 1985 and 1983. MIwb and IBI scores are compared to Ecoregional Biocriteria for the HELP[1].

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3 km)	Mean Rel. wt. (wt. /0.3 km)	QHEI	Mean MIwb	Mean IBI	Narrative Evaluation[a]
Portage River (1994)	*Huron-Erie Lake Plain - WWH Use Designation (Existing)*							
35.8	18.0	18	8,818	26.6	55.0	8.7	32	Good/Fair
35.6	22.0	22	1,389	8.5	61.5	8.4	34	Good/M.Good
35.0	23.0	23	3,606	31.5	65.0	9.1	38	V.Good/Good
34.8	17.0	20	1,775	6.4	59.0	7.6	33	M.Good
34.6	20.0	20	2,286	7.7	63.0	8.5	36	Good/M.Good
29.5	22.0	25	1,759	16.2	63.5	9.0	34	V.Good/M.Good
27.7	18.0	22	2,058	26.1	65.5	8.2	34	Good/M.Good
24.2	16.5	18	1,002	38.6	81.0	7.9	38	Good
22.2	14.0	18	475	7.2	43.5	6.8[ns]	29[ns]	Fair
22.1	15.0	19	579	9.6	57.5	7.1[ns]	28[ns]	Fair
17.6	21.0	25	994	8.3	59.5	8.7	37	Good/M.Good
17.4	16.5	23	535	7.0	58.5	7.1[ns]	31[ns]	Fair
16.8	19.0	24	591	60.7	67.0	9.0	39	V.Good/Good
16.5[mz]	10.0	16	629	57.1		7.9	31[ns]	Good/Fair
16.3	17.0	23	437	46.6	68.0	8.3	33	Good/Fair
Portage River Estuarine Zone[b]								
13.3	24.0	30	1,092	216.5	64.5	9.8	37	Excp./Good
12.3	27.3	32	1,027	403.5	51.5	9.8	37	Excp./Good
5.9	19.3	26	475	217.6	49.0	6.4*	23*	Fair
0.6	16.7	30	534	135.4	52.5	8.4	31[ns]	Good/M.Good
0.2	20.7	29	285	117.3	57.0	8.4	33	Good
Little Portage River (1994)[b]								
0.6	4.0	4	738	1.4		4.1*	18*	Poor
Portage River (1985)								
17.6	24.3	33	1,082	80	63.0	9.4	41	V.Good/Good
17.3	20.3	27	728	66	62.0	9.1	36	V.Good/M.Good
16.7	19.7	29	703	27	62.0	8.0*	34	Fair/M.Good
16.3	16.0	21	622	38	62.0	8.0*	33[ns]	Fair
15.0	19.0	29	474	33	59.0	7.8*	27*	Fair
13.0	20.7	30	646	40	NA	8.8	31[ns]	Good/Fair
East Branch Portage River (1994)								
17.4	5.0	6	660	1.3	31.0		17*	V.Poor
12.5	12.5	15	2,100	11.5	53.0		22*	Poor
10.4	6.5	8	282	1.2	50.5		18*	Poor

Table 13. Continued.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3 km)	Mean Rel. wt. (wt. /0.3 km)	QHEI	Mean MIwb	Mean IBI	Narrative Evaluation[a]
East Branch Portage River (1994)								
10.2	3.5	6	33	0.7	52.0		15*	V.Poor
9.1	4.0	7	8	0.3	31.0		12*	V.Poor
4.9	11.0	16	99	4.5	48.0	4.8*	24*	V.Poor/Poor
0.8	14.0	16	1,246	8.6	63.0	7.4	29ns	M.Good/Fair
East Branch Portage River (1988)								
17.3	8.5	10	407	3	24.0		20*	Poor
12.6	7.5	9	876	4	59.5		21*	Poor
11.3	8.0	10	378	15	49.5		21*	Poor
10.4	0	0	0	0	51.5		12*	V.Poor
10.2	1.5	3	4.5	0	59.5		12*	V.Poor
6.2	1.0	2	3	0	76.5	0.9*	12*	V.Poor
0.8	12.5	14	612	13	53.0	6.5*	23*	Fair/Poor
Rocky Ford (1994)								
10.8	17.0	23	2,051	11.2	35.5	7.0ns	22*	Fair/Poor
9.8	21.0	23	1,791	9.0	42.5	6.8ns	26*	Poor
5.2	23	26	1,119	44.3	38.5	7.2ns	36	Fair/M.Good
Rocky Ford (1993)								
10.7	16.0	16	337	274.8		6.0*	24*	Fair/Poor
8.9	18.0	18	846	7.4		6.9ns	28ns	Fair/Poor
Rocky Ford (1985)								
15.1	18.0	18	637		76.5		30ns	Fair
11.9	14.0	14	534		51.0		24*	Poor
9.8	18.0	18	284		60.0		26*	Poor
9.2	9.0	9	80		64.5		26*	Poor
8.1	13.0	13	132		56.5		28ns	Poor
6.3	15.0	15	729		57.0		22*	Poor
5.1	18.0	18	420		45.5		32	Fair
3.9	12.0	12	776	0.5		5.3*	14*	Poor/V.Poor
Nichol's Ditch (KOA trib to Rocky Ford) (1994)								
0.1	7.0	7	1,016	0.6	28.0		32	Fair
Nichol's Ditch (KOA trib to Rocky Ford) (1985)								
0.1	10.0	10	459		24.5		38	M.Good

Table 13. Continued.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3 km)	Mean Rel. wt. (wt. /0.3 km)	QHEI	Mean MIwb	Mean IBI	Narrative Evaluation[a]
North Branch (1994)								
6.6	16.5	19	826	29.9	29.0	7.0[ns]	32	Fair
1.3	18.0	18	832	10.7	59.5	8.4	40	Good
North Branch (1983)								
4.8	15.0	18	265	9		6.8[ns]	31[ns]	Fair
South Branch (1994)								
8.35	16.5	21	2,148	9.9	56.5	7.6	30[ns]	M.Good/Fair
South Branch (1988)								
8.3	14.0	17	1,485	10	51.5	8.3	31[ns]	Good/Fair
South Branch (1985)								
11.7	11.0	11	408	0		6.4*	18*	Fair/Poor
Sugar Creek (1994)								
13.4	16.0	16	4,164	11.5	44.5	8.1	32	Good/Fair
8.9	16.0	16	7,579	25.1	63.5	8.6	36	Good/M.Good
Bull Creek (1994)								
0.6	18.0	18	889	3.7	24.5	7.5	24*	M.Good/Poor
Bull Creek (1985)								
1.7	15.0	15	1,101	4.7		7.4	34	M.Good
Needles Creek (1994)								
1.3	18.0	18	2,578	3.7	25.0	8.8	28[ns]	Good/Fair

Ecoregion Biocriteria: Huron-Erie Lake Plain

	Index of Biotic Integrity			Mod. Index of Well-Being		
Site Type	WWH	EWH	MWH[c]	WWH	EWH	MWH[c]
Headwaters	28	50	20	NA	NA	NA
Wading	32	50	22	7.3	9.4	5.6
Boat	34	48	24	8.6	9.6	5.7
Interim Estuary	32	48	--	7.5	9.6	--

a - Criteria used for Narrative Evaluation are based on the next highest ecoregional biocriteria (see OEPA 1988).
ns - Nonsignificant departure from biocriteria (≤4 IBI units or ≤0.5 MIwb units).
* - Indicates significant departure from applicable biocriteria (>4 IBI units or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range
b - Interim estuarine criteria applied
c - Modified Warmwater Habitat criteria for channel modified areas.

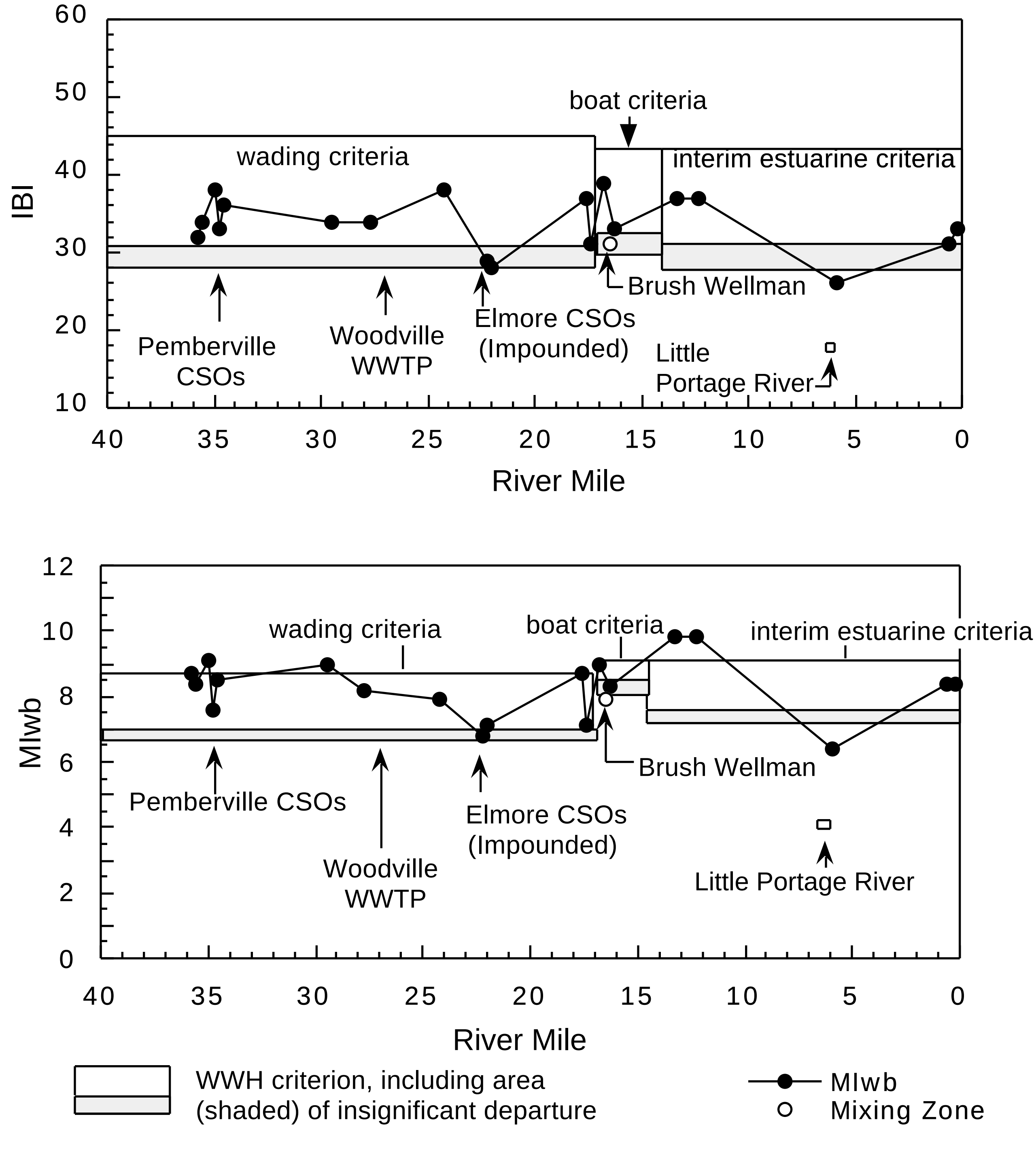


Figure 34. Longitudinal trends in IBI scores (top) and MIwb scores (bottom) for locations sampled in the Portage River mainstem 1994.

The performance of the fish community in the estuarine portion of the mainstem met or exceeded the interim Lake Erie estuary criteria at all mainstem sites except RM 5.6 (Figure 34). The one site sampled in the Little Portage River (RM 0.6) also did not meet the criteria. The percentage of individual fish exhibiting DELT anomalies increased in the estuarine segment, especially between RM 13.3 and 5.6. The predominant type of anomalies observed were eroded fins and lesions, suggesting that the fish community may have periodically been stressed by low or marginal levels of dissolved oxygen. The section of the estuary near RM 5.6 (including the mouth of the Little Portage River) is broad and shallow and appears to be the reach of the estuary segment where the deposition of silt and clay is highest.

Historical accounts of drowned river mouths in the Western Basin of Lake Erie indicate that submerged aquatic macrophytes, particularly eel grass (*Vallisneria american*), covered the bottom of the these broad, shallow areas (Trautman 1981). Beds of macrophytes in Sandusky Bay were present in the 1950s, but were largely extirpated by the end of the 1960s coincident with the advent of intensive agricultural practices and increased sedimentation. Losses of sea grass (*Ruppia* and *Zostera* sp.) in Chesapeake Bay during the same time period were equally severe (Ruiz *et al.* 1993). The importance of submerged aquatic vegetation to aquatic community integrity, fisheries yields, and waterfowl is well documented for marine estuaries in the southeastern United States (Dawes 1981, Weinstein and Brooks 1983). Consequently, considerable research and management is directed toward their rehabilitation. Similar efforts are needed if the drowned river mouths in Lake Erie are to be restored.

East Branch Portage River

The performance of the fish community in the East Branch of the Portage River departed significantly from WWH criteria at all sampling locations (RM 17.4 to RM 4.9; Figure 35). The fish community in and downstream from Fostoria was extensively degraded as a result of raw sewage entering the stream from CSOs, untreated industrial effluents discharged to the sewers, and bypasses of untreated sewage by the Fostoria WWTP. A 5-10 cm layer of sludge covered the bottom of pools and the stream margins at RM 10.4. The amount of sludge decreased downstream from the WWTP; however, sludge deposits were evident as far down stream as RM 6.2. The fish community within this reach (RM 10.4 to 9.1) was severely degraded as indicated by IBI scores in the poor to very poor range (Table 13; Figure 35) which suggests a response to toxicity associated with industrial discharges to the CSOs in addition to raw sewage from the CSOs and the WWTP. The fish community upstream from Fostoria showed significant departures from WWH criteria even though the physical habitat is capable of sustaining a fish community consistent with WWH criteria for wading sites in the Huron/Erie Lake Plain. The departure at this location may also be attributable, in part, to an unsewered development discharging at approximately RM 14.3. The stream downstream from this development was observed to be grossly impacted by sewage by Ohio EPA - NWDO personnel. In addition to the chemical impacts, Fostoria withdraws water from this segment to replenish upground water supply reservoirs, resulting in reduced stream flows. Prior to the first electrofishing pass, the stream had been subjected to extremely low flows, as evidenced by the desiccated appearance of the stream bed (the first pass occurred several days following a significant rainfall). Pioneering species comprised 74% of the individual fish in the first pass on July 5 and 70% on the second pass on September 1. Severe pollution has eliminated populations of non-pioneering species and presents a barrier to further recolonization, which may well contribute to the poor performance of the fish community upstream of Fostoria. Partial recovery of the fish community occurred at RM 0.8, as the mean MIwb and IBI scores either met or were within nonsignificant departure from the WWH criteria (Table 13).

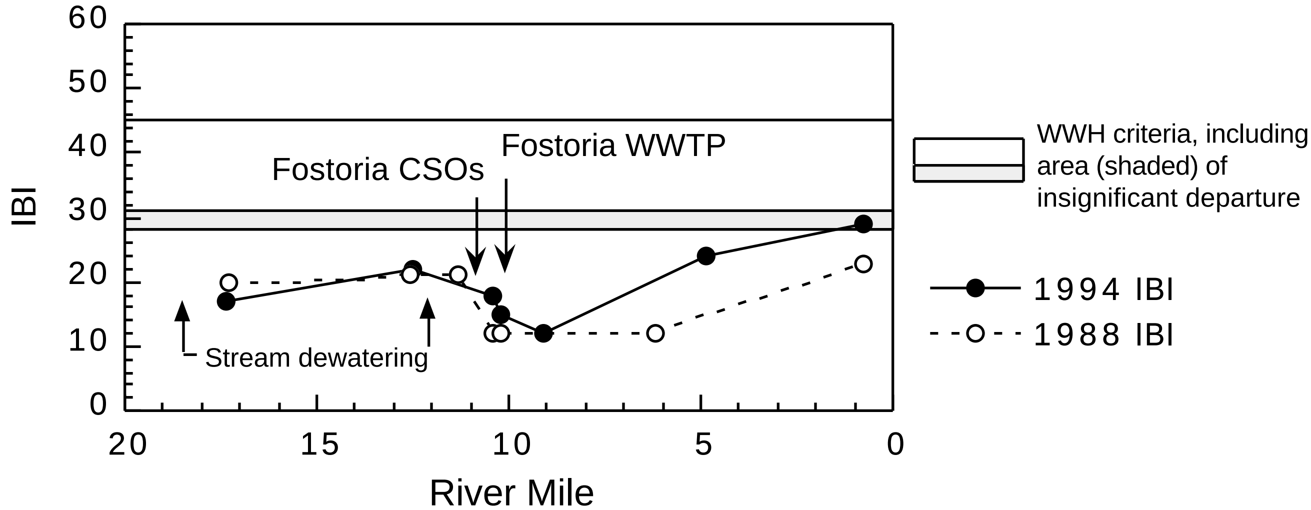


Figure 35. Longitudinal trends in IBI scores for the East Branch Portage River Portage River, 1994.

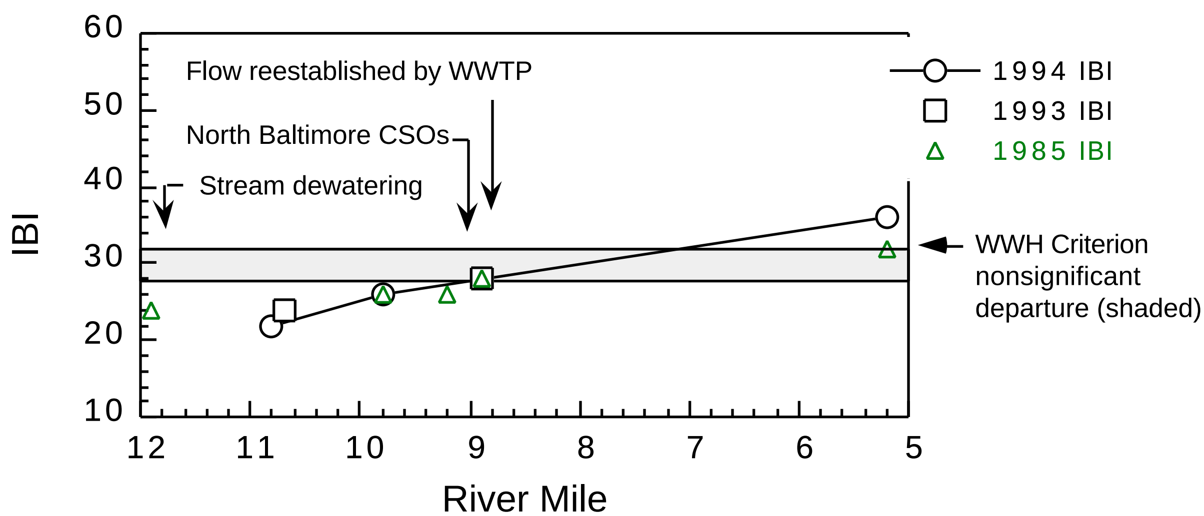


Figure 35. Longitudinal trends in IBI scores for locations sampled in Rocky Ford in 1985, 1993, and 1994.

Rocky Ford
Water appropriation for drinking water supply and the North Baltimore CSOs were the sources associated with the degraded fish community at the two upstream sampling locations (RMs 10.8 and 9.8) in Rocky Ford (Table 13; Figure 36). Pollution tolerant and pioneering species (*e.g.*, white sucker, fathead and bluntnose minnow, and green sunfish) comprised 75% and 74%, respectively, of the individual fish at each location. Rocky Ford is impounded at RM 15.3 to create a public water supply reservoir (Van Buren Lake). All flow was retained by the reservoir during the summer-fall sampling period, resulting in very low flows (interstitial in some areas) upstream from the North Baltimore WWTP. Sludge deposits were observed downstream from the CSOs which discharge at Eagleville Rd. and near RM 10.1 in North Baltimore. Stream flow was re-established by the North Baltimore WWTP discharge, which allowed the fish community to recover and meet the WWH IBI criterion at RM 5.2 (Table 13; Figure 35).

North Branch Portage River
The fish community was sampled at two locations in the North Branch Portage River, RM 1.3 and 6.6 (Table 13), to assess impacts from nonpoint sources of pollution and to evaluate the existing WWH use designation. The fish community at RM 1.3, an unchannelized reach, performed better than the channelized reach at RM 6.6 reflecting the differences in physical habitat. The QHEI scores at RMs 1.3 and 6.6 were 59.5 and 29.0, respectively. The reach at RM 6.6 showed little recovery; riparian vegetation was composed primarily of early successional vegetation, and the parent substrates were highly embedded by silt. The mean MIwb and IBI scores met the HELP ecoregion WWH criteria, however. The lower several miles of the North Branch have not been channelized (or are fully recovered), allowing for partial amelioration of nonpoint source impacts and extensive channelization in the upper watershed, as evidenced by IBI and MIwb scores. Channelization has less of an effect on the ability of the fish community to meet the WWH criteria in the HELP ecoregion, given the lower community performance expectations, than in the other ecoregions of Ohio.

South Branch Portage River
The reference site at RM 8.4 in the South Branch was sampled in 1994. The stream at RM 8.4 has partially recovered from past channelization, allowing the IBI and MIwb scores to meet the lower expectations for WWH criteria in the HELP ecoregion. However, central stoneroller comprised the largest percentage of the total sample by weight and numbers, indicating the composition of the fish community is also influenced by the combined effects of hydromodification and nutrient enrichment.

Sugar Creek
The IBI and MIwb scores for the two locations (RM 8.9 and 13.4) sampled in Sugar Creek met the WWH biocriteria (Table 13). The two locations differed markedly in the quality of physical habitat. The location at RM 13.4 (QHEI=44.5) exhibited the effects of channelization whereas the site at RM 8.9 retained more natural characteristics (QHEI=63.5). The biological index scores were remarkably similar however, due to the close proximity of RM 8.9 to extensively channelized segments upstream. The fish communities at both locations were predominated in weight and numbers by central stoneroller which implies the combined effects of hydromodification and nutrient enrichment.

Bull and Needles Creeks
Bull and Needles Creeks are both channelized ditches. As such, pioneering species accounted for 54.5% and 64.1%, respectively, of the fish community in each stream (Appendix Table D).

However, biological index scores were lower for Bull Creek than Needles Creek (Table 13) owing to the effects of relatively small differences in flow and average depth on the composition of the fish community. Bull Creek was nearly intermittent and had an average depth of less than 10 cm and tolerant species predominated the fish community. Needles Creek exhibited continuous flow and an average depth of approximately 10 cm, and thus had a more balanced fish community. The Western banded killifish, a state endangered species, was collected in both creeks (Poly and Miltner 1995).

TREND ASSESSMENT

Chemical Water Quality Changes: 1985 vs. 1994

Portage River

Water column chemistry results obtained from similar locations in 1985 and 1994 were compared to assess trends in ambient chemical water quality (Figure 37). Concentrations of nitrate-N were essentially the same between years at all stations. Ammonia-N concentrations were also similar at most locations except for downstream from Brush Wellman where the concentration decreased in 1994 relative to 1985. Concentrations of total phosphorus were lower at all locations in 1994 than in 1985, possibly reflecting the discontinued use of phosphorus in detergents and also nonpoint source management efforts. Reductions in phosphorus loadings were also apparent in the historical record from the STORET station in Woodville (RM 28.03; Figure 37). The increased use of nitrification in municipal wastewater treatment was also evidenced by the decreasing trend in ambient ammonia-N concentrations, and a slight increase in nitrate+nitrite-N concentrations over the 22 year period of record.

East Branch Portage River

Water quality samples from the East Branch Portage River were collected at similar locations in 1988 and 1994. As with the Portage River mainstem, nitrate-N concentrations were similar at all locations, and total phosphorus levels were lower in 1994 compared to 1988 (Figure 38). No discernable trend in ammonia-N concentrations were evident between years, given that the 1988 means were based on only two samples, compared to six in 1994. Longitudinal trends in D.O. were similar in 1988 and 1994 further demonstrating little change and continued impacts from the Fostoria CSOs and WWTP.

Rocky Ford

Levels of nitrate+nitrite-N increased while ammonia-N decreased in 1994 compared to 1985 (Figure 39). The differences between years was due to increased nitrification in the North Baltimore WWTP. Total phosphorus concentrations decreased between 1985 and 1994 by nearly an order of magnitude possibly owing to the reduced use of phosphates in detergents.

Changes in Biological Community Performance: Macroinvertebrate Community 1980-1994

Portage River Mainstem

At the NAWQMN ambient monitoring site (RM 27.3) the ICI was 50 in 1994 and was significantly higher than the mean ICI from 1977 to 1987 (35.0; Figure 40). This increase is attributed to the improved quality of WWTP effluents and reduced inputs from other sources (*e.g.,* CSOs) as evidenced by the declining trends in ammonia-N and nutrient levels (Figure 37).

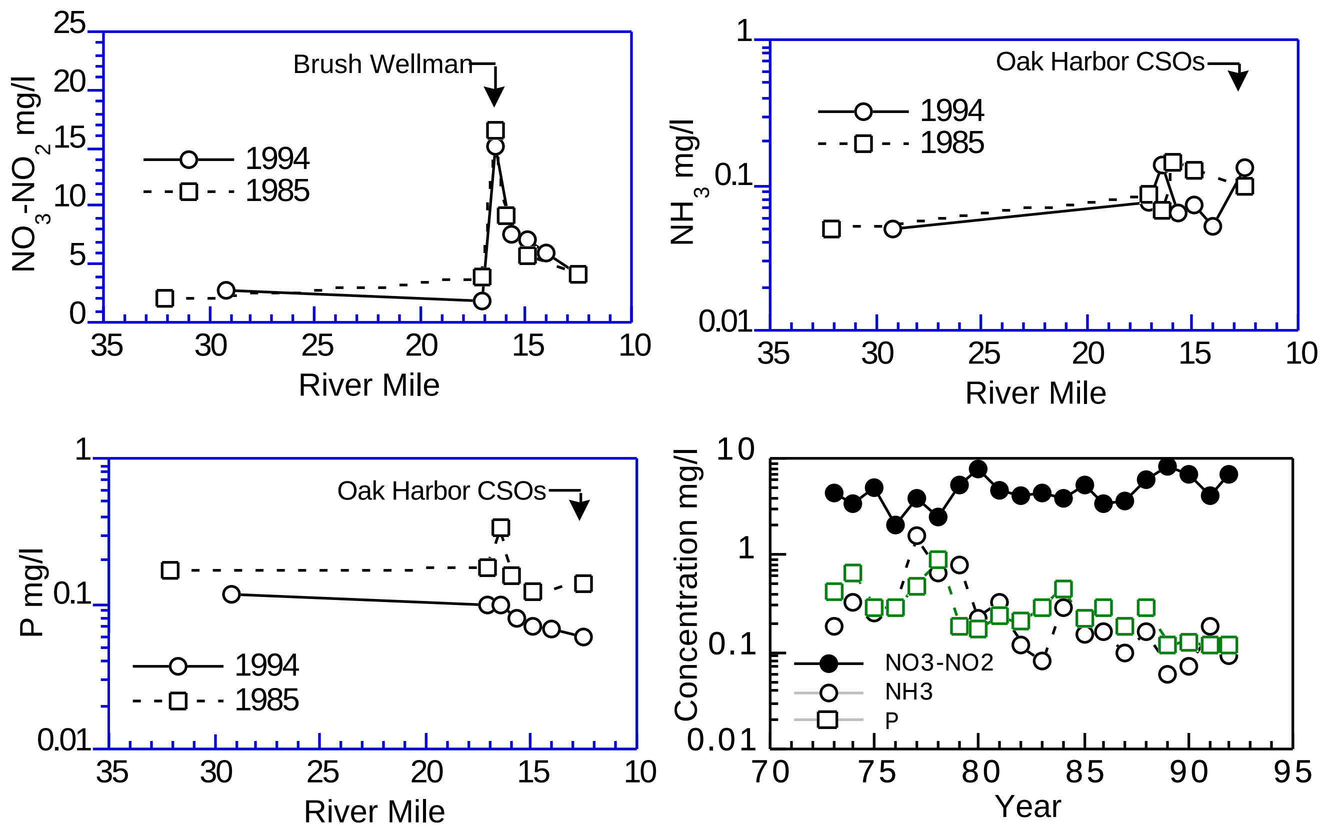


Figure 37. Mean concentrations of nitrate-N (NO_3-N), nitrite-N (NO_2-N), ammonia-N (NH_3-N) and total phosphorus (P) at similar locations in the Portage River during 1985 and 1994, and at the National Ambient Water Quality Monitoring Network (NAWQMN) station in Woodville (RM 28.03) for the period 1973-1992 (lower right).

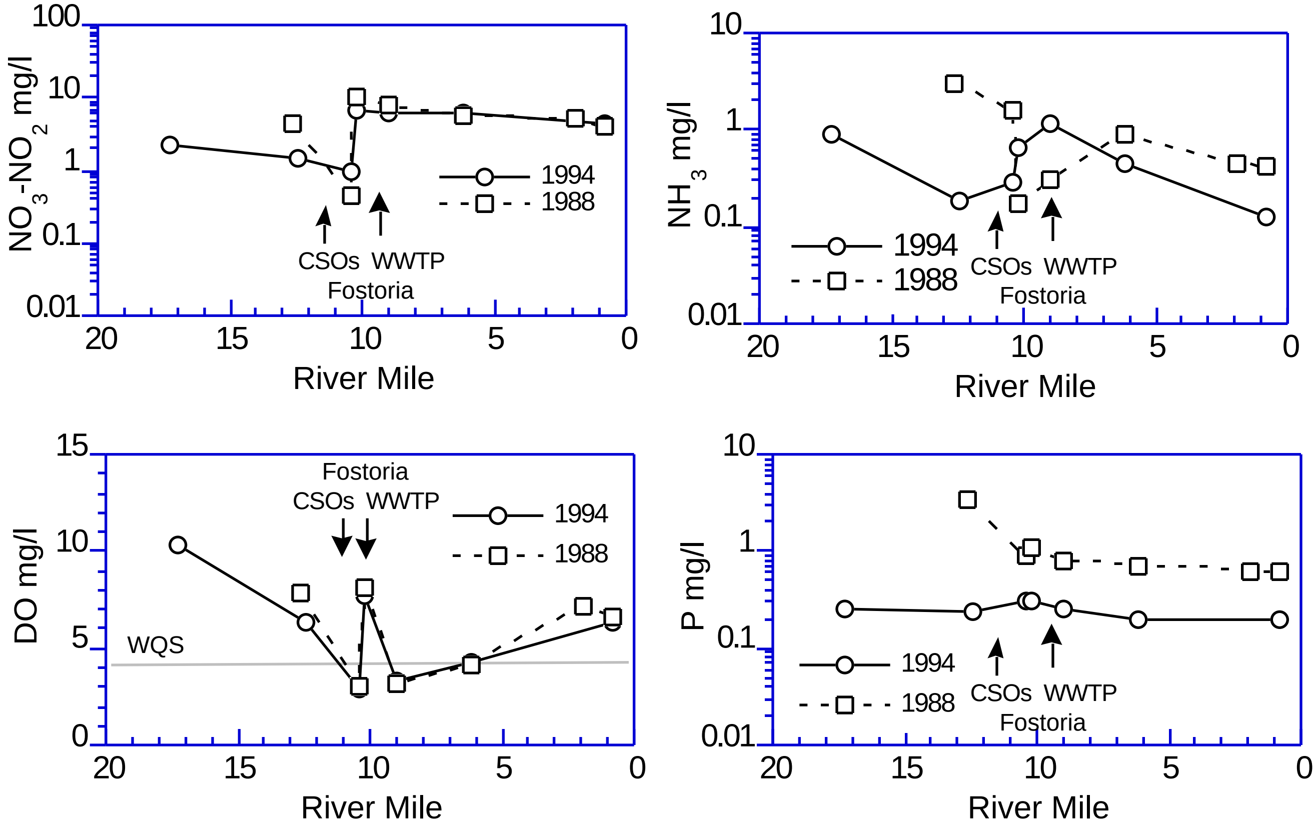


Figure 38. Concentrations of nitrate-N (NO_3-N), nitrite-N (NO_2-N), ammonia-N (NH_3-N), total phosphorus (P), and dissolved oxygen for the East Branch Portage River sampled at similar locations in 1985 and 1994.

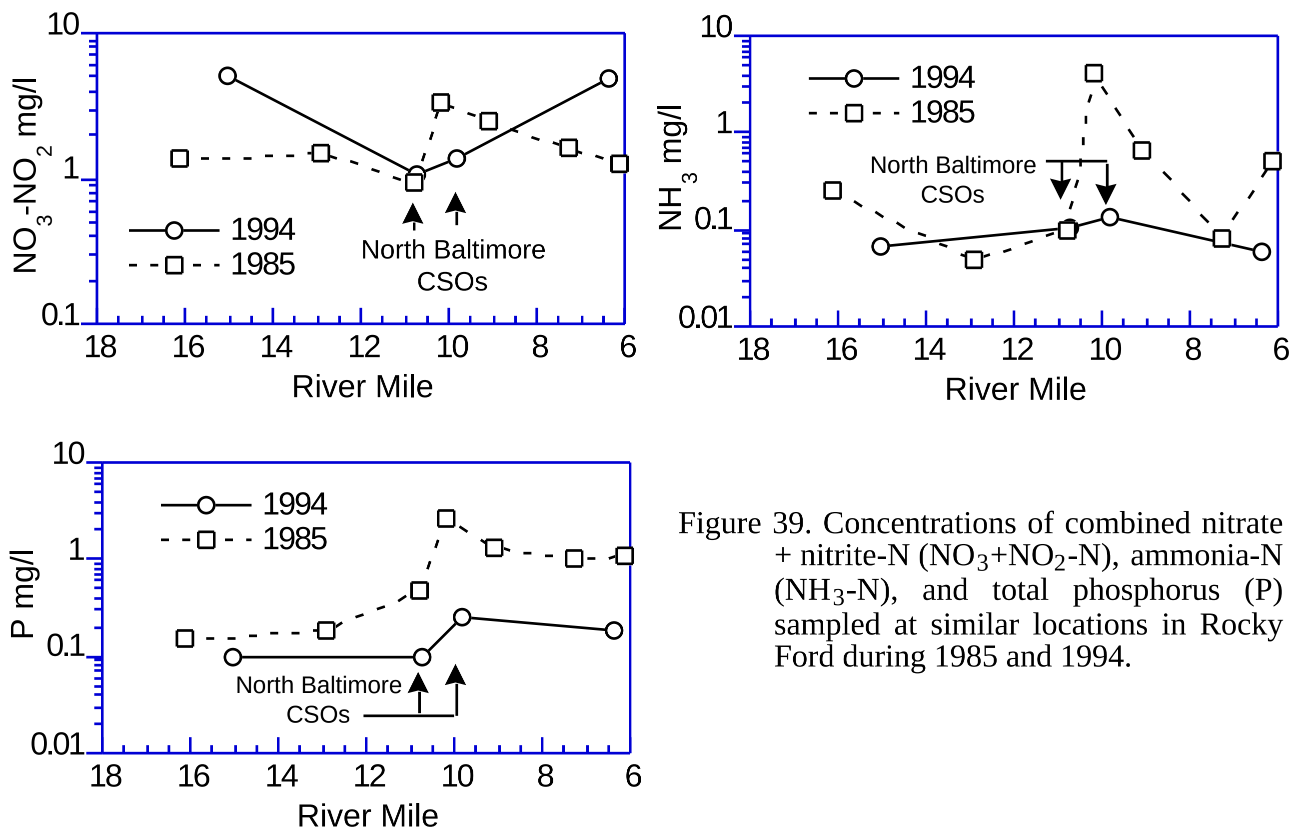


Figure 39. Concentrations of combined nitrate + nitrite-N (NO_3+NO_2-N), ammonia-N (NH_3-N), and total phosphorus (P) sampled at similar locations in Rocky Ford during 1985 and 1994.

From RMs 18.1 to 17.0, the 1994 ICI values, scoring in the exceptional range, were improved over the 1985 results, but the stream reach near Brush Wellman scored similarly in 1985, 1990 (data collected by EA Engineering) and 1994 (Figure 41).

East Branch Portage River
Macroinvertebrate communities in the East Branch Portage River were severely degraded in both 1988 and 1994 (Figure 32). However, slight improvements were noted at RMs 12.4 and 0.7, where the ICI met and marginally met, respectively, the WWH biocriterion. This was more likely the result of increased stream flows in 1994 over 1988 which was a severe drought year.

Rocky Ford
The macroinvertebrate communities in Rocky Ford performed similarly between 1985 and 1994 at most sites. An exception was at RM 7.5, where the 1994 sample improved compared to 1985, which was associated with the improved performance of the WWTP (Figure 33).

Changes in Biological Community Performance: Fish Community

Portage River
The Portage River from RM 18.1 to RM 16.4 was sampled at similar locations in 1994 and 1985. Index scores and longitudinal trends were similar between years for both indices (Figure 42). Comparison of MIwb Area of Degradation Values (ADV) values for 1985 and 1994 suggests some slight improvement between the two years (Table 14). However, the portion of the river where the scores did not meet the WWH biocriteria is in the transitional zone between the free-flowing river and the estuary. Consequently, the variability between years may be due to the degree to which the transitional zone was riverine or estuarine for a given year and not necessarily to improved environmental quality. The level of Lake Erie was approximately one foot higher in 1985 than in 1994, which moved the estuarine effect further upstream in 1985. The riffle habitat that was exposed downstream from RM 16.9 in 1994 was absent in 1994.

East Branch Portage River
The extremely polluted conditions documented in the East Branch Portage River in 1988 were observed once again in 1994 (Figure 35; Table 15). One exception was at RM 0.8 where the IBI and MIwb scores met the WWH biocriteria in 1994 (Table 13). The difference is likely attributable to the improved flows in 1994 compared to those experienced during the drought of 1988. However, the overall extent and shape of the longitudinal trend is very similar between years and does not show substantial differences. The severely degraded sites in closer proximity to Fostoria have shown little change despite the two different flow regimes between 1988 and 1994. The improved performance of the fish community well downstream of Fostoria at RM 0.8 demonstrates that recovery of the fish fauna is possible in the East Branch.

Rocky Ford
No trends were evident in IBI scores for Rocky Ford between 1985 and 1994 (Figure 36). IBI scores for the same locations sampled in 1994, 1993, and 1985 were nearly identical and showed similar impacts. Low stream flows in the reach upstream from North Baltimore and CSO impacts appear to be the two factors preventing recovery of the fish community and eventual attainment of the WWH biocriteria.

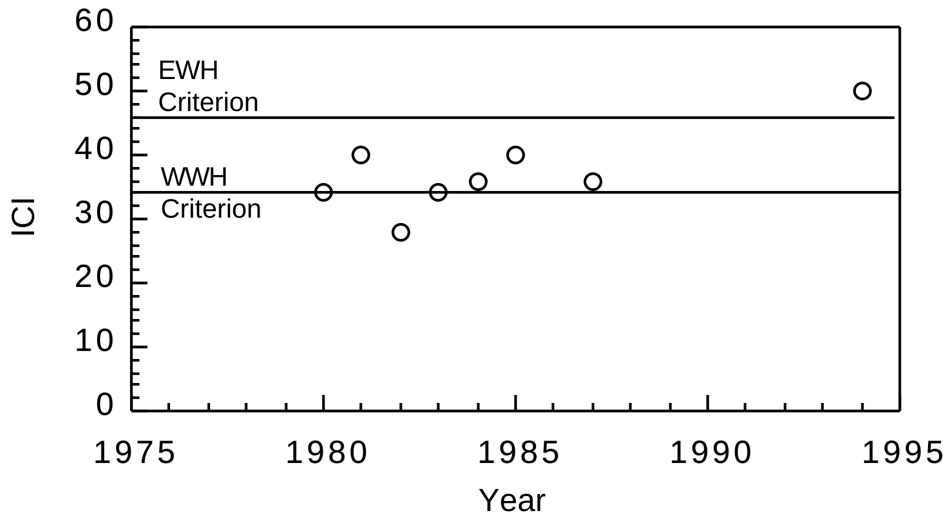


Figure 40. ICI scores at the National Ambient Water Quality Monitoring (NAWQMN) site (RM 27.3) of the Portage River for years 1980-85, 1987 and 1994.

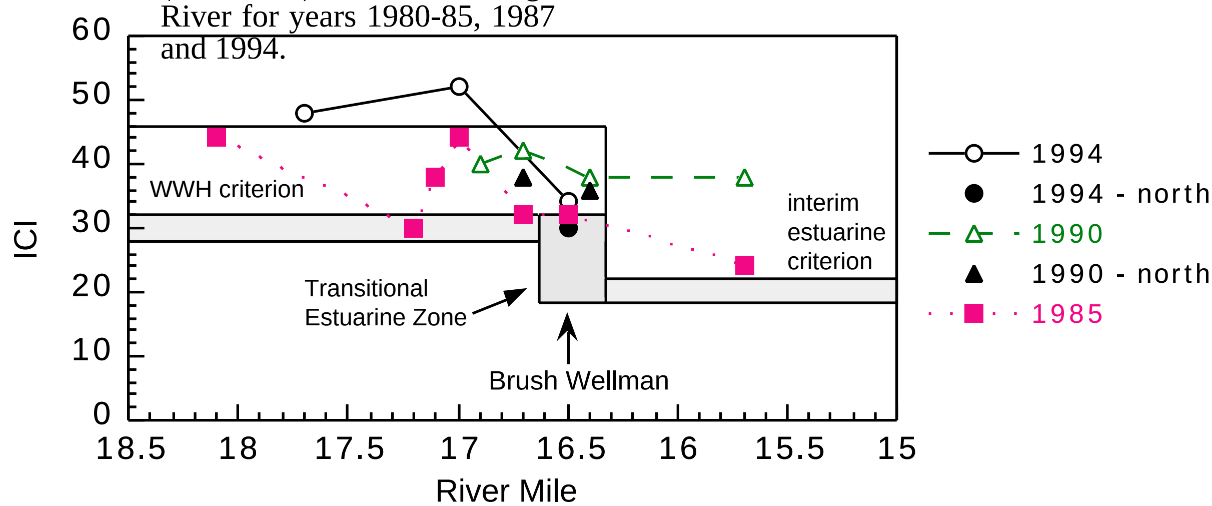


Figure 41. Longitudinal trends in ICI scores in the Portage River mainstem in the vicinity of the Brush Wellman discharges during 1985, 1990 and 1994.

Table 14. Area of Degradation (ADV) statistics for similar segments in the Portage River basin sampled in 1985, 1988 and 1994.

	Biological Index Scores				Area of Degradation Values			Attainment Status			
Year Index	Upper RM	Lower RM	Mini- mum	Maxi- mum	ADV	**ADV/ Mile**	Poor/VP ADV	FULL	PARTIAL	**NON**	Poor/VP
Portage River											
1994											
IBI			31	39	0	**0.0**	0				
MIwb	17.7	16.5	7.1	9.0	0	**0.0**	0	1.6	0.2	0.0	0.0
ICI			30	52	0	**0.0**	0				
1985											
IBI			28	41	4	**3.3**	0				
MIwb	18.1	16.4	7.4	9.4	15	**12.5**	0	1.1	1.4	0.6	0.0
ICI			30	44	-	-	-				
East Branch											
1994											
IBI			12	29	914	**53.5**	1155				
MIwb	17.8	0.7	4.8	7.4	215	**12.6**	13	1.0	0.9	16.0	16.0
ICI			2	34	2366	**138.6**	426				
1988											
IBI			12	23	1462	**88.6**	1682				
MIwb	17.3	0.8	0.9	6.5	1005	**60.9**	142	0.0	0.0	17.6	17.6
ICI			0	14	4156	**251.9**	1055				
Rocky Ford											
1994											
IBI			22	36	82	**14.4**	60				
MIwb	10.8	5.1	6.7	7.2	5	**0.9**	0	2.0	2.2	2.2	2.2
ICI			4	42	409	**71.7**	54				
1985											
IBI			22	32	204	**20.4**	127				
MIwb	5.1	15.1	0.0	7.3	1250	**125.0**	143	0.0	0.0	10.7	7.7
ICI			-	-							

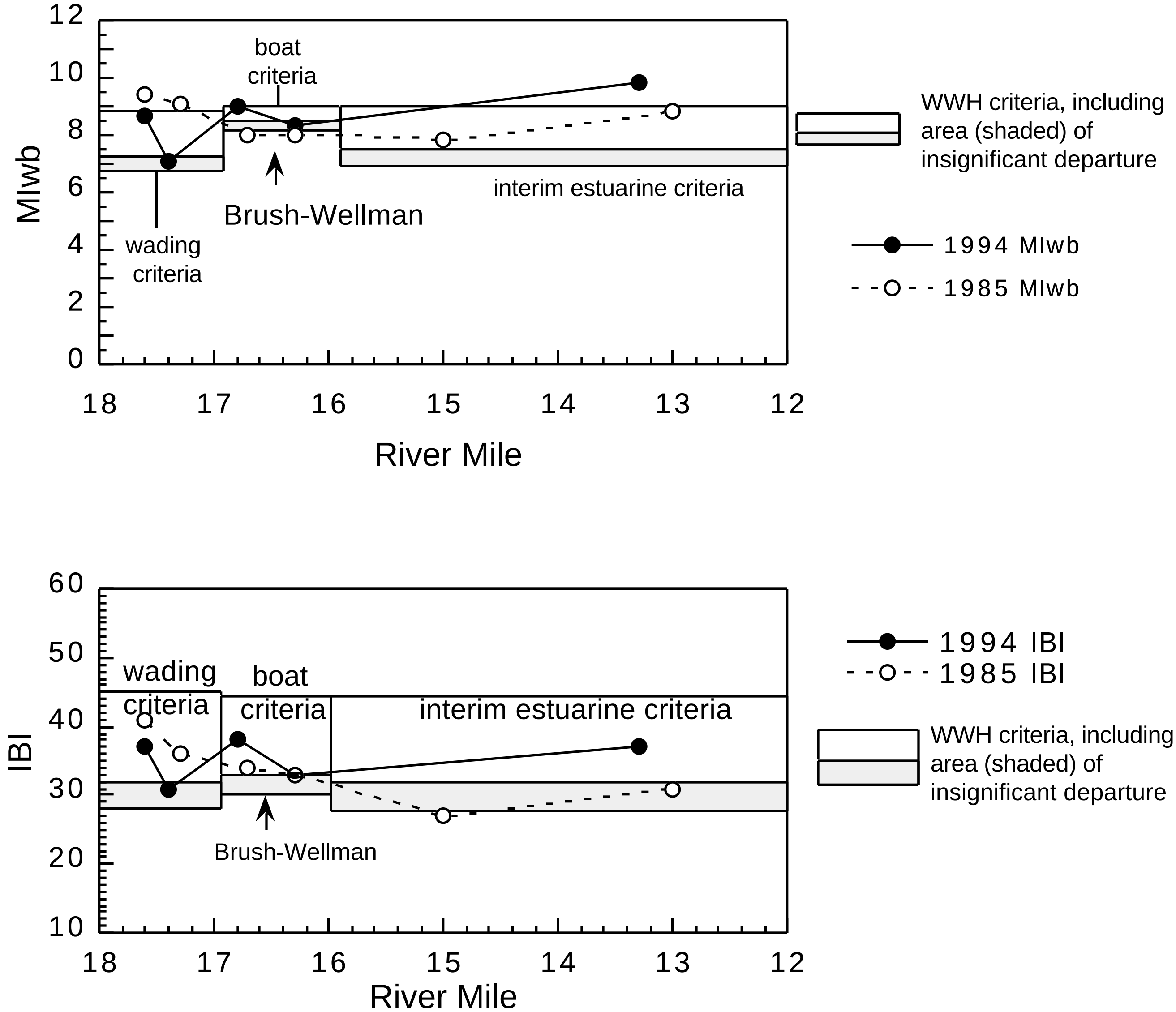


Figure 42. IBI (upper) and MIwb (lower) scores for the Portage River in the vicinity of Brush Wellman, 1985 and 1994.

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