Assessment of Nonpoint Source Pollution of the Ohio River

Ohio River Valley Water Sanitation Commission

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1.0 INTRODUCTION

1.1 Objective

The objective of this report is to define the extent of water quality impairment of the Ohio River attributable to nonpoint sources to identify specific sources causing the impairment, and recommend courses of action to reduce water quality impairment.

1.2 Definition of Nonpoint Source Pollution

The United States Environmental Protection Agency (U.S. EPA) uses the following as the definition of nonpoint source pollution.

> Nonpoint Source Pollution: Nonpoint source (NPS) pollution is caused by diffuse sources that are not regulated as point sources and normally associated with agriculture, silviculture and urban runoff, runoff from construction activities, etc. Such pollution results in the human-made or human induced alteration of the chemical, physical, biological and radiological integrity of water. In practical terms, nonpoint source pollution does not result from a discharge at a specific, single location (such as a single pipe) but generally results from land runoff, precipitation, atmospheric deposition, or percolation. (U.S. EPA, 1987)

1.3 Overview of the Problem

Water quality analyses performed by water quality management agencies show the largest contributors of pollutants to the Nation's surface waters are nonpoint sources. This is due partly to the success of the control of point source discharges, which have occurred over the past 20 years. Within the Ohio River basin alone, control of domestic waste discharges has improved from providing treatment to 39% of the sewered population in 1951 (ORSANCO, 1979) to providing at least secondary treatment to 95%

of the sewered population in 1988 (ORSANCO, 1988). Similar improvements in industrial waste treatment can be documented.

ORSANCO reports contamination from nonpoint sources of pollution are causing or contributing to stream criteria exceedances (ORSANCO, 1988), such that the exceedance frequency of these criteria is causing the Ohio River to be less than fully supporting of its designated uses. ORSANCO suggests nonpoint sources contribute toxic substances such as PCBs and chlordane which bioaccumulate in fish tissue. Analysis performed as part of the ORSANCO programs indicate many parameters of concern, more specifically toxic substances, are associated with nonpoint source pollution.

Assessment of the problem is difficult due to the number of possible sources, particularly in large watersheds. Nonpoint source pollution can emanate from both overland runoff and diffuse sources such as ground water infiltration. While nonpoint source pollution is typically associated with high flows, ground water contribution will be the greatest during low flow periods.

1.4 Assessment Method

The assessment method used for this report is as follows:

1) Analysis of Commission data to identify which parameters are non point source related. These analyses consist of performing correlation analysis of parameter concentration with flow and regression analysis of land use with parameter concentration.

2) Review of the compact states nonpoint source pollution assessment reports.

Conclusions are presented with regard to the impact and causes of nonpoint source pollution of the Ohio River. Types of nonpoint source pollution are indicated as well as an assessment of the dominant nonpoint source categories, by geographic area. While this does not give definitive answers to the questions of specific causes it does provide a problem overview.

Recommendations are broad and should provide guidance for future program development. These recommendations include specific monitoring for new point sources and development of goals for reduction of pollutant loads from tributaries.

2.0 BASIN DESCRIPTION

The Ohio River forms in Pittsburgh, Pennsylvania at the confluence of the Allegheny and Monongahela Rivers, and flows 981 miles in a generally southwest direction to join the Mississippi River at Cairo, Illinois. The total drainage basin of the Ohio River covers an area of 203,940 square miles, which constitutes over five percent of the total area of the United States. Figure 1 displays the extent of the Ohio River Basin, exclusive of the Tennessee River drainage area.

Land use and topographic relief within the basin are diverse. Land use ranges from row cropping to resource extraction. Over 25,000,000 people reside within the Ohio River Basin with approximately one half of these people residing within standard metropolitan statistical areas, as defined by U.S. Department of Commerce. Topographic features of the basin include rugged terrain found in West Virginia, Pennsylvania, and parts of Kentucky to the flat and gently rolling glaciated areas of Ohio, Indiana, and Illinois.

Land Use

Table 1 and Figure 2 display land use patterns of the major tributary basins of the Ohio River. These are a combination of data compiled by ORSANCO and the 1982 National Resources Inventory.

These data provide an indication of the diversity of land use patterns found in the Ohio Basin, from over 70% agricultural in the Little Miami and the Wabash subbasins to over 80% forest land in the Big Sandy/Guyandotte subbasin. Urban land use varies from over 11% in the Beaver, Little Miami and Great Miami subasins to less than 2% in the Big Sandy/Guyandotte subbasin. The highest percentage of mine disturbed lands are found in the watersheds of the upper 350 miles of the Ohio River.

FIGURE 1.   OHIO RIVER BASIN MAP

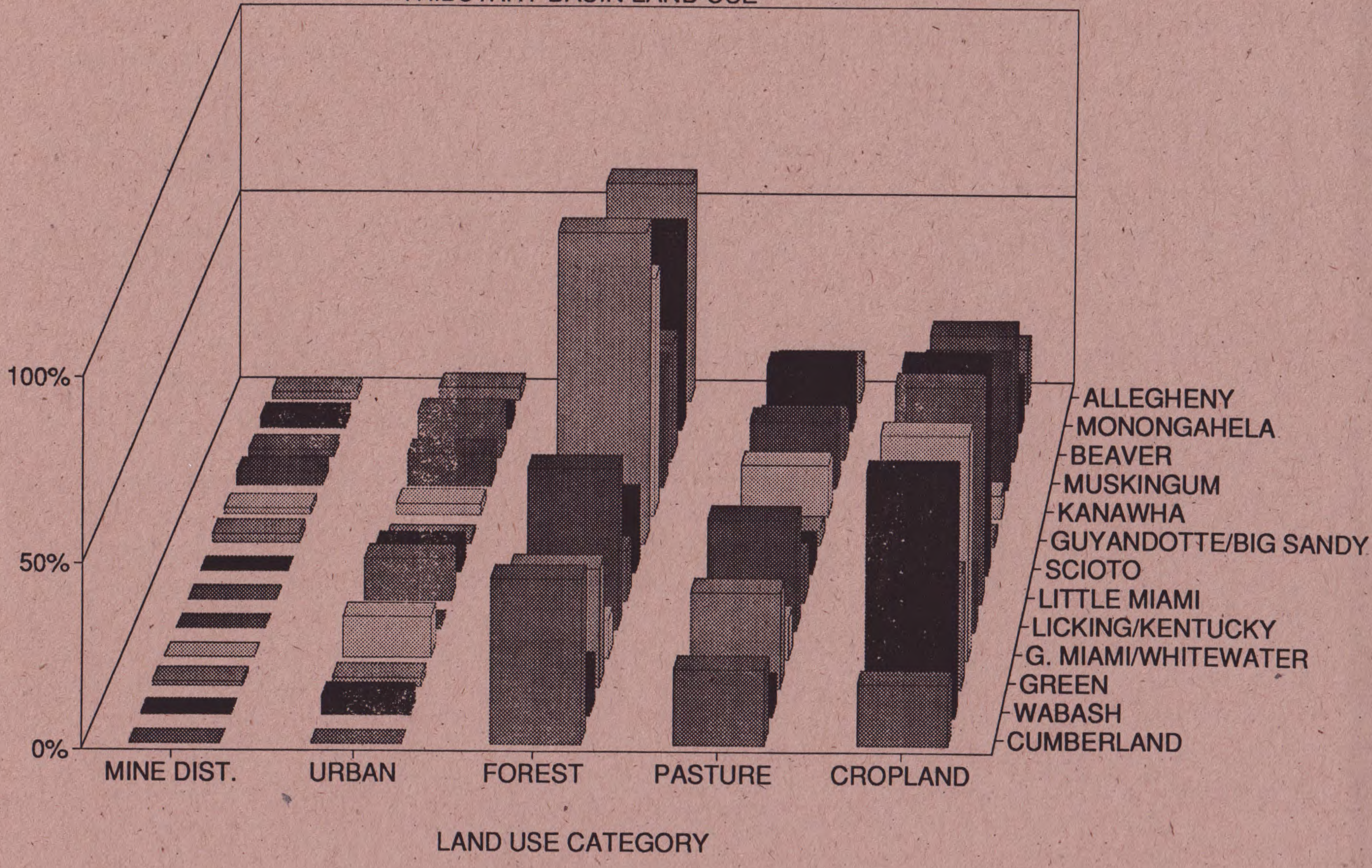
TABLE 1

LAND USE OF THE MAJOR SUBBASINS OF THE OHIO RIVER

BASIN DESCRIPTION	CROPLAND	PASTURE	FOREST	BARREN	URBAN	MINE DISTURBED	TOTAL AREA (SQ. MI.)
ALLEGHENY	14.6%	10.0%	58.2%	1.4%	3.4%	2.00%	11,700
MONONGAHELA	12.0%	17.2%	52.9%	1.8%	4.1%	3.00%	7,400
BEAVER	33.6%	10.7%	30.7%	0.0%	11.9%	2.0%	3,130
MUSKINGUM	33.5%	17.7%	32.3%	1.2%	8.6%	3.49%	8,040
KANAWHA	6.2%	13.8%	63.7%	0.3%	3.1%	1.56%	12,200
GUYANDOTTE/BIG SANDY	2.5%	4.2%	83.6%	3.0%	1.2%	2.52%	4,280
SCIOTO	55.9%	7.6%	19.8%	0.2%	7.0%	0.02%	6,510
LITTLE MIAMI	58.0%	12.3%	13.6%	0.0%	11.3%	0.0%	1,670
LICKING/KENTUCKY	15.2%	29.9%	43.2%	1.1%	1.3%	0.03%	10,640
GREAT MIAMI/WHITEWATER	60.2%	10.9%	10.4%	0.3%	11.1%	0.00%	5,400
GREEN	30.7%	25.7%	31.8%	1.8%	2.4%	1.30%	9,230
WABASH	65.2%	8.2%	13.5%	0.5%	4.8%	0.44%	33,100
CUMBERLAND	16.5%	20.3%	44.4%	1.1%	0.0%	0.00%	17,920
OVERALL	33.2%	14.5%	37.0%	1.0%	3.8%	2.0%	131,220

FIGURE 2

TRIBUTARY BASIN LAND USE



3.0 CHARACTERIZATION OF NONPOINT SOURCE POLLUTION

3.1 Background

Section 208(b)(2) of the Clean Water Act requires the development of plans to identify sources and effects of nonpoint pollution. In response to these requirements federal, state, and local agencies conducted assessments to identify nonpoint source pollution causes and impacts. The outputs from these efforts provide an overview of the problems of nonpoint source pollution, an assessment of the types of pollutants associated with different land uses and, investigations of impacts of specific activities such as resource extraction.

3.2 Major Land Use Patterns Associated With Nonpoint Source Pollution

As is stated in the definition (see Section 1.2), nonpoint source pollution "results from land runoff, precipitation, atmospheric deposition, or percolation". Based on this definition it is apparent land use patterns and land management are important factors for assessing the sources and impacts of nonpoint source pollution.

Five major land uses are normally considered for assessment of nonpoint source pollution: cropland, pastureland, forest land, urban area, and mine disturbed. Land resources inventories show that in excess of 90% of all land area in the United States can be accounted for by considering these five categories.

3.2.1 Agriculture

Agricultural land (cropland and pastureland) use has been called "the most pervasive cause of nonpoint source water quality problems" (U.S. EPA 1984). This is based on the intensive use of the resource (plowing, tilling, etc) and the extensive amount of land used for agricultural purposes, approximately 48% of the land (33% cropland and 15% pastureland) in the Ohio River Basin.

The largest contributor of nonpoint pollution from agricultural land is sediment, which is carried off with overland runoff. Sediment carries with it any residual fertilizers, pesticides and herbicides applied to the land. It has been estimated most erosion (54% of soil lost by sheet and rill erosion and 62% of soil lost by wind erosion) occurs on crop land (USDA 1987). Over 40% of the cropland in the Ohio River basin has soil loss which exceeds the soil loss tolerance level (5 tons/acre-yr (U.S. EPA, 1984). The soil loss tolerance level, or T, is the tons/acre per year of soil loss that a soil can tolerate and yet maintain productivity.

The most common parameters associated with agricultural runoff are nutrients (nitrogen and phosphorous), pesticides and herbicides. Historically, some of the pesticides and herbicides contained metallic elements such as mercury (seed treatment fungicides), arsenic (insecticides, herbicides), manganese and zinc (fungicides). The corn belt states (IL, IN, IO, MO, and OH) use 39% of the nation's phosphorous fertilizer and 32% of the nation's nitrogen fertilizer (U.S. EPA, 1984).

3.2.2 Silviculture

Forest lands typically have low erosion rates when undisturbed (U.S. EPA, 1984) and the drainage from undisturbed woodlands are the determinants of background pollution levels against which all other land uses are judged (Navotny and Chesters, 1981). The methods used for harvest and the management of the logging sites are factors which can determine the soil loss due to erosion at a disturbed site. Sediment loading is the greatest concern for pollutant loadings from forest lands, the majority of which reaches waterways can be attributed to road construction and clearcutting (Novotny and Chesters, 1981). Nutrients are used in promoting reforestation but the frequency of application is only a minor concern (once or twice in 30 years).

3.2.3 Mining

The impacts of mining operations vary, from surface runoff from disturbed areas to discharge from inactive mining areas. The most serious impact from coal mining is acid mine drainage. Acidic wastes can render streams biologically dead. While the extent of land use for mining is not extensive, the impacts to water quality can be more harmful than agricultural land use (U.S. EPA 1984). The pollutants associated with mining are sulfates and heavy metals.

3.2.4 Construction

Soil loss is the greatest concern with regard to nonpoint source pollution from construction sites. The main problem is a site specific problem. It is not considered a problem on a regional scale.

3.2.5 Urban Runoff

Urbanized areas, due to their high percentage of impervious surfaces (roof tops, parking lots, etc), allow a greater proportion of rainfall to runoff and not be absorbed (U.S. EPA, 1984). This coupled with the intensity of human activity in urban areas provides the potential for significant loadings to receiving waters.

Because of varied activities within an urbanized area, assessments on a large area become difficult. Land use within an urban area can include residential (from high to low density), commercial and industrial (light to heavy) uses. Generalized characterizations of urban runoff are presented, but should be used with caution as the characteristics of specific urban areas vary widely.

A major activity conducted by the U.S. EPA under Section 208 of the Clean Water Act was the Nationwide Urban Runoff Program (NURP). The program consisted of data assessment from 28 locations to characterize urban stormwater runoff. Table 2 displays the most frequently detected priority pollutants in the samples analyzed. As the data indicates, stormwater runoff from urban areas would be expected to contain metals and to a lesser extent heavy organics.

TABLE 2

MOST FREQUENTLY DETECTED PRIORITY POLLUTANTS IN NURP RUNOFF SAMPLES

Priority Pollutants Detected in 75 Percent or More of the NURP Samples

Inorganics		Organics	
30.	Lead (94%)		None
36.	Zinc (94%)		
29.	Copper (91%)		

Priority Pollutants Detected in 50 Percent to 74 Percent of the NURP Samples

Inorganics		Organics	
27.	Chromium (58%)		None
23.	Arsenic (52%)		

Priority Pollutants Detected in 20 Percent to 49 Percent of the NURP Samples

Inorganics		Organics	
26.	Cadmium (48%)	105.	Bis(2-ethylhexyl) phthalate (22%)
32.	Nickel (43%)	3.	a-Hexachlorocyclohexane (20%)
29.	Cyanides (23%)		

Priority Pollutants Detected in 10 Percent to 19 Percent of the NURP Samples

Inorganics		Organics	
22.	Antimony (13%)	12.	a-Endosulfan (19%)
25.	Beryllium (12%)	94.	Pentachlorophenol (19%)
33.	Selenium (11%)	7.	Chlordane (17%)
		5.	y-Hexachlorocyclohexane (Lindane) (11%)
		122.	Pyrene (15%)
		90.	Phenol (14%)
		121.	Phenanthrene (12%)
		47.	Dichloromethane (methylene chloride) (11%)
		96.	4-Nitrophenol (10%)
		115.	Chrysene (10%)
		117.	Fluoranthene (16%)

From Results of the Nationwide Urban Runoff Program, Volume 1 - Final Report, U.S. EPA, Washington, D.C., December 1983.

4.0 STATE NONPOINT SOURCE ASSESSMENTS

4.1 Background

Section 319 of the Federal Clean Water Act, as amended in 1987, requires each state to submit a report identifying those navigable waters which, without additional action to control nonpoint source pollution, cannot be reasonably expected to attain or maintain applicable water quality standards. The states are also required to identify the categories of the nonpoint sources present, best management plans for control of these categories, and describe state and local programs for controlling nonpoint source pollution. The state nonpoint source assessments and management plans were to be completed and submitted to USEPA by August, 1988.

The Commission has compiled the nonpoint source assessment reports from the member states. Information from these documents are useful in determining specific nonpoint sources and to identify problem watersheds which may adversely impact Ohio River water quality. Use of these data in conjunction with analysis of Commission monitoring data will provide insight to the impact of nonpoint sources to the Ohio River.

Each of the Ohio River states performed their assessments using similar methods. Data and/or the results of a survey were compiled, assessed and evaluated to determine the extent of use impairment due to nonpoint sources. The following is a brief summary of the methods and data sources used by each state.

Pennsylvania	Assessed waterbody specific data base established for water quality assessments. Data compiled based on chemical and biological monitoring, best professional judgement and other qualitative information.

West Virginia	Assessed data generated by a survey distributed to soil conservation districts. The Division of Forestry performed a field survey of the impacts of silviculture on water quality and the Office of Surface Mining and the Abandoned Mine Land Program has extensive data available describing impacts of mining on water quality.
Ohio	Assessed data generated by survey along with available chemical and biological monitoring data. The survey was distributed to local conservation districts, local planning agencies, etc.
Kentucky	Assessed data generated by survey along with available chemical and biological monitoring data. The survey was distributed to Soil Conservation Service district offices.
Indiana	Assessed data generated by a survey distributed to extension services, county health departments, regional planning agencies, etc.
Illinois	Assessment of waterbodies was performed using chemical, biological, physical, toxicological, and sediment data, as well as best professional judgement.

4.2 Pennsylvania

Approximately 7.8% of the Ohio River drainage basin lies in Pennsylvania, where it is dominated by three major subbasins; the Allegheny, the Monongahela and the Ohio. Land use in this area is dominated by forests with relatively high levels of mine disturbed lands. Urban areas are prevalent along the major rivers, particularly near the confluence of the Allegheny and the Monongahela, at

Pittsburgh, and continuing downstream on the Ohio River to the Pennsylvania - Ohio state line.

The Pennsylvania Department of Environmental Resources (PA DER) has identified four nonpoint source areas of concern with regard to surface water degradation and five nonpoint source areas of concern with regard to ground water degradation. These are:

Surface Water

1) Acid mine drainage
2) Agricultural Activities
3) Urban Runoff
4) On lot Sewage disposal

Ground Water

1) Leaking underground storage tanks
2) Industrial landfills
3) On lot sewage disposal
4) Hazardous waste disposal
5) Agricultural activities

With regard to toxic substances the PA DER has the following concerns for both surface and ground water:

High Priority

1) Agricultural - silvicultural - Commercial pesticide use
2) Urban runoff
3) Landfill leachate
4) Spills and leaks at industrial sites
5) Surface impoundments

Low Priority

6) Acid mine drainage
7) Airborne pollutants
8) On site sewage disposal (disposal of household chemicals)
9) Land application of wastes
10) Road deicing compounds

It should be noted while acid mine drainage has been identified as the largest nonpoint source pollution problem in Pennsylvania ("responsible for the largest amount of pollution in the state") (PA DER 1988) it is not considered a high priority problem with regard to toxic substances. PA DER makes this assessment due to the level of toxics in the acid mine drainage (trace levels of heavy metals), (PA DER, 1988).

There are approximately 17,000 stream miles in the Ohio River drainage area of Pennsylvania. PA DER has assessed approximately 2890 stream miles. The PA DER has determined that approximately 1000 stream miles have been adversely impacted by nonpoint sources. Table 3 provides a summary, by river basin, of the assessment. Figure 3 shows the location of these basins. As is indicated in Table 3, acid mine drainage is the greatest problem in the Pennsylvania portion of the Ohio River basin.

In addition to identifying waterbodies impacted and the cause of the impact the PA DER also identified pollutants associated with the nonpoint sources. Table 4 displays the types of parameters associated with the sources.

TABLE 3

STREAM MILES IMPACTED BY NONPOINT SOURCES
PENNSYLVANIA AREA OF OHIO RIVER BASIN

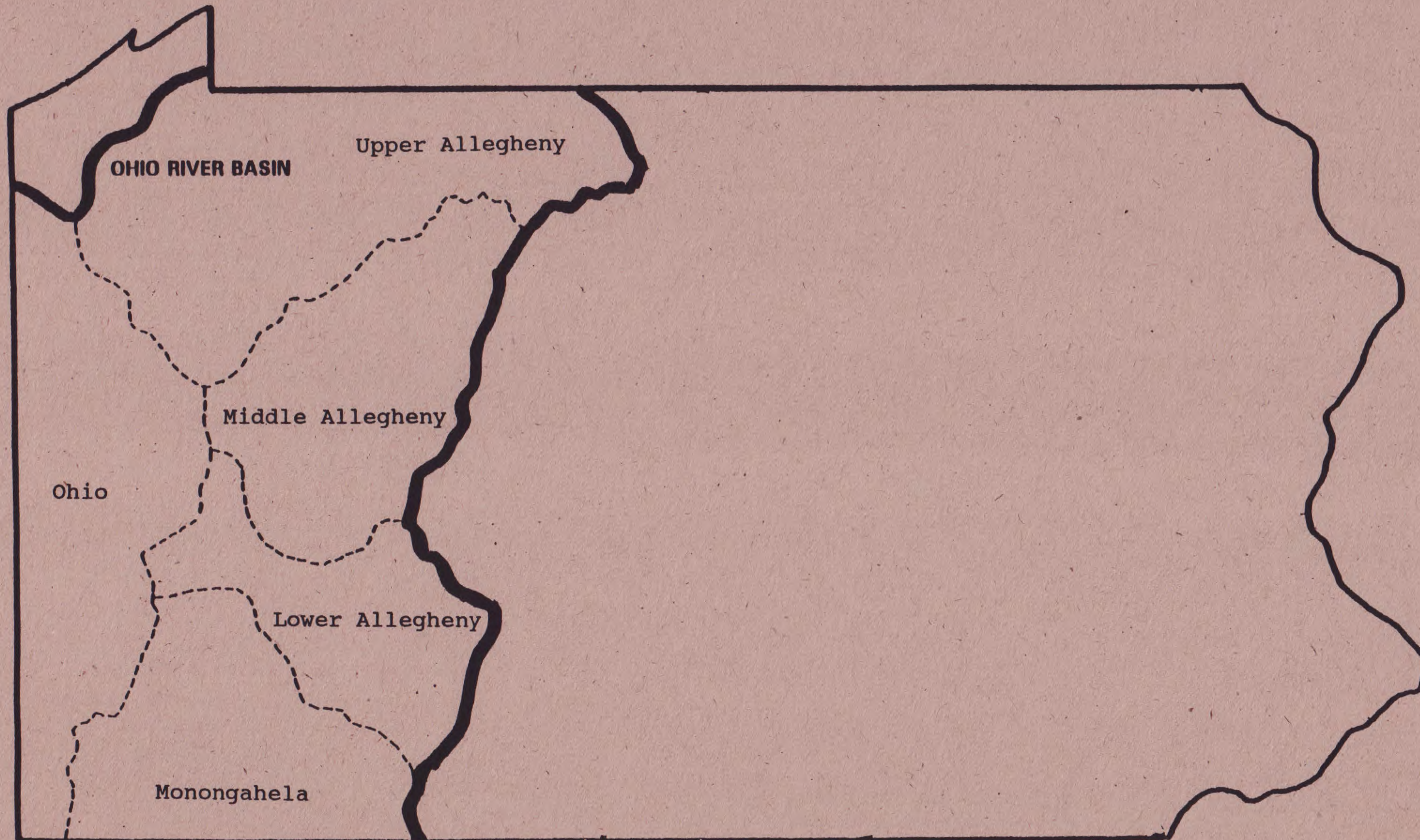
Basin	AMD	Agri.	Urb.	OLS	O&G	Fish	Other
U. Alleg.		2.5	0.1	0.4	25.9		
M. Alleg.	118.0	56.0		7.2	6.3		3.9
L. Alleg.	324.8	0.2	12.5	9.3		14.5	1.0
Monongah.	184.5	1.5	5.8	15.3		12.2	1.4
Ohio	133.5	26.1	2.5	10.0		24.3	
Total	760.8	86.3	20.9	42.2	32.2	51.0	6.3

AMD - Acid Mine Drainage
Agri. - Agricultural
Urb. - Urban runoff
OLS - On lot sewage
O&G - Oil and Gas exploration and extraction
Fish - Fish tissue contamination (such that consumption advisories are issued)
Other - Other

See Figure 3 for map displaying basins
Compiled from data presented in Commonwealth of Pennsylvania, 1988 Nonpoint Source Assessment, Final Draft, 1988.

Figure 3

Ohio River Basin in Pennsylvania



From: <u>Commonwealth of Pennsylvania, 1988 Water Quality Assessment (Section 305(b) PL 95-217 as amended), PA DER, Harrisburg, PA 1988</u>

TABLE 4

POLLUTANTS ASSOCIATED WITH NONPOINT SOURCES
PENNSYLVANIA

Mining (including acid mine drainage)	pH, metals, turbidity, TDS
Agricultural	nutrients, turbidity, pathogens, undetermined
Urban	DO/BOD, undetermined, other
On lot sewage disposal	nutrients, DO/BOD, pathogens
Oil and Gas development	turbidity, other
Other	pesticides or herbicides in fish tissue

Compiled from data presented in <u>Commonwealth of Pennsylvania, 1988 Nonpoint Source Assessment</u>, Final Draft, 1988.

4.3 West Virginia

Approximately 10% of the Ohio River drainage basin is in West Virginia. This area is dominated by rugged forest lands. It contains six principle subbasins, the Monongahela, the Upper Ohio, the Little Kanawha, the Kanawha, the Guyandotte and the Big Sandy. Land use is dominated by forests with a relatively high level of mine disturbed lands.

Resource extraction is the dominant economic force in the State of West Virginia. West Virginia is one of the top coal producers in the United States (WVDNR, 1988). The environmental impact due to this activity has been severe primarily due to acid mine drainage, which has been identified as the largest pollution problem in the state (WVDNR, 1988).

The nonpoint source assessment conducted by the West Virginia Department of Natural Resources (WVDNR) ranked watersheds by impact of nonpoint sources. This assessment identified 22 watersheds (18 in the Ohio River basin) for additional follow up activities. Table 5 lists the watersheds within the Ohio River Basin. Figure 4 is a location map which displays the location of the watersheds in the state and Figure 4a displays the priority watersheds. The 18 watersheds identified do not include those watersheds impacted by acid mine drainage.

The impact and the extent of the impact of acid mine drainage has been documented extensively in West Virginia as part of the water quality management process pursuant to the Clean Water Act Sections 208 and 303(e). These assessments have identified 96 watersheds (484 streams) which have been impacted by mine drainage. More specific analysis showed 31 watersheds are impacted by acid mine drainage and 65 are impacted by metals alone (WVDNR, 1988). Table 6 lists these watersheds (see Figure 4b). It is obvious that the Monongahela basin is the most heavily impacted by acid mine drainage. The Kanawha, Guyandotte and the Big Sandy basins have also been significantly impacted.

TABLE 5

LIST OF WATER SHEDS IN OHIO RIVER VALLEY
DESIGNATED AS NONPOINT SOURCE PRIORITY
WEST VIRGINIA

WATERSHED #	WATERSHED NAME
43	Three Forks Creek
64	Little Sandy Creek
98	Little Kanawha Direct Drain
120	Wheeling Creek
136	Middle Island Creek
150	Old Town Creek
168	Teays Valley
173	Lower Pocatalico River
192	New River
202	Indian Creek
207	Middle Bluestone River
216	Hominy Creek
226	Elk River
228	Little Sandy Creek
231	Sandy Creek
239	Elk River
268	Lower Mud River
287	Oceana

This list is arranged by watershed number not by priority number.

See Figure 4a for location.

This list was developed without considering impacts from mining. Mining impacts have been considered separately.

From West Virginia Nonpoint Source Assessment, August 1988.

FIGURE 4

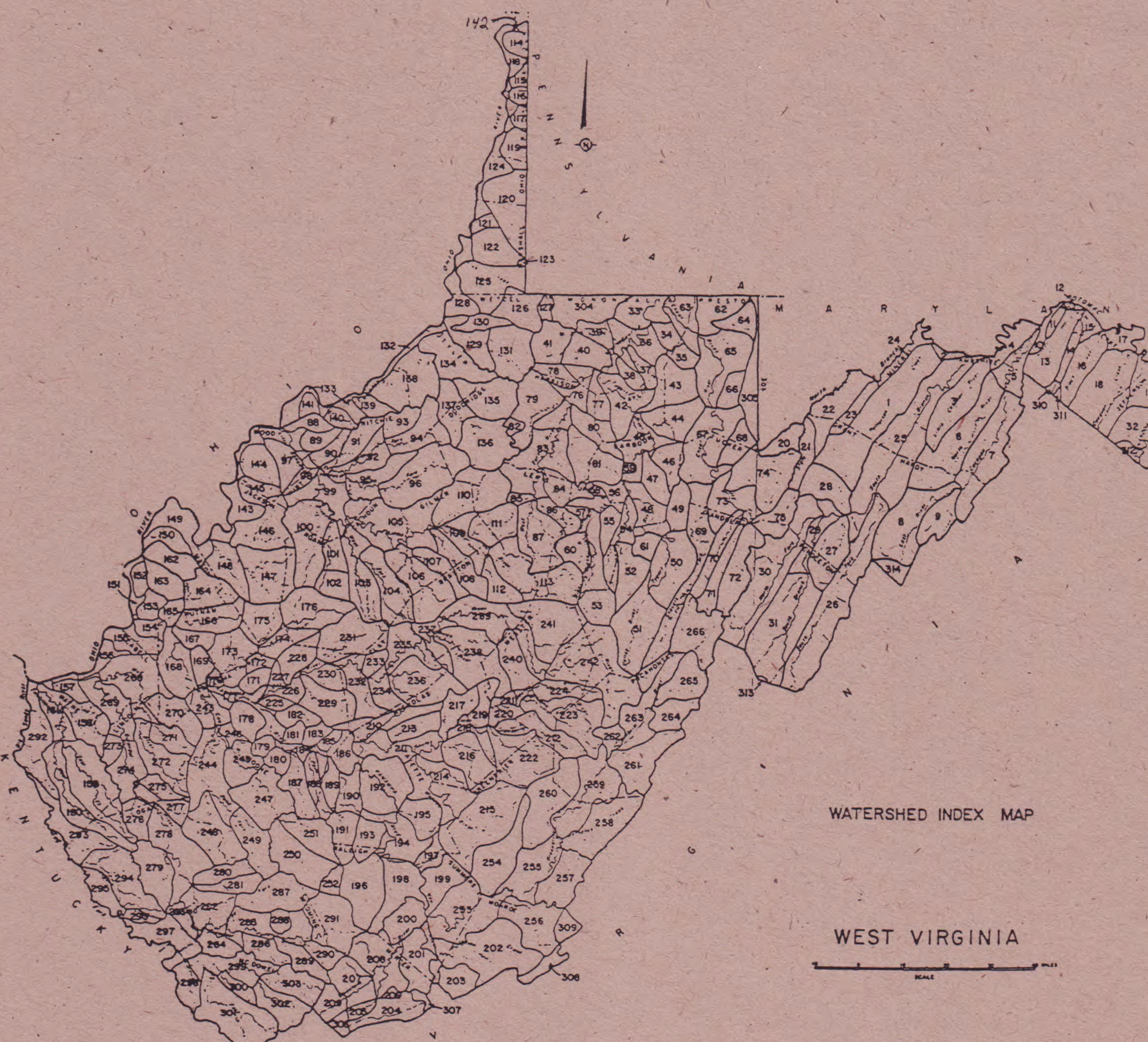

PENNSYLVANIA
MARYLAND
VIRGINIA
KENTUCKY
OHIO
WATERSHED INDEX MAP
WEST VIRGINIA

FIGURE 4a

Water Sheds in Ohio River Valley Designated as Priority by West Virginia Department of Natural Resources

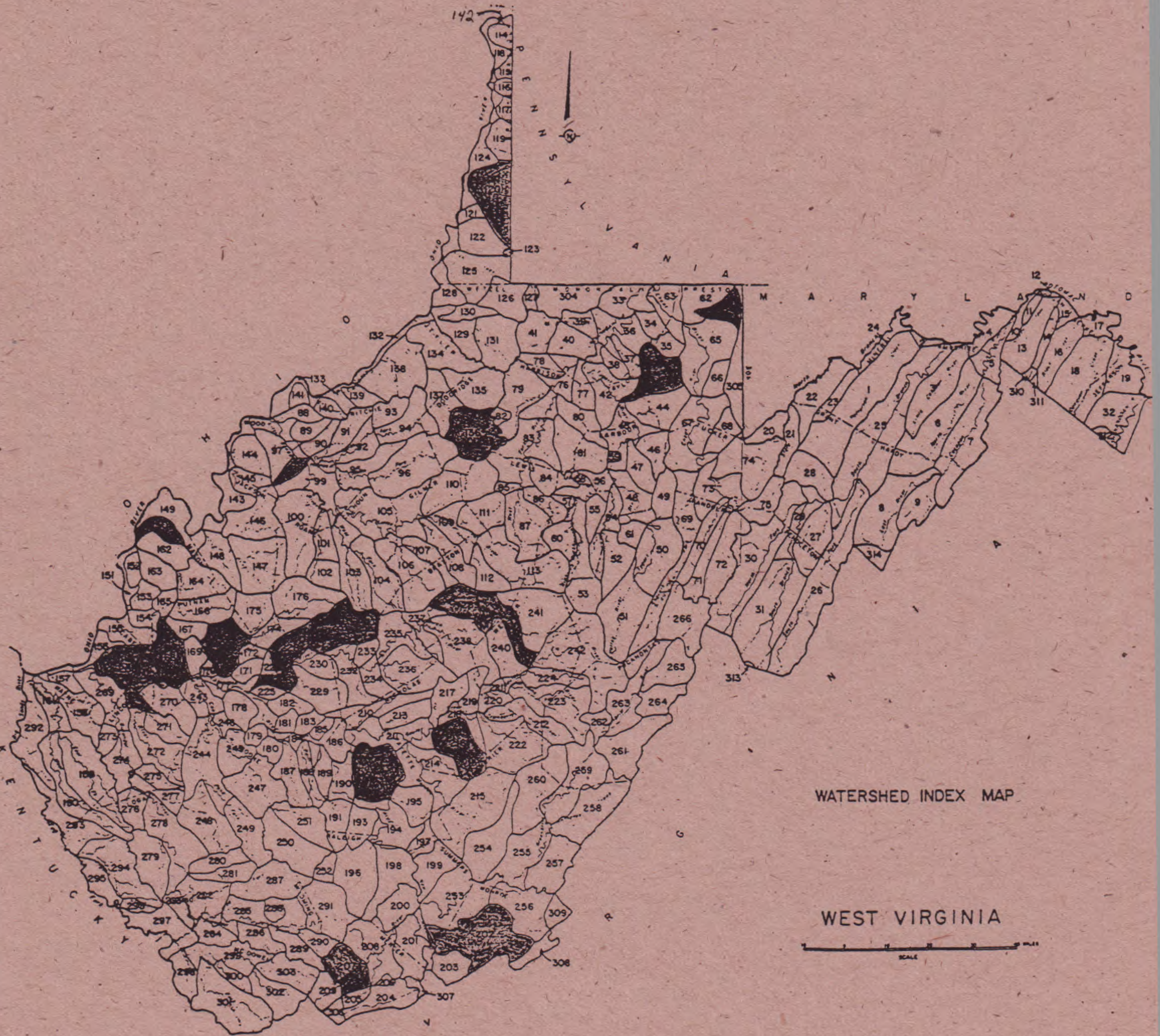


TABLE 6

WATERSHEDS IMPACTED BY ABANDONED MINE DRAINAGE
OHIO RIVER BASIN

WEST VIRGINIA

WATERSHED NUMBER	STREAM
33	Monongahela Direct Drain
34*	Lower Deckers
35*	Upper Deckers
36*	Monongahela Direct Drain
40	Upper Buffalo
41	Lower Buffalo
42	Tygart Direct Drain
43*	Three Forks Creek
44*	Sandy Creek
45	Tygart Direct Drain
48*	Tygart Direct Drain
52*	Upper Middle Fork
53	Buckhannon River
57*	Finks Run
58*	Pecks Run
60	French Creek
61*	Roaring Creek
62	Big Sandy Creek
63*	Cheat Direct Drain
64*	Little Sandy Creek
65*	Cheat Direct Drain
74	Blackwater River
76	West Fork Direct Drain
77	Booths Creek
78	Bingamon Creek
79	Tenmile Creek
80*	Simpson Creek
81	Elk Creek
82	Salem Fork
83	West Fork Direct Drain
84	Hackers Creek
86	Stonecoal Creek
109	Little Kanawha Direct Drain
111	Sand Fork
118*	Ohio Direct Drain
119	Buffalo Creek
120	Wheeling Creek
124	Ohio Direct Drain
149*	Ohio Direct Drain
159*	East Fork Twelvepole
172*	Tupper Creek
173*	Lower Pocatalico River
178*	Davis Creek
179	Lens Creek

(Continued on next page)

TABLE 6

WATERSHEDS IMPACTED BY ABANDONED MINE DRAINAGE
OHIO RIVER BASIN

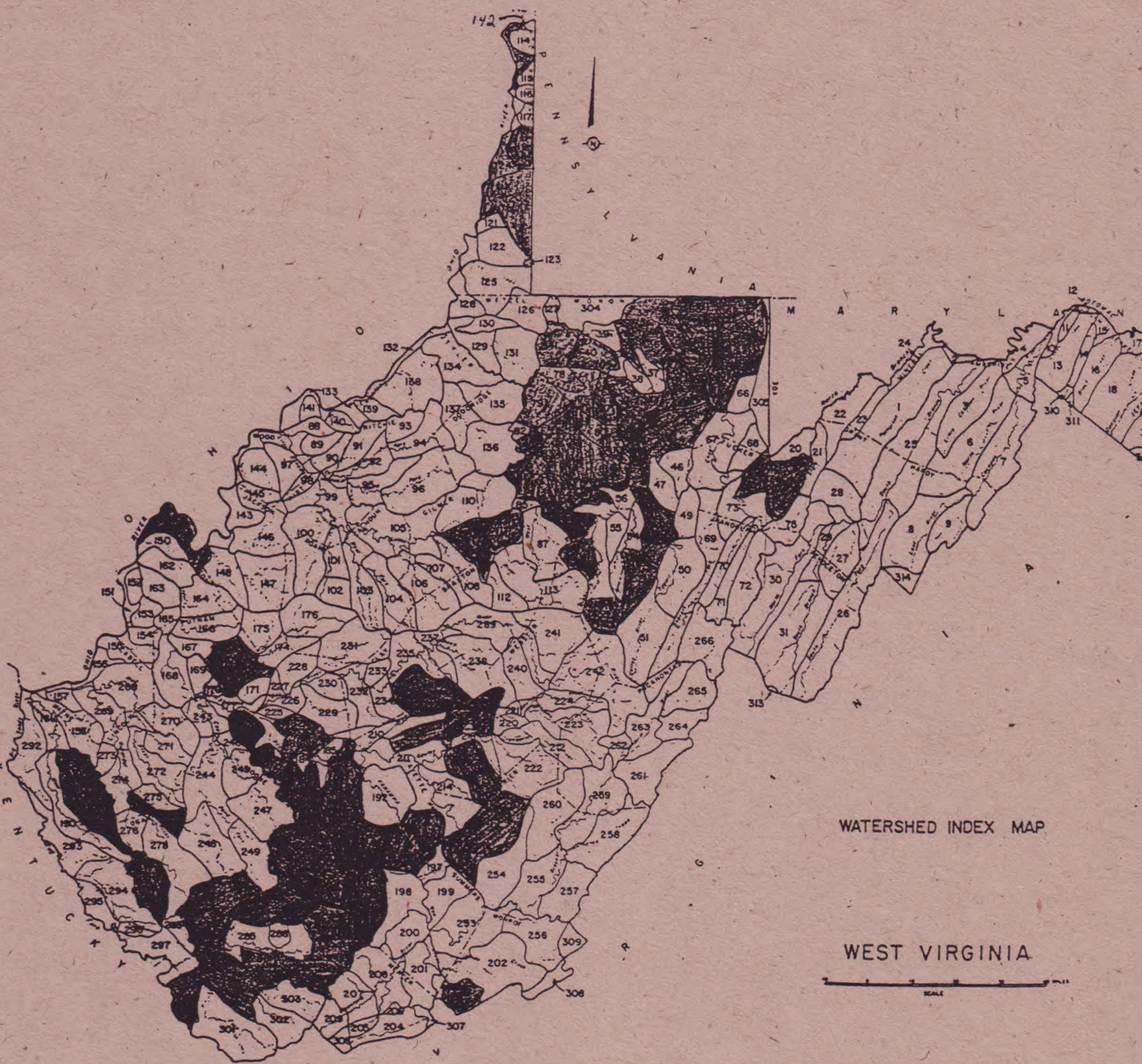
WEST VIRGINIA

WATERSHED NUMBER	STREAM
180	Kanawha River
181	Witchers Creek
182	Campbells Creek
183	Kelley Creek
186	Smithers Creek
187*	Cabin Creek
188	Lower Paint Creek
189	Armstrong Creek
190	Loop Creek
191	Upper Paint Creek
193	Dunloup Creek
194	New River
195	Mann's Creek
196	Piney Creek
203	Rich Creek
213	Peters Creek
215*	Upper Meadow Creek
216	Homing Creek
217*	Muddlety Creek
219	Beaver Creek
236*	Buffalo Creek
250	Lower Marsh Fork
251*	Clear Fork
252	Upper Marsh Creek
277*	Big Creek
279	Island Creek
280*	Buffalo Creek
281	Huff Creek
282*	Guyandotte Direct Drainage
284	Little Huff Creek
286*	Indian Creek
287	Oceana
289*	Pinnacle Creek
290	Barker's Creek
291*	Mullens
293	Tug Fork Direct Drainage
294*	Pigeon Creek
295	Tug Fork Direct Drainage
296*	Mate Creek
298	Panther Creek
299*	Tug Fork Direct Drainage
300	Clear Fork

*Acid Mine Drainage Impacted Watersheds
See figure 4b for location
From West Virginia Nonpoint Source Assessment, August 1988

FIGURE 4b

Water Sheds in Ohio River Valley Impacted by Abandoned Mine Drainage - West Virginia



4.4 Ohio

Approximately 14.5% of the Ohio River drainage basin is in Ohio, an area with terrain which varies from the glaciated portions of moderate relief and gentle slopes to the unglaciated portions characterized by rugged terrain and steep slopes. Land use is also varied, ranging from the urbanized areas of Columbus, Dayton, and Cincinnati to the Wayne National Forest in Southeast Ohio. Agriculture is the dominant use in the glaciated portion, such as the upper Muskingum basin and the upper Scioto basin.

The Muskingum, Scioto, and Great Miami are the largest subbasins. The Mahoning, Hocking, Little Miami and Ohio Rivers (minor tributaries draining directly to the Ohio River) are the other principle subbasins.

The nonpoint source assessment conducted by the Ohio Environmental Protection Agency (Ohio EPA) was based on available biological and chemical monitoring data and on the results of a statewide survey of conservation districts, local planning agencies, etc. The results of these efforts indicated statewide, 8.9% of all stream segments are use impaired due to nonpoint source pollution and up to 33% are impacted by nonpoint source pollution. Stream segments were judged to be impaired or threatened based on available biological and chemical data. Waterbodies were deemed as impacted if the decision was based solely on chemical specific data.

Agricultural activity was identified as the largest nonpoint source pollution problem, based on the statewide survey, with cropland use the most pervasive problem. Stream segments impaired due to agricultural land use were identified in every major river basin. The second largest NPS problem identified was resource extraction. Urban runoff is a major problem of the Mill Creek, Little Miami, Great Miami and upper Scioto Rivers.

Table 7 displays a summary of the subbasins of the Ohio basin in the state. The table shows over 40% of all stream miles have been use impaired or impacted by nonpoint sources alone. Another 6% of the stream miles are threatened. Another 10% of the stream miles have been identified as impaired or impacted due to a combination of point and nonpoint sources. The magnitude of the problem may increase as additional stream miles are assessed.

TABLE 7

Stream Miles Impacted by Nonpoint Sources
Ohio Portion of Ohio River Basin

	Total Miles	Total Ass.	Impaired	Impacted	Threatened	Sources
Central Ohio River Tributaries	1705	748	283	224	126	Major coal mining. Res. Extraction (Ag, Silvilculture lesser extent), sign. prob. Yellow Creek, Cross Creek, Wheeling Creek, McMahon Creek, Sunfish Creek, Duck Creek
Great Miami	1622	1119	227	243	113	324 Miles NPS/PS affected (impaired and impacted) Urban, Agriculture, Land disposal, hydromodification
Hocking	869	437	154	162	22	107 NPS/PS affected. Major impact Resource Extraction Hydromodification, minor-agriculture
Little Beaver Creek	234	79	28	13	32	Hydromodification, pasture, unknown
Little Miami/Mill Creek			169	238	86	191 miles NPS/PS impacted. Major problem urban runoff
Mahoning	520	156	26	21	2	Hydromodification (Dam construction), O&G production
Muskingum	5313		839	712	249	956 miles NPS/PS to affected. Upper basin-agriculture/res. extraction. Lower basin-Res. extraction primary, agriculture-to a lesser extent. Some urban
Scioto	3211		546	1571	218	Headwaters-hydromodification, urban, onsite sewage disposal systems. Lower basin-agriculture, res. extraction
Southeast Ohio River Tributaries	1904	747	187	509	27	Resource extraction (coal mining/O&G prod.)/ agriculture
Southwest Ohio River Tributaries	998	457	132	213	87	Major agriculture, specific concern, Ohio Brush Creek

Compiled from data presented in Ohio Nonpoint Source Assessment 1988

4.5 Kentucky

Approximately 19% of the Ohio River drainage basin lies in the Commonwealth of Kentucky. The topography of Kentucky is varied ranging from the rugged, steeply sloped terrain of the Cumberland mountains of Eastern Kentucky to the gently rolling hills and flood plains of Western Kentucky. Predominant land uses are agriculture, and siliviculture, with resource extraction being a small but important use.

There are seven major subbasins in Kentucky: Big Sandy, Licking, Kentucky, Cumberland, Salt, Green, and Tennessee. Minor subbasins include Ohio River minor tributaries and the Tradewater River basin.

The nonpoint source assessment conducted by the Kentucky Division of Water (KYDOW) was based on monitoring data and professional evaluations. The survey results indicate that statewide, of 9380.4 stream miles assessed (of 18,464.9 total), over 3000 have been use impaired due to nonpoint sources (KYDOW, 1988). Many more streams have been impacted without loss of use.

Agricultural use and resource extraction are identified as the most pervasive nonpoint source problems in Kentucky. Agricultural uses include cropland, pastureland and livestock operations with cropland being identified as the greatest problem. Resource extraction (surface and underground coal mines and oil and gas development) is the major nonpoint source of pollution in the eastern drainage basins of Kentucky. Agricultural impacts are greater in the western basins. Urban runoff has impacted several smaller watersheds.

The parameters identified as causing degradation of use or impact to waterbodies are identified as sediment, nutrients, sulfate, bacteria, chloride, and metals. Pesticides, arsenic, solid waste, and oil and grease are also identified but to a lesser degree. Table 8 presents a summary of the findings by river basin. The table outlines the major nonpoint sources causing the impact and the parameters attributed to the problem.

TABLE 8

Nonpoint Impacts on River Basins in Kentucky

River Basin	Kentucky Drainage Area Mi^2	Sources: Major	Sources: Minor	Parameters: Major	Parameters: Minor
Big Sandy	2284	Acid Mine Drainage Onsite Sewage Disposal		Sed., bact. SO_4, metals	Nutrients, chloride
Little Sandy	724	Resource Extraction Onsite Sewage Disposal Agriculture		Sed., bact., metals, SO_4 nutrients, chloride	
Tygarts Creek	340	Onsite Sewage Disposal Agriculture		Sed., bact., nutrients	Metals
Licking River	3707	Agriculture Solid Waste Disposal Resource Extraction	Feedlots Silviculture Urban	Sed., nutrients, bact. Metals, SO_4, Cl, Solid waste	Pesticides, Herbicides Oil & Grease
Ohio River Minor Tributaries (M.P. 360-460)		Agriculture	Urban (Four Mile Cr.)	Sed., Nutrients, bact.	Metals
Kentucky River	6966	Resource Extraction (Upper Basin) Agriculture (Lower Basin) Solid Waste Disposal	Onsite Sewage Disposal Stream Bank Erosion Construction Silviculture	Metals, SO_4, Cl, nutrients sed., solid waste	Pesticides (Lindane, DDT) As, pH, Oil & Grease
Ohio River Minor Tributaries (M.P. 575-540)		Urban Cropland		Sed., nutrients, bact.	
Upper Cumberland	4919	Resource Extraction Agriculture Silviculture	Urban Stream Bank Erosion	Sed., metals, nutrients, SO_4, bact.	Cl, Solid Waste pH

TABLE 8 (Continued)

Nonpoint Impacts on River Basins in Kentucky

River Basin	Kentucky Drainage Area Mi^2	Sources		Parameters	
		Major	Minor	Major	Minor
Salt River	2980	Agriculture	Construction Silviculture Urban (Pond Creek) Stream Bank Erosion	Sed., nutrients, bact.	Metals, Cl, As, DO
Ohio River Minor Tributaries (M.P. 546-700)		Agriculture	Urban (Goose Creek, Beargrass Creek)	Sed., nutrients	Metals, bact.
Green River Basin	8821	Agriculture Resource Extraction (Acid Mine Drainage)	Landfill Leachate Onsite Sewage Disposal Solid Waste Disposal	Sed., nutrients, bact., SO_4, metals	pH, iron, Cl, Pesticides, Solid Waste
Ohio River Minor Tributaries (M.P. 700-780)		Agriculture Resource Extraction	Urban (Yellow Creek)	Sed., Nutrients, metals, SO_4, bact.	
Lower Cumberland	1456	Agriculture	Silviculture	Sed., nutrient, bact.	Metals, iron, SO_4
Tradewater	943	Agriculture	Resource Extraction (Coal Mining)	Sed., SO_4, Conductance	Metals, pH
Ohio River Minor Tributaries (M.P. 780-870)		Agriculture	Resource Extraction (Oil & Gas Development)	Sed., Cl	Metals, pH, SO_4, iron
Tennessee	1000	Agriculture	Urban (Paducah)	Sed., nutrients, pesticides bacteria	
Ohio River Minor Tributaries (M.P. 935-981)		Agriculture		Sed., nutrients, bact.	Metals

4.6 Indiana

Approximately 14% of the Ohio River drainage basin lies in the State of Indiana. The terrain varies from the flat plains of the northern portion to the steep hills of the south central and southeastern part of Indiana (INDNR, 1980).

The Wabash basin is the predominant subbasin of the Ohio River in Indiana. There are two other Ohio River subbasins in Indiana: the Whitewater, and the minor tributaries of the Ohio River.

The Indiana Department of Environmental Management (IDEM) has identified agriculture (cropland) as the most pervasive nonpoint source pollution problem in Indiana. This conclusion was based on the results of a statewide survey and is not necessarily based on monitored observations. According to the IDEM, 40% of the croplands are eroding at faster than the tolerable rate (IDEM, 1988). Other nonpoint sources identified were resource extraction and urban runoff.

Parameters identified by the IDEM were nutrients, sediment, pesticides, priority organics, metals, organic enrichment, and pathogens. Several stream segments were listed by the IDEM due to fish tissue contaminated by PCBs, chlordane, and/or dieldrin.

4.7 Illinois

Approximately five percent of the Ohio River drainage basin lies in the State of Illinois. The Wabash is the principal subbasin of the Ohio River in Illinois. The Ohio River tributaries is the other drainage area identified by the Illinois Environmental Protection Agency (IEPA).

Agriculture is identified as having the greatest impact due to nonpoint sources with resource extraction and hydromodification impacting surface waters to a lesser degree. Table 9 shows the results of the assessment conducted by the IEPA. The principal causes of nonattainment of uses by nonpoint sources are identified as nutrients, siltation and habitat/flow modification.

TABLE 9

Total River Miles Not Fully Supporting Uses
By Cause Categories

ILLINOIS

	Wabash Basin		Ohio River Basin	
Source Category	Major Impact River Miles	Moderate/Minor Impact River Miles	Major Impact River Miles	Moderate/Minor Impact River Miles
Agricultural		688.6		
Nonirrigated Crop Production	71.9	603.3		276.9
Pasture Land				22.6
Urban Runoff		37.8		
Storm Sewers	14.0			
Surface Runoff		12.7		
Resource Extraction/Exploration				
Surface Mining			11.3	86.1
Subsurface Mining				6.6
Petroleum Activities		454.6		38.1
Mine Tailings		6.7		
Land Disposal				
Onsite Wastewater Systems	14.0			
Hydrologic/Habitat Modification		35.0		
Channelization		186.8	47.6	226.4
Removal of Riparian Vegetation				117.4
Streambank Modification/Destabilization				13.3
Source Unknown		11.5		

5.0 DATA ANALYSIS
(Commission Monitoring Data)

5.1 Introduction

Data analyses used data obtained from the Commission's manual sampling system, which currently consists of 36 stations, including 22 on the Ohio River and 14 on the lower reaches of the major tributaries. Samples are collected monthly at each station and analyzed for certain physical and chemical characteristics. These data are stored in STORET, the US EPA water quality data base, with stream flow data.

The analyses presented here uses a total of 37 stations, utilizing several stations which are currently not used but contain a larger period of record (for example Meldahl). The period of record for all of the analyses was the last 10 water years (10/01/78 through 09/31/88)

The Commission's monitoring system was not established to monitor the effects of nonpoint source pollution. Monitoring, specifically for runoff related pollution, would involve collecting samples during periods of high flow and during storm events. (The Commission data is collected at a wide range of flow levels. This allows analyses of the relationship of flow with concentrations of pollutant.)

An additional concern to the Commission is the presence of the toxic substances PCBs and chlordane in fish tissue. While no water column data is available to perform flow correlations, the results of fish tissue sampling are presented.

5.2 Methodology

In order to understand which parameters present in the water column are associated with nonpoint source pollution, correlations of parameter concentration with flow were performed. For the analysis presented here, the correlations were parameter concentration with the natural logarithm of flow. The correlations were run with conc. vs flow and ln(conc) vs ln(flow) with very little difference in the results. Using conc vs ln(flow) was the most appropriate model given the wide variability of the flow values.

Monitoring stations used for the analyses are shown in Table 10. In several cases, data from two stations were combined to give a full period of record. The results from the analyses are located by the station currently used.

These correlations were performed using the SAS Procedure CORR. (SAS, 1985) The output obtained provides the significance of the correlation along with the Pearson product-moment correlation coefficient.

A positive correlation with flow, (parameter concentration increases with flow), indicates the parameter is associated with runoff related sources. Conversely, a negative correlation with flow indicates, in most cases, the parameter is associated with point sources (constant loading to the system).

The exceptions to this are acid mine drainage and ground water infiltration. These sources are by definition nonpoint sources but the contributions are diluted with increased flow and they are considered a constant load on the system.

Land use patterns also have an effect on the contribution due to nonpoint sources. Croplands may provide high levels of sediment to surface waters during periods of runoff and with it associated agricultural chemicals. Mine disturbed lands have the potential for contributing acid mine drainage and sediment loads.

TABLE 10

COMMISSION MONITORING STATIONS USED FOR ANALYSIS

OHIO RIVER MILE POINT	STATION NAME	STORET #	RIVER	PERIOD OF RECORD BEGINNING DATE	PERIOD OF RECORD ENDING DATE	
0.0	PITTSBURGH WATER WORKS	AR7.4M	ALLEGHENY	07/15/86	CURRENT	COMBINED
0.0	OAKMONT WATER WORKS	AR13.3M	ALLEGHENY	11/03/75	09/03/86	
0.0	SOUTH PITTSBURGH	MR-4.5M	MONONGAHELA	11/03/75	CURRENT	
15.2	SOUTH HEIGHTS	OR9658M	OHIO	11/03/75	CURRENT	
25.4*	BEAVER FALLS	BR-5.3M	BEAVER	11/12/75	CURRENT	
40.2	EAST LIVERPOOL WATER WORKS	OR9408M	OHIO	12/11/75	CURRENT	
84.2	PIKE ISLAND L&D	OR8968M	OHIO	04/11/75	09/22/86	COMBINED
86.8	WHEELING WATER TREATMENT PLANT	OR894.2M	OHIO	10/04/86	CURRENT	
126.4	HANNIBAL L&D	OR8546M	OHIO	09/26/77	CURRENT	
161.8	WILLOW ISLAND L&D	OR8192M	OHIO	11/19/75	CURRENT	
172.2*	MUSKINGUM L&D #2	MU-5.8M	MUSKINGUM	11/19/75	CURRENT	
203.9	BELLEVILLE L&D	OR7771M	OHIO	11/11/75	CURRENT	
260.0	ADDISON - KYGER CREEK	OR7210M	OHIO	11/11/75	CURRENT	
265.7*	WINFIELD L&D	KR31.1M	KANAWHA	11/11/75	CURRENT	
279.2	GALLIPOLIS L&D	OR7018M	OHIO	11/11/75	CURRENT	
306.9	HUNTINGTON WATER CORPORATION	OR6741M	OHIO	11/11/75	CURRENT	
317.1	LOUISA	SR20.3M	BIG SANDY	11/10/75	CURRENT	

*Mile Point at confluence of tributary with the Ohio River

TABLE 10

COMMISSION MONITORING STATIONS USED FOR ANALYSIS
(Continued)

OHIO RIVER MILE POINT	STATION NAME	STORET #	RIVER	PERIOD OF RECORD BEGINNING DATE	ENDING DATE	
341.0	GREENUP L&D	OR6400M	OHIO	11/12/75	09/09/86	COMBINED
350.7	PORTSMOUTH WATER TREATMENT PLANT	OR630.3M	OHIO	10/23/86	CURRENT	
356.5	LUCASVILLE	SC15.0M	SCIOTO	11/12/75	CURRENT	
408.5	MAYSVILLE WATER WORKS	OR572.5M	OHIO	07/08/86	CURRENT	
436.2	MELDAHL L&D	OR5448M	OHIO	11/12/75	09/23/86	
462.8	CINCINNATI WATER WORKS	OR5182M	OHIO	11/07/75	CURRENT	
464.1*	NEWTOWN	LM-7.5M	LITTLE MIAMI	07/06/76	CURRENT	
470.2	COVINGTON	LR-4.5M	LICKING	11/18/75	CURRENT	
490.0*	NORTH BEND	OR4910M	OHIO	11/17/75	CURRENT	
491.1	ELIZABETHTOWN	GM-5.5M	GREAT MIAMI	11/10/75	CURRENT	
531.5	MARKLAND L&D	OR4495M	OHIO	11/17/75	CURRENT	
600.6	LOUISVILLE WATER COMPANY	OR3804M	OHIO	11/10/75	CURRENT	
625.9	WEST POINT	OR3551M	OHIO	11/10/75	CURRENT	
720.7	CANNELTON L&D	OR2603M	OHIO	11/13/75	CURRENT	
784.2*	SEEBREE	GR41.3M	GREEN RIVER	11/14/75	CURRENT	
791.5	EVANSVILLE WATER WORKS	OR1895M	OHIO	11/03/75	CURRENT	
846.0	UNIONTOWN L&D	OR1350M	OHIO	11/11/75	CURRENT	
848.0*	NEW HARMONY	WA9295M	WABASH	11/11/75	CURRENT	
918.5	SMITHLAND L&D	OR62.5M	OHIO	01/19/82	CURRENT	
952.3	JOPPA	OR28.7M	OHIO	11/17/75	CURRENT	

*Mile Point at confluence of tributary with the Ohio River

Stepwise regression analysis is a statistical procedure useful for evaluating the relationship between land use patterns and parameter concentration. These analyses were performed using land use as the independent variable and parameter concentrations as the dependent variable. The SAS stepwise procedure was utilized, with the maximum R^2 technique (SAS, 1985), for this analysis. The results of these analyses are presented in a qualitative form as it is unlikely water quality is solely a function of land use.

The majority of the land use data used for these analyses were obtained from the USDA National Resources Inventory data base. Other land use data was obtained from various sources as compiled in the Commission's Ohio River Water Quality Fact Book 1988.

5.3 Results of the Analyses

5.3.1 Correlation Analysis

Tables 11 and 12 show the results of the correlation analyses. Table 11 is a summary of the correlations for nutrients, sulfate, phenolics and cyanide. Table 12 is a summary of the correlations for metals. A "+" indicates a positive correlation exists ($p<0.1$), a "-" indicates a negative correlation with flow ($p<0.1$) and a "0" indicates no significant correlation exits.

Sulfate -

Sulfate negatively correlates with flow at 32 of the 33 stations. No significant correlation with flow is observed at Joppa (m.p. 952.3).

Hardness -

Hardness correlates negatively with flow at 29 of the 33 stations. No significant correlation with flow is

TABLE 11

FLOW CORRELATIONS

+ POS. CORR. WITH FLOW
- NEG. CORR. WITH FLOW
0 NO SIGNIFICANT (p>0.1) CORRELATIONS WITH FLOW

STATION	RIVER MILE	SULFATE	HARD.	TOTAL PHOSPH.	ORTHO-PHOSPH.	TKN	AMMONIA NITROGEN	NO3/NO2	PHENOLS	CYANIDE
OAK/PITT. WW - ALLEG. R.	0.0	-	-	+	0	0	0	+	0	0
S. PITTS. - MONONGAHELA R.	0.0	-	-	0	+	-	-	-	0	0
SOUTH HEIGHTS	15.2	-	-	0	-	-	-	+	0	0
BEAVER FALLS - BEAVER R.	25.4	-	-	0	-	-	0	-	0	0
EAST LIVERPOOL	40.2	-	-	+	-	0	-	0	0	0
WHEELING/PIKE ISLAND	86.8	-	-	+	0	+	0	-	0	0
HANNIBAL LOCK	126.4	-	-	+	0	0	0	0	+	0
WILLOW ISLAND	161.8	-	-	0	0	0	0	0	0	0
L&D #2 - MUSKINGUM R.	172.2	-	-	+	0	+	+	+	0	+
BELLEVILLE LOCK	203.9	-	-	+	0	0	0	+	0	0
ADDISON - KYGER CREEK	260.0	-	-	+	0	+	+	0	0	0
WINFIELD - KANAWHA R.	265.7	-	-	+	0	0	-	0	0	0
GALLIPOLIS LOCK	279.2	-	-	0	+	+	+	0	0	0
HUNTINGTON WW	306.9	-	-	0	0	+	0	0	0	0
LOUISA - BIG SANDY R.	317.1	-	-	0	+	+	0	+	0	0
PORTSMOUTH/GREENUP	350.7	-	-	+	+	+	0	0	0	0
LUCASVILLE - SCIOTO R.	356.5	-	-	0	-	-	0	+	0	0
MELDAHL	436.2	-	-	0	0	0	0	+	0	0
CINCINNATI WW	462.8	-	-	0	+	+	+	+	0	0
NEWTOWN - L. MIAMI R.	464.1	-	-	-	-	0	+	+	0	0
COVINGTON - LICKING R.	470.2	-	0	0	0	0	0	+	0	+
NORTH BEND	490.0	-	-	+	0	+	0	+	0	0
ELIZABETHTOWN - G. MIAMI R.	491.1	-	-	0	0	0	0	+	0	0
MARKLAND LOCK	531.5	-	-	+	+	+	0	+	+	0
LOUISVILLE WW	600.6	-	-	+	0	+	+	+	0	0
WEST POINT	625.9	-	-	+	0	+	0	0	0	0
CANNELTON	720.7	-	0	0	+	+	+	0	0	-

TABLE 11

FLOW CORRELATIONS

+ POS. CORR. WITH FLOW
- NEG. CORR. WITH FLOW
0 NO SIGNIFICANT (p>0.1) CORRELATIONS WITH FLOW

STATION	RIVER MILE	SULFATE	HARD.	TOTAL PHOSPH.	ORTHO-PHOSPH.	TKN	AMMONIA NITROGEN	NO3/NO2	PHENOLS	CYANIDE
SEBREE - GREEN RIVER	784.2	-	-	+	0	+	+	+	0	0
EVANSVILLE WW	791.5	-	-	+	+	+	+	+	0	0
UNIONTOWN L&D	846.0	-	-	+	0	+	+	+	0	0
NEW HARMONY - WABASH R.	848.0	-	-	+	+	0	0	+	0	+
SMITHLAND	918.5	-	0	-	+	0	0	+	+	0
JOPPA	952.3	0	+	-	+	+	+	+	0	0

TABLE 12

FLOW CORRELATIONS

+ POS. CORR. WITH FLOW
- NEG. CORR. WITH FLOW
0 NO SIGNIFICANT (p>0.1) CORRELATIONS WITH FLOW

STATION	RIVER MILE	ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	ZINC
OAK/PITT. WW - ALLEG. R.	0.0	+	0	+	0	+	0	0	0	+
S. PITTS. - MONONGAHELA R.	0.0	+	0	0	0	+	0	0	0	+
SOUTH HEIGHTS	15.2	0	0	0	0	+	0	0	0	+
BEAVER FALLS - BEAVER R.	25.4	0	0	0	0	+	0	0	0	+
EAST LIVERPOOL	40.2	0	0	0	0	+	0	0	0	+
WHEELING/PIKE ISLAND	86.8	0	0	+	0	+	0	0	0	+
HANNIBAL LOCK	126.4	+	0	+	0	+	0	0	0	+
WILLOW ISLAND	161.8	0	0	0	0	+	0	0	0	+
L&D #2 - MUSKINGUM R.	172.2	0	0	+	0	+	0	0	0	+
BELLEVILLE LOCK	203.9	0	0	0	0	+	0	0	+	+
ADDISON - KYGER CREEK	260.0	0	0	+	0	+	+	0	+	+
WINFIELD - KANAWHA R.	265.7	0	0	0	+	+	0	0	0	+
GALLIPOLIS LOCK	279.2	0	0	+	0	+	0	0	0	+
HUNTINGTON WW	306.9	0	0	0	0	+	0	0	0	0
LOUISA - BIG SANDY R.	317.1	+	0	0	0	+	0	0	0	+
PORTSMOUTH/GREENUP	350.7	0	0	0	0	+	+	0	+	+
LUCASVILLE - SCIOTO R.	356.5	0	0	0	0	+	0	0	0	0
MELDAHL	436.2	0	0	0	0	+	0	0	+	0
CINCINNATI WW	462.8	0	0	0	0	+	0	0	0	+
NEWTOWN - L. MIAMI R.	464.1	0	0	0	0	+	0	0	0	0
COVINGTON - LICKING R.	470.2	0	0	0	0	+	+	0	0	0
NORTH BEND	490.0	0	0	0	0	+	+	0	0	+
ELIZABETHTOWN - G. MIAMI R.	491.1	0	0	0	+	+	0	0	0	+
MARKLAND LOCK	531.5	+	0	0	0	+	0	0	0	+
LOUISVILLE WW	600.6	+	0	0	0	+	+	0	0	+
WEST POINT	625.9	+	+	0	+	+	+	0	+	+
CANNELTON	720.7	0	0	0	0	+	0	+	0	+

TABLE 12

FLOW CORRELATIONS

+ POS. CORR. WITH FLOW   - NEG. CORR. WITH FLOW
0 NO SIGNIFICANT ($p>0.1$) CORRELATIONS WITH FLOW

STATION	RIVER MILE	ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	ZINC
SEBREE - GREEN RIVER	784.2	0	0	0	0	+	0	0	0	0
EVANSVILLE WW	791.5	+	0	0	+	+	0	0	+	+
UNIONTOWN L&D	846.0	0	0	0	+	+	+	0	0	+
NEW HARMONY - WABASH R.	848.0	0	-	+	+	+	-	+	0	+
SMITHLAND	918.5	0	-	0	+	+	0	0	0	+
JOPPA	952.3	0	0	0	0	+	0	+	0	+

observed at Covington (Licking River - Ohio River M.P. 464.1), Cannelton (M.P. 720.7), and Smithland (M.P. 918.5). Hardness showed a positive correlation with flow at Joppa (M.P. 952.3).

Total Phosphorus -

Total phosphorus correlates positively with flow at 17 stations, has no significant correlation with flow at 13 stations, and three negative correlations with flow (Little Miami River, Smithland (M.P. 918.5) and Joppa (M.P. 952.3). Most of the positive correlations were seen at monitoring stations located between Ohio River miles 40.2 - 350.7 and 490.0 - 952.3.

Ortho - Phosphates -

Ortho - phosphates correlates positively with flow at 11 stations, has no significant correlation with flow at 17 stations and negatively correlates with flow at five stations. The majority of the positive correlations are observed in the lower 350 miles of the Ohio River.

Total Kjeldahl Nitrogen -

Total Kjeldahl nitrogen correlates positively with flow at 17 stations, has no significant correlations with flow at 12 stations and a negative correlation with flow at four stations. All of the Ohio River stations from Markland (M.P. 531.5) to Uniontown (M.P. 846.0) show a positive correlation with flow.

Ammonia Nitrogen -

Ammonia nitrogen is positively correlated with flow at 11 stations, has no significant correlation with flow at 18 stations and is negatively correlated with flow at four stations. A majority of the positive correlations are observed in the lower half of the Ohio River.

Nitrate/Nitrite Nitrogen -

Nitrate/nitrite nitrogen is positively correlated with flow at 20 stations, has no significant correlation with at 10 stations and a negative correlation with flow at three stations. The majority (15) of the stations showing a positive correlation are from the Scioto River (Ohio River M.P. 356.5) downstream to Joppa (M.P. 952.3). Of the other six stations showing a positive correlation three are on tributaries, the Allegheny, the Muskingum, and the Big Sandy Rivers.

Phenolics -

Phenolics are positively correlated with flow at three stations (Hannibal,(M.P. 126.4), Markland (M.P. 531.5) and Smithland (M.P. 918.5)), and have no significant correlation with flow at 30 stations.

Cyanide -

Cyanide is positively correlated with flow at two stations (Muskingum River (M.P. 172.2), and Licking River (M.P. 470.2)), has no significant correlation with flow at 30 stations and a negative correlation with flow at one station.

Arsenic -

Arsenic is positively correlated with flow at eight stations and has no significant correlation with flow at 25 stations.

Cadmium -

Cadmium is positively correlated with flow at one station (West Point M.P. 625.9), has no significant correlation with flow at 30 stations and two stations demonstrating negative correlation of cadmium concentration with flow.

Chromium -

Chromium is positively correlated with flow at seven stations and has no significant correlations with flow at 26 stations.

Copper -

Copper is positively correlated with flow at seven stations, has no significant correlations with flow at 26 stations, and is negatively correlated with flow at one station. Four of the eight stations exhibiting a positive relationship are in the lower river, from the Evansville (M.P. 791.5) station to the Smithland (M.P. 918.5) station.

Iron -

Iron is positively correlated with flow at all stations.

Lead -

Lead is positively correlated with flow at seven stations, has no correlations at 25 stations and is negatively correlated with flow at one station (Wabash River).

Mercury -

Mercury is positively correlated with flow at three stations (Cannelton M.P. 720.7, Wabash River, Joppa M.P. 952.3), and has no correlations with flow at 30 stations.

Nickel -

Nickel is positively correlated with flow at six stations, and has no significant correlations with flow at 27 stations.

Zinc -

Zinc is positively correlated with flow at 27 stations and has no significant correlations with flow at six stations. Of the stations which exhibit no significant correlation with flow only two, Huntington (M.P. 306.9) and Meldahl (M.P. 531.1) are on the Ohio River.

Figures 5-9 provide a schematic of the Ohio River and associated major tributaries. The figures show which parameters are positively correlated with flow. Land use information is presented for the major tributary basins. Sulfate, which is negatively correlated with flow, is also included as indicating acid mine drainage contribution.

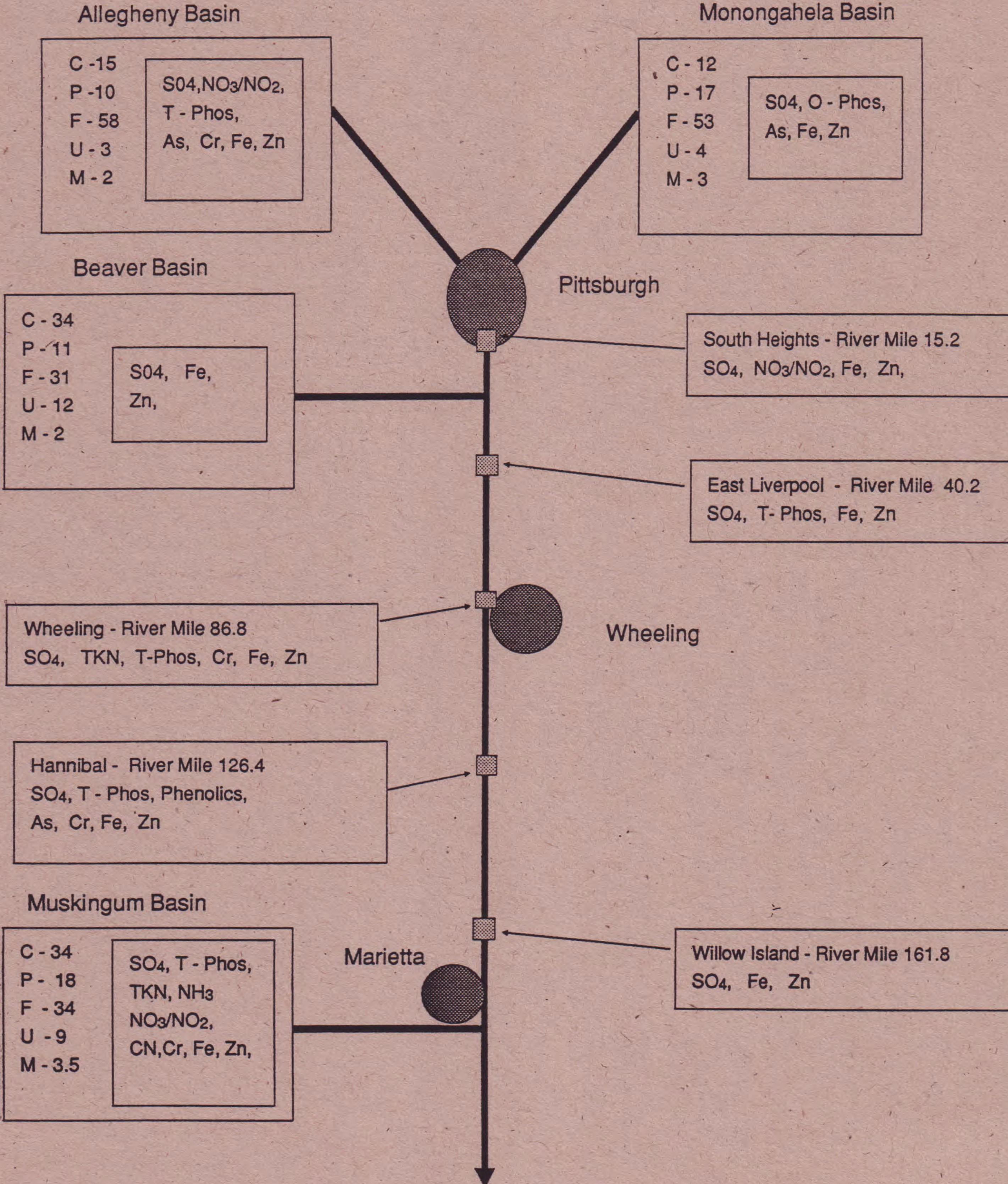
5.3.1.1 Limitations to the Correlation Analysis

Correlation analysis provides some insight to the relative contribution from point and nonpoint sources. In general, a positive correlation with flow indicates runoff related sources are the major contributor, a negative correlation with flow indicates point sources are the major contributor and no significant correlation with flow indicates a combination of sources.

The limitations to the analyses include:

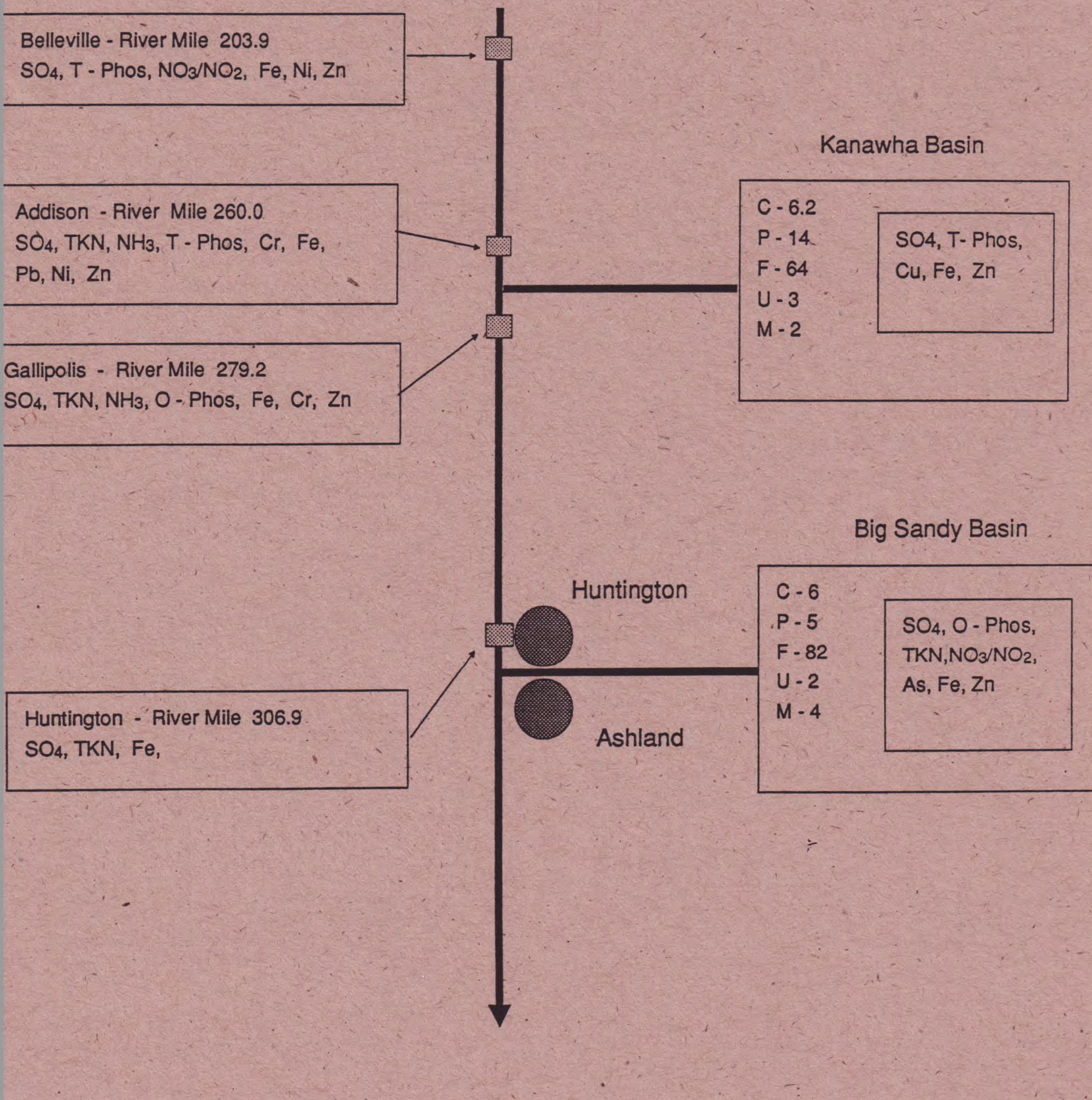
1. Some of the parameters used for analysis are monitored on a quarterly schedule or an irregular schedule. Parameters monitored quarterly are As, Cr, and Ni. This provides a limited data base, with the data collected in

FIGURE 5
LAND USE AND NONPOINT SOURCE RELATED PARAMETERS
OHIO RIVER MILES 0 - 200



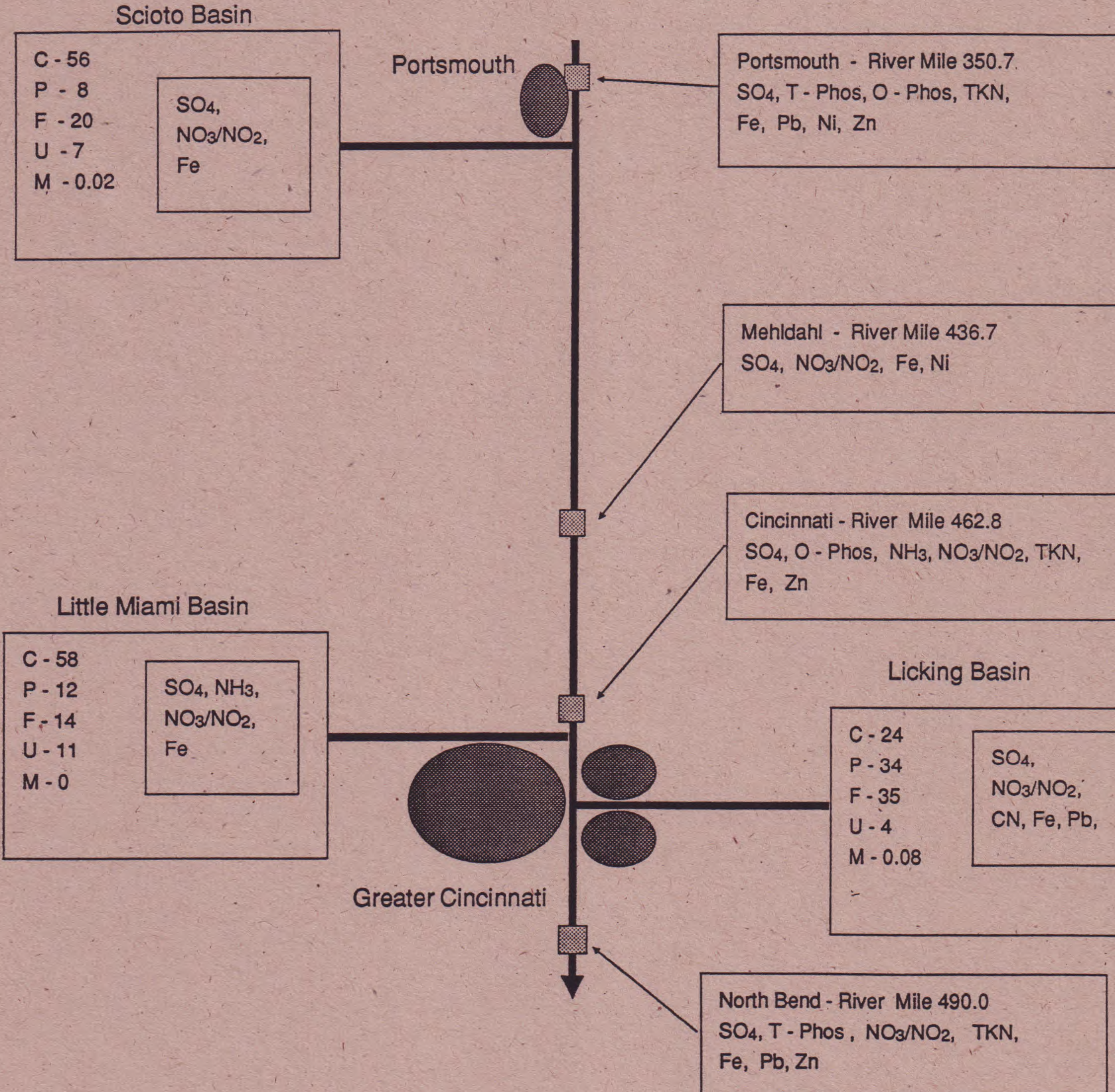
C - % Cropland, P - % Pastureland, F - % Forest Land, U - % Urban, M - Mine Disturbed Lands

FIGURE 6
LAND USE AND NONPOINT SOURCE RELATED PARAMETERS
OHIO RIVER MILES 200 - 350



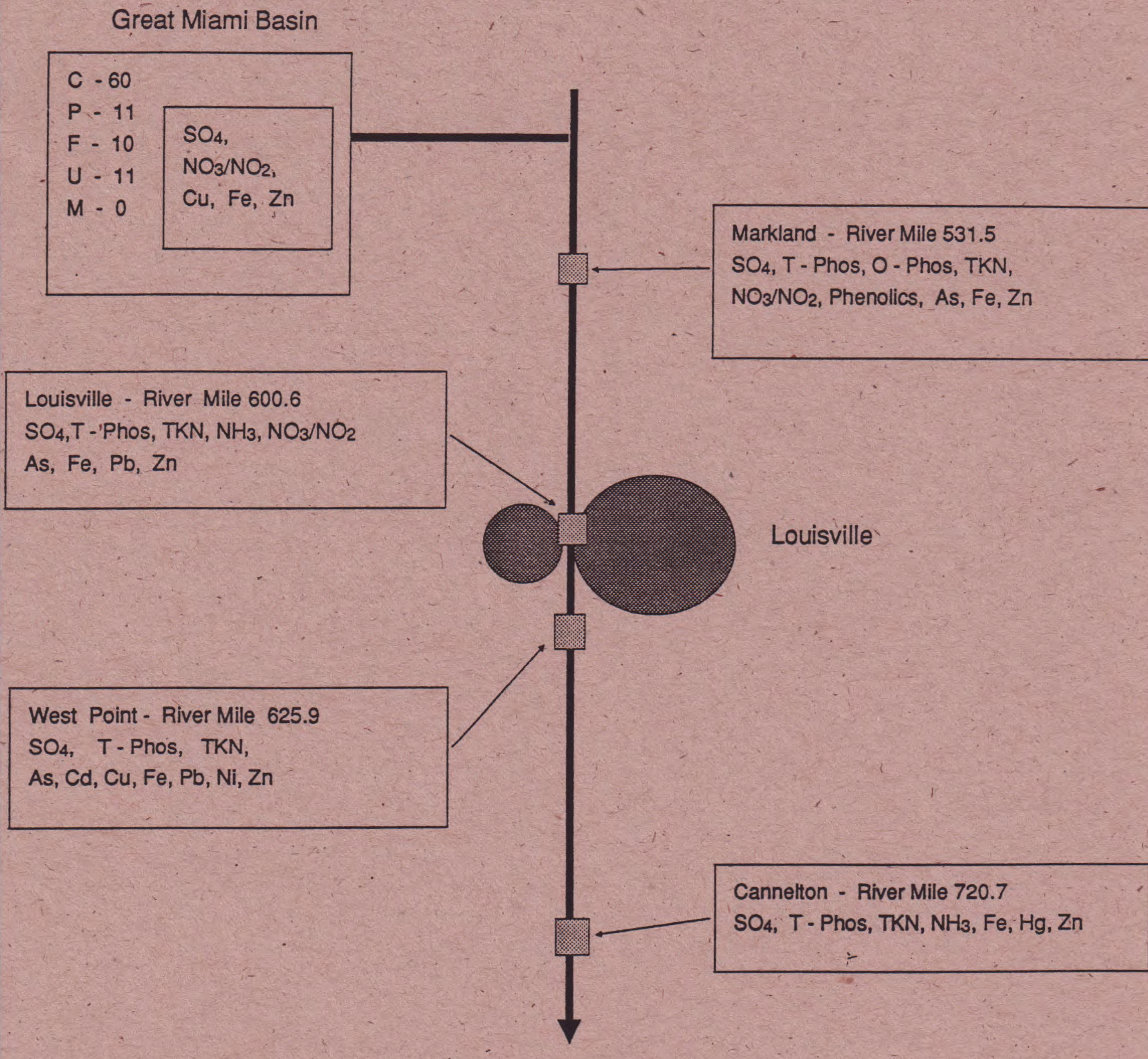
C - % Cropland, P - % Pastureland, F - % Forest land, U - % Urban, M - % Mine Disturbed Lands

FIGURE 7
LAND USE AND NONPOINT SOURCE RELATED PARAMETERS
OHIO RIVER MILES 350 - 490



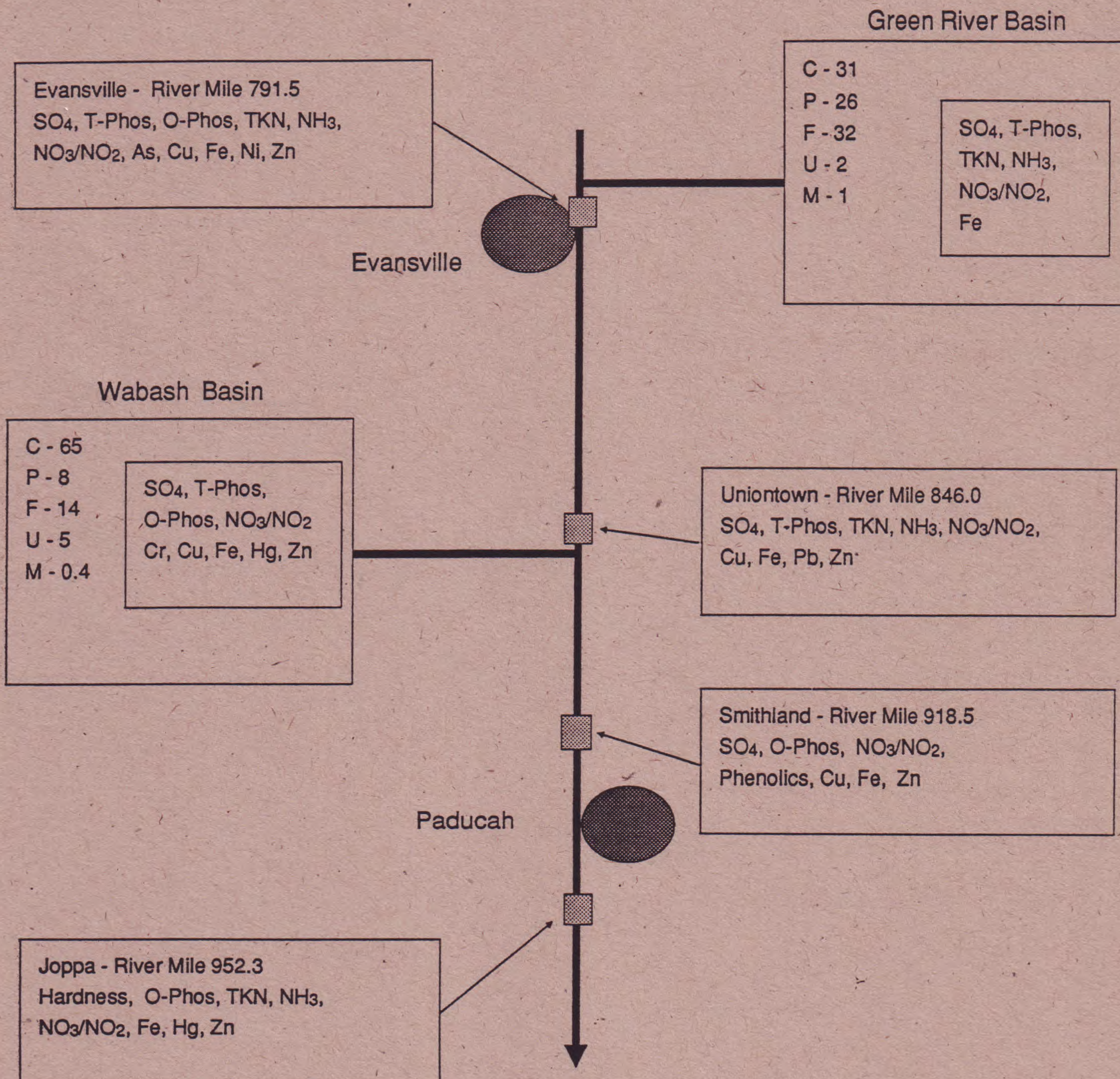
C - % Cropland, P - % Pastureland, F - % Forest Lands, U - % Urban, M - % Mine Disturbed Lands

FIGURE 8
LAND USE AND NONPOINT SOURCE RELATED PARAMETERS
OHIO RIVER MILES 490 - 750



C - % Cropland, P - % Pastureland, F - % Forest Land, U - % Urban, M % Mine Disturbed Lands

FIGURE 9
LAND USE AND NONPOINT SOURCE RELATED PARAMETERS
OHIO RIVER MILES 750 - 981



C - % Cropland, P - % Pastureland, F - % Forest Lands, U - % Urban, M - % Mine Disturbed Lands

January, April, June, and October. Of these months elevated flow levels would only be expected in April.

2. At many stations nutrient analysis is conducted from May through October only. This eliminates data from peak runoff periods of March and April.

3. Contributions due to ground water and acid mine drainage may be masked by point sources.

4. The analyses performed assumes the data is normally distributed whereas water quality data typically show a skewed distribution

5.3.2 Stepwise Regression

Stepwise regression analyses were performed to determine the extent of the relationship between parameter concentration and land use patterns. The data were analyzed on a basin wide basis, using land use data (see section 2, table 1) from the subbasins and the monitoring data from the same subbasins. Of the 21 parameters analyzed eight, BOD, TDS, sulfate, ammonia nitrogen, nitrite/nitrate nitrogen, manganese, hardness, and orthophosphate, demonstrated land use has at least a slight effect on parameter concentration.

It should be noted, except for manganese, the variation of metals concentration cannot be explained by examining land use patterns. This is significant, most use impairment in the Ohio River is due to metals.

For the purposes of this presentation the following qualitative limits are used:

Slight $0.1 \leq R^2 < 0.3$

Moderate $0.3 \leq R^2 < 0.7$

Strong $0.7 \leq R^2 < 1.0$

Table 13 is a qualitative exhibit of the results of this analysis, including only those parameters which demonstrated an $R^2 \geq 0.1$ (slight).

TABLE 13

EFFECT OF LAND USE ON PARAMETER CONCENTRATION
OHIO RIVER BASIN

Parameter	Influence	Land Use Effecting Parameter Concentrations
BOD	Slight	Pasture, Forest, Urban
TDS	Moderate	Pasture, Forest, Urban, Cropland, Mine lands
Sulfate	Moderate	Cropland, Urban, Mine lands
Ammonia Nitrogen	Slight	Cropland, Pasture, Forest, Urban
Nitrite/Nitrate	Slight	Cropland
Manganese	Slight	Cropland, Pasture, Urban, Forest, Mine lands
Hardness	Moderate	Cropland, Pasture, Urban, Forest, Mine lands
Ortho-Phosphates	Moderate	Cropland, Pasture, Urban, Forest, Mine lands

The limitations to this analysis include:[1]

1) The effects of point sources of pollution are not taken into account. To some degree, they may be reflected under urban land use.

2) The separate land uses are not independent of each other. For example, it is obvious that the percentage of cropland is dependent on the percentage of the other land uses.

With the limitations in mind it can be stated for some parameters there is a relationship between land use and parameter concentration.

5.4 Fish Tissue

Bioaccumulation of pesticides and PCBs in fish tissue provides a direct route of exposure for humans consuming the fish. Monitoring for these parameters is limited to analysis of fish tissue because levels in the water column are typically lower than laboratory detection levels. Therefore only limited data is available.

PCBs and chlordane have been identified by the Commission as parameters of concern due to their presence in fish tissue at levels exceeding the FDA action levels. The levels were established to control levels of contaminants in foods in interstate commerce. While the levels established by the FDA were not intended for use in determining the safety in consumption of fish taken by sport fishermen, they do provide guidance for data

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[1] From an Assessment of Water Quality Conditions, Ohio River Water Years 1986-87, Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio 1988.

interpretation until more appropriate risk based methods are developed. Table 14 provides a summary of the exceedances in samples collected in 1987 and 1988.

In general the exceedances of the chlordane action level were found down river from urban areas as were the majority of the PCB exceedances. This indicates chlordane and to a lesser extent PCBs are contributed to the Ohio River from urban runoff. This is accentuated by the condition observed on the Great Miami River, an urbanized watershed (>10% urban), which is of specific concern to the Commission due to PCB contamination of fish tissue. Fish tissue analyses conducted by the Ohio EPA have indicated that PCBs have been a long term problem in the Great Miami River. Additional fish collection and analysis is planned as part of the Commissions Toxic Substances Control Program.

TABLE 14

SUMMARY OF COMPOSITE FISH TISSUE DATA - 1987, 1988
EXCEEDING U.S. FDA ACTION LEVELS

PCB'S
FDA ACTION LEVEL: 2.0 mg/kg (wet wt.)

SITE	FISH SPECIES	CONCENTRATION (mg/kg) 1987	1988
Dashields (R.M. 13.2)	Carp	3.78	--
	Channel Catfish	3.51	3.56
New Cumberland (R.M. 54.4)	Carp	6.68	2.51
	Channel Catfish	--	2.57
Hannibal (R.M. 126.4)	Carp	--	2.32
	Channel Catfish	--	2.84
Willow Island (R.M. 161.7)	Carp	2.04	--
Gallipolis (R.M. 279.2)	Channel Catfish	2.27	--
Cincinnati (R.M. 472.8)	White Bass	3.24	--
	Channel Catfish	2.76	2.54
McAlpine (R.M. 606.8)	Channel Catfish	--	4.60
West Point (R.M. 625.9)	White Bass	2.20	--
	Carp	--	2.35
	Channel Catfish	4.94	--
Smithland (R.M. 918.5)	Channel Catfish	2.48	NS

CHLORDANE
FDA ACTION LEVEL: 0.3 mg/kg (wet wt.)

SITE	FISH SPECIES	CONCENTRATION (mg/kg) 1987	1988
Dashields (R.M. 13.2)	Channel Catfish	0.36	0.35
Hannibal (R.M. 126.4)	Carp	--	0.33
	Channel Catfish	--	0.36
Willow Island (R.M. 161.7)	Carp	--	0.37
Marietta (R.M. 172.5)	Channel Catfish	0.39	0.35
Cincinnati (R.M. 472.8)	Channel Catfish	0.3	--
West Point (R.M. 625.9)	Carp	0.76	6.25
	Channel Catfish	0.88	--
Smithland (R.M. 918.5)	Channel Catfish	2.48	NS

-- = Results did not exceed FDA Action Level
NS = Not Sampled

6.0 CONCLUSIONS

6.1 Discussion

Evaluation of the sources and effects of nonpoint source pollution on a large river system is complex due to the large number of inputs to the system. In the case of the Ohio River and the associated tributary basins, there is a wide range of land uses and topographical features, which all contribute nonpoint source related pollution. One must also consider the inputs of point sources which may mask or be masked by the contribution due to nonpoint sources. The lack of nonpoint specific monitoring data exacerbates the problem. The Commission monitoring data is more characteristic of average conditions, as is reflected by flow.

Based on the analysis presented, some conclusions can be made with regard to the effects of nonpoint sources and the parameters associated with those sources.

Table 15 shows the locations where use impairment can be attributed to nonpoint sources. This is based on those parameters impairing designated uses (ORSANCO 1988) of the Ohio River which also show a positive correlation with flow.

TABLE 15
USE IMPAIRMENT DUE TO NONPOINT SOURCES

STATION	MP	PARAMETERS
Hannibal	126.4	As, Phenolics
Belleville	203.9	Ni
Addison	260.0	Pb, Ni
Ashland	319.7	As, Pb
Portsmouth	350.7	As, Pb
North Bend	490.0	Pb
Markland	531.5	As, Phenolics
Louisville	600.6	As, Pb
West Point	625.9	As, Pb, Ni
Cannelton	720.7	Hg
Evansville	791.5	As, Ni, Zn
Uniontown	846.0	Pb, Zn
Paducah	935.5	As
Joppa	952.3	Hg

Loading analyses presented in the Commission's 1988 305(b) report indicated contributions of these parameters by point sources were not significant. This led to the conclusion that nonpoint source pollution caused a major impact on the full length of the Ohio River. While this may be true, the analysis presented in this report does not fully support that conclusion. Two points can be made with regard to this:

- Point source discharges on tributaries may be contributing significant loadings.

- The Commission manual monitoring data is not typically collected during periods of high flows. This would cause the impact due to nonpoint source pollution to be understated.

The effects of resource extraction and in particular acid mine drainage, are the predominant nonpoint source problem in the upper part of the Ohio River Basin, that portion of the basin drained by the first 350 miles of the Ohio River. The negative correlation with flow of sulfate is an indication of these effects. Any metals associated with acid mine drainage would not be expected to behave in the same manner as sulfate. The metals would precipitate from solution as the acid mine drainage is buffered by the receiving stream. These metals may be subsequently suspended during high flows caused by storm events.

It appears that nickel may be associated with resource extraction at the monitoring stations located from mile point 203.9 to mile point 306.9. The Ohio EPA identified resource extraction as the major problem in the drainage area identified as the Southeast Ohio River tributaries. The positive correlation with flow to iron, zinc and chromium and the negative correlation with flow to sulfate may also be explained by mining impacts. The behavior of trace metals resulting from acid mine drainage and eventual impact on larger, downstream waterbodies is not well understood.

The effects of agriculture, cropland in particular, is the dominant nonpoint source in the lower Ohio River Basin, (that portion of the Ohio River basin drained by the lower 350 miles of the river.) The impacts of agricultural development are observed in the positive correlation with flow of nitrogen and phosphorous compounds. These compounds have not been identified as causing degradation of designated use in the Ohio River. Analysis regarding long term trends of these compounds is being carried out by the Commission.

It appears agricultural activities may also be contributing loadings of trace metals, such as copper, mercury and zinc. These metals are present in agricultural chemicals such as pesticides, herbicides and fungicides. This would explain the occurrence in the lower river where there are no identified point sources of the metals, and agriculture is the dominant land use.

In the central Ohio River Basin, that portion of the Ohio River basin drained by the middle 280 miles of the Ohio River, there appears to be a combination of effects from resource extraction and agricultural sources. The agricultural impacts in this section of the river are typically from the tributaries to the north and the impacts from resource extraction are from the tributaries from the south.

The effects of urban runoff are apparent at monitoring stations in the vicinities of Pittsburgh, PA, Wheeling, WV, Huntington, WV, Portsmouth, OH, Cincinnati, OH, and Louisville, KY. The Beaver, Scioto, Little Miami, Great Miami, and Licking Rivers all appear to be impacted by urban runoff. These impacts are indicated by the positive correlation with flow of certain metals such as arsenic, chromium, lead, nickel, and zinc at monitoring stations downstream from urban areas or in water sheds with a high percentage of land use identified as urban. The behavior of these metals, specifically in the upper 85 miles of the Ohio River, may be due in part to runoff from industrial sites such as steel mills or chemical manufacturing sites. It should be noted that the Commission's analyses do not differentiate between overland urban runoff and the contribution from storm or combined sewers.

Of additional concern to the Commission is the presence of elevated levels of toxic substances, such as PCBs and chlordane, found in fish tissue. It appears the areas where the FDA action level for chlordane are exceeded are downstream of urban areas. PCB problems are not as well defined and it appears the problem is more wide spread.

6.2 Conclusions

1. Contributions due to nonpoint sources are causing degradation of designated uses in certain reaches of the Ohio River.

2. Agricultural and resource extraction activities have the greatest impact on water quality of the Ohio River.

3. Resource extraction, mine drainage in particular, is the dominant nonpoint source in the upper Ohio River basin, the area drained by the upper 350 miles of the Ohio River.

4. Agricultural activities, crop production in particular, is the dominant nonpoint source in the lower Ohio River Basin, the area drained by the lower 350 miles of the Ohio River.

5. A combination of effects from resource extraction and agricultural activities is observed in the area drained by the middle 281 miles of the Ohio River.

6. The drainage area identified as the southeast Ohio River Tributaries (State of Ohio) appears to be contributing loadings of nickel to the Ohio River such that the designated use as a drinking water is moderately impaired. (Partially supporting)

7. Urban runoff contributes loadings of metals and may be causing exceedances of water quality criteria.

8. Excessive levels of chlordane present in fish tissue are associated with urban runoff.

9. Contamination of fish tissue by PCB's appears to be a basin wide problem.

6.3 Recommendations

Because of the impact due to nonpoint sources and the lack of nonpoint source specific water quality data several recommendations can be made. The recommendations are aimed at enhancing the understanding of the magnitude of nonpoint source pollution in the Ohio River Basin and providing the impetus towards abating the problem on a basinwide scale.

While the Commission is not in the position to establish a basinwide nonpoint source management plan, it can set goals for improvement and coordinate efforts throughout the basin. Targeting the Ohio River for improvement would establish goals for pollutant loadings from tributaries to the Ohio River. This has been the type of approach taken for abatement of nonpoint source pollution to Lake Erie and the Chesapeake Bay.

It is therefore recommended that the Ohio River Valley Water Sanitation Commission

(1) Establish goals for reducing loads of nonpoint source pollutants to the Ohio River.

(2) Coordinate efforts among the basin states to ensure that goals will be achieved.

(3) Meet with the International Joint Commission of the Great Lakes and personnel involved with the Chesapeake Bay agreement to gain insight into how these programs have approached nonpoint source pollution management on an interstate basis.

(4) Modify its monitoring strategy to reflect a greater emphasis on nonpoint source pollution.

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