FERC/FEIS-0051

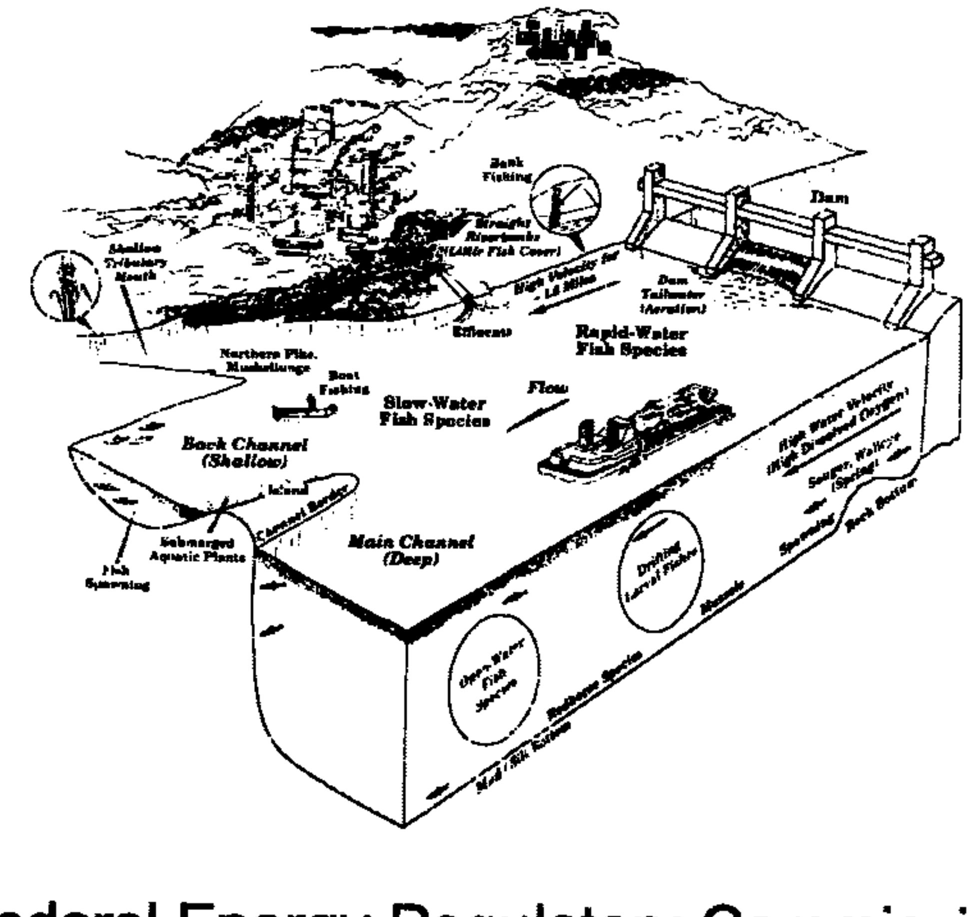
Part 1 of 2

Filed: 10/1/88

HYDROELECTRIC DEVELOPMENT
IN THE
UPPER OHIO RIVER BASIN
FERC Docket No. EL85-19-114

Ohio, Pennsylvania, West Virginia

FINAL
Environmental Impact Statement



Federal Energy Regulatory Commission
Office of Hydropower Licensing

September 1988

FERC – FEIS

Hydroelectric Development
In the Upper Ohio River Basin under:

EL85-19-114
P-7914-003
P-7909-002
P-4474-003
P-4017-002
P-7307-000
P-7399-000
P-8990-000
P-8654-001
P-7660-000
P-8908-000
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P-7041-001
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P-3490-003
P-6901-001
P-10332-000
P-3218-001
P-6902-003
P-9999-000
P-6939-001
P-9042-000
P-10098-000
P-6998-0001

FINAL ENVIRONMENTAL IMPACT STATEMENT
HYDROELECTRIC DEVELOPMENT IN THE UPPER OHIO RIVER BASIN

SEPTEMBER 1988

OFFICE OF HYDROPOWER LICENSING
FEDERAL ENERGY REGULATORY COMMISSION

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OFFICE OF HYDROPOWER LICENSING

FINAL ENVIRONMENTAL IMPACT STATEMENT

HYDROELECTRIC DEVELOPMENT IN THE UPPER OHIO RIVER BASIN

DOCKET NO. EL85-19-114

Applicants: 1/ Allegheny Electric Cooperative (FERC No. 2971)
Allegheny Hydropower, Inc. (FERC No. 7914)
Borough of Brownsville, Washington County Board of Commissioners, and Pennsylvania Renewable Resources, Inc., (FERC No. 8908)
Borough of Charleroi, Washington County Board of Commissioners, and Pennsylvania Renewable Resources, Inc., (FERC No. 4675)
Borough of Cheswick, Pennsylvania, and Allegheny Valley North Council of Governments (FERC No. 4474)
Borough of Point Marion, Pennsylvania, and Noah Corporation (FERC No. 7660)
City of Grafton, West Virginia (FERC No. 7307)
City of Jackson, Ohio (FERC No. 6939)
City of New Martinsville, West Virginia (FERC Nos. 6901 and 6902)
City of Orrville, Ohio (FERC No. 3218)
City of Pittsburgh, Pennsylvania (FERC No. 4017)
City of Point Pleasant, West Virginia, and WV Hydro, Inc. (FERC No. 10098)
City of St. Marys, West Virginia (FERC No. 9999)
County of Allegheny (FERC Nos. 7568 and 7909)
Gallia Hydro Partners (FERC No. 9042)
Noah Corporation (FERC Nos. 7399, 8990, and 8654)
Potter Township (FERC Nos. 3490 and 7041)
Upper Mississippi Water Company, Inc. (FERC No. 6998)
WV Hydro, Inc. (FERC No. 10332)

1/ Full name and address of each applicant are provided in Appendix A.

Additional copies of the Final EIS are available from:

Division of Public Information
Federal Energy Regulatory Commission
825 North Capitol Street, NE
Washington, DC 20426

September 1988

COVER SHEET

a. Title: Hydroelectric Development in the Upper Ohio River Basin

Applications for FERC licenses to construct, operate, and maintain 24 proposed hydroelectric projects at 19 sites in the Upper Ohio River Basin

b. Final Environmental Impact Statement

c. Lead Agency: Federal Energy Regulatory Commission

d. Cooperating Agency: The Department of the Army, Corps of Engineers

e. Abstract: Twenty-four hydroelectric projects (including competing applications at five sites) that would produce a total of 1910 gigawatt-hours per year of electric power and would be sited at 19 existing dams in the upper Ohio River Basin have been evaluated to determine the environmental effects and economic benefits. Four hydroelectric generation alternatives were evaluated, as well as a non-hydroelectric alternative consisting of a 400-megawatt coal-fired power plant. The cumulative and site-specific impacts of the projects were evaluated, taking into account the potential for mitigating adverse impacts. The staff recommends the fourth hydroelectric alternative, which would allow development of hydroelectric projects at 16 of the 19 proposed sites. This alternative allows for generation of 82 percent of the power proposed by project applicants, prevents projects from causing dissolved oxygen concentrations low enough to affect aquatic life, and avoids significant adverse impacts to wetlands, fisheries, and recreation. This alternative would produce 1560 gigawatt-hours per year of electric power and avoid or minimize all significant environmental impacts to target resources.

f. Contact: Mr. George H. Taylor
Federal Energy Regulatory Commission
Office of Hydropower Licensing
825 North Capitol Street, NE
Washington, DC 20426
Telephone (202) 376-1900

g. Copies of the final environmental impact statement are available for public review at the New York Regional Office of FERC.

h. This final environmental impact statement (FEIS) has been prepared by the Commission's staff in connection with applications filed by Allegheny Hydropower, Inc., for proposed project No. 7914; County of Allegheny for proposed projects Nos. 7909 and 7568; the Borough of Cheswick and the Allegheny Valley North Council of Governments for proposed project No. 4474; the City of Pittsburgh for proposed project No. 4017; the City of Grafton for proposed project No. 7307; Noah Corporation for proposed projects Nos. 7399, 8990, and 8654; the Borough of Point Marion and Noah Corporation for proposed project No. 7660; the Borough of Brownsville, the Washington County Board of Commissioners, and Pennsylvania Renewable Resources, Inc., for proposed project No. 8908; the Borough of Charleroi, Washington County Board of Commissioners, and Pennsylvania Renewable Resources, Inc., for proposed project No. 4675; Allegheny Electric Cooperative, Inc., for proposed project No. 2971; Potter Township for proposed projects Nos. 7041 and 3490; the City of New Martinsville, West Virginia, for proposed projects Nos. 6901 and 6902; WV Hydro, Inc., for proposed project No. 10332; the City of Orrville, Ohio, for proposed project No. 3218; the City of St. Marys, West Virginia, for proposed project No. 9999; the City of Jackson, Ohio, for proposed project No. 6939; Gallia Hydro Partners for proposed project No. 9042; the City of Point Pleasant, West Virigina, and WV Hydro, Inc., for proposed project No. 10098; and the Upper Mississippi Water Company, Inc., for proposed project No. 6998. The FEIS is being made available to the public on or about September 30, 1988, as required by the National Environmental Policy Act of 1969 and the Commission's Regulations Implementing the National Environmental Policy Act of 1969 (52 FR 47897; 47910-47911; December 17, 1987).

FOREWORD

The Federal Energy Regulatory Commission (FERC), pursuant to the Federal Power Act (FPA) 1/ and the U.S. Department of Energy (DOE) Organization Act 2/ is authorized to issue licenses for terms up to 50 years for the construction and operation of non-federal hydroelectric developments subject to its jurisdiction, on the necessary conditions:

> (T)hat the project adopted . . . shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water power development, for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds), and for other beneficial public uses, including irrigation, flood control, water supply, and recreational and other purposes referred to in section 4(e) . . . 3/

The Commission may require such other conditions not inconsistent with the provisions of the FPA as may be found necessary to provide for the various public interests to be served by the project. 4/ Compliance with such conditions during the license period is required. Section 385.206 (1987) of the Commission's Rules of Practice and Procedure allows any person objecting to a licensee's compliance with such conditions to file a complaint noting the basis for such objection for the Commission's consideration. 5/

1/ 16 U.S.C. §§791(a)-825(r), as amended by the Electric Consumers Protection Act of 1986, Pub. L. 99-495 (1986).

2/ Pub. L. 95-91, 91 Stat. 556 (1977).

3/ 16 U.S.C. §803(a) (1).

4/ 16 U.S.C. §803(g).

5/ 18 C.F.R. §385.206 (1988).

ACKNOWLEDGMENTS

An environmental impact study of this scope could not have been completed without the assistance of many agencies and individuals. Evaluation of impacts and mitigative measures for entrainment and turbine-induced mortality was greatly assisted by the contributions of participants in a workshop held on December 8-9, 1987, in Charleston, West Virginia. The assessment of impacts to recreational fishing was greatly assisted by the contributions of participants in a recreation workshop held on November 2-3, 1987. Workshop participants included representatives from the Ohio Department of Natural Resources, the Pennsylvania Fish Commission, the West Virginia Department of Natural Resources, Huntington and Pittsburgh Districts of the Army Corps of Engineers (Corps), and the U.S. Fish and Wildlife Service.

The following individuals have been especially helpful in providing information and advice during the preparation of this environmental impact statement.

Mike Koryak, Corps, Pittsburgh District, for water quality data and information, review of methods and results, advice, and escorting staff on site visits.

Rose Reilly, Corps, Pittsburgh District, for wetlands information and maps.

Bob Schmitt, Alex Barna, Al Rogalla, Pat Clancy, and their colleagues at the Corps, Pittsburgh District, Hydraulics and Hydrology, Reservoir Regulation, and Surveying sections for information, advice, data, maps, aerial photographs, and other assistance.

George Kincaid, Huntington District, for water quality information.

Ron Yates, Mark Anthony, Dan Steiner, Jack Kepler, and their colleagues at the Corps, Ohio River Division for information, reviews, and other assistance.

Mark Dortch of the Corps Waterways Experiment Station for a very helpful review of the water quality modeling methods.

Peter Tennant, Paul McConocha, Valerie Thomas, Louise Ahles-Kedziora, and Alan Vicory, Ohio River Valley Water Sanitation Commission, for data, advice, information, reviews, and other assistance.

Dean Harschbarger of the Tennessee Valley Authority for information on dissolved oxygen management at hydro projects.

Frank Bailey, Corps, Pittsburgh District, for recreational use statistics.

Benjamin Borda, Corps, Huntington District, for recreational use statistics.

Project applicants and their consultants, for conducting the field studies.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEP	American Electric Power Company, Inc.
APS	Allegheny Power System, Inc.
BEL	Belleville
BOD	biochemical oxygen demand
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
D_a	deficit above the dam
DAS	Dashields
D_b	deficit below the dam
DEIS	draft environmental impact statement
DNR	Department of Natural Resources
DO	dissolved oxygen
EA	environmental assessment
ECAR	East Central Area Reliability Coordination Agreement
EIA	Energy Information Administration
EIS	environmental impact statement
EMS	Emsworth
EPRI	Electric Power Research Institute
FEIS	final environmental impact statement
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
FWCA	Fish and Wildlife Coordination Act
GAL	Gallipolis
GPU	General Public Utilities Corp.
GWh	gigawatt-hour
HEP	Habitat Evaluation Procedures
HIL	Hildebrand
HSI	Habitat Suitability Indices
IPP	Independent Power Producer
kcal	kilocalorie
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
L&D	Lock and Dam
MAAC	Mid-Atlantic Area Council
MAX	Maxwell
MECS	Michigan Electric Coordinated Systems
mg/L	milligrams per liter
MONT	Montgomery
MUSK	Muskingum
MW	megawatts
NAS/NAE	National Academy of Sciences/National Academy of Engineering
NC	New Cumberland
NEPA	National Environmental Policy Act of 1969, as amended
NERC	North American Electricity Reliability Council
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
OPE	Opekiska
ORSANCO	Ohio River Valley Water Sanitation Commission
PFC	Pennsylvania Fish Commission
PI	Pike Island
PM	Point Marion
POW	palustrine open water wetland
R&D	research and development
RAB	riverine aquatic beds
REM	riverine emergents

RM	river mile
SERC	Southeastern Electric Reliability Council
SES	Steam Electric Stations
TD	Tygart
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VACAR	Virginia-Carolina Power Area
VEPCo	Virginia Electric Power Company
WI	Willow Island
WVDNR	West Virginia Department of Natural Resources

EXECUTIVE SUMMARY

This final environmental impact statement (FEIS) evaluates potential environmental impacts of up to 19 hydropower projects in the upper Ohio River Basin. The Federal Energy Regulatory Commission (FERC) is considering license applications for 24 projects, which are proposed at 19 existing dams on the Allegheny, Monongahela, Tygart, Muskingum, and Ohio rivers (5 sites have competing applications). All of the projects are proposed at navigation dams, except the two competing projects at Tygart Dam. All of the dams are operated by the U.S. Army Corps of Engineers (Corps) except Muskingum Lock and Dam (L&D No. 3), which is operated by the Ohio Division of Parks and Recreation.

The action of licensing multiple hydroelectric projects in the upper Ohio River Basin involves tradeoffs between new energy production and environmental quality. The alternatives considered in this FEIS were developed by the staff (1) to give equal consideration to power generation and environmental quality values, in accordance with the Electric Consumers Protection Act of 1986 (Pub. L. 99-495) and the National Environmental Policy Act of 1969 (Pub. L. 91-190), as amended, and (2) to respond to concerns raised during the scoping process.

The staff has analyzed both cumulative and site-specific impacts that would occur to target and other environmental resources. The target resources related to hydroelectric development in the upper Ohio River Basin that were defined during scoping are water quality, fisheries, recreation, wetlands, and river navigation. The staff has also evaluated impacts to other, nontarget resources, including land use, endangered and threatened species, historic and archaeological resources, aesthetics, and socioeconomics.

The alternatives include four different ways of developing hydropower resources, ranging from production of all the proposed power with little environmental protection to producing 82 percent of the proposed power while causing no major environmental impacts. Other alternatives that are considered include producing electricity with a coal-fired power plant (the non-hydroelectric generation alternative), nongenerating alternatives, and licensing none of the projects (the no-action alternative).

Alternative 1 entails constructing and operating projects at each of the 19 sites as proposed by developers in their license applications. Mitigation, including spill flows and recreation facilities, are those proposed by applicants following consultation with resource agencies. Alternative 1 would cause major impacts to water quality, fisheries, recreation, and wetlands. Dissolved oxygen (DO) concentrations that would be toxic to, or would reduce the growth of, many species of fish would result. Significant reductions in the recently improved fisheries of the Ohio River Basin could occur, with resulting reductions in the quantity of recreational fishing. Three projects (Allegheny L&D No. 7, Montgomery, recreation, L&D, and Muskingum L&D No. 3) would cause significant adverse impacts to important fish habitat, recreation, and wetlands, with a net loss of at least 7 acres of wetlands. Benefits to recreation would result from development of fishing access at power plant tailrace areas, and socioeconomic benefits would result from increased employment during construction.

Alternative 2 maintains state DO standards but does not maximize the protection of the fisheries resource. This alternative involves modifying operations of projects built at the 19 sites to ensure that the state DO standard of 5 mg/L in Pennsylvania, West Virginia, and Ohio would be met wherever and whenever possible. This objective would be accomplished by requiring projects at Allegheny L&D No. 2, Emsworth, Dashields, Montgomery, New Cumberland, and Pike Island to cease operations when flows in the Ohio River fall below 9000 cubic feet per second during the period July through October. Overall, the impacts of Alternative 2 would be very similar to those of Alternative 1. Reductions in DO would occur that do not violate standards but still significantly affect aquatic life. Impacts to fisheries, recreation, and wetlands would be similar to those under Alternative 1. Benefits to recreation would result from development of fishing access at power plant tailrace areas, and socioeconomic benefits would result from increased employment during construction.

Alternative 3 protects water quality by modifying project operations to avoid degradation of water quality that would affect aquatic life. The objective of this alternative is to maintain DO concentrations at 6.5 mg/L where possible to ensure that hydroelectric development will not adversely affect the fishery resources. This alternative responds to comments received during the scoping process to the effect that hydropower projects must maintain existing DO conditions downstream from the project dams. Alternative 3 would eliminate significant adverse impacts to water quality by requiring spill flows sufficient to provide DO concentrations greater than or equal to 6.5 mg/L, while maximizing basin-wide power generation. Significant water quality impacts to fisheries and recreation would not occur. Mitigation for the water quality, fisheries and recreational target resources would be implemented. Major adverse impacts to fish habitat, recreation, and wetlands would still occur at three sites. Benefits to recreation would result from development of fishing access at power plant tailrace areas, and socioeconomic benefits during construction would result from increased employment during construction.

Alternative 4 maximizes protection of all target resources by developing 16 projects that do not cause significant unavoidable impacts. Cumulative impacts of these 16 projects are evaluated. The staff's recommended spill flows to maintain DO concentrations at or above 6.5 mg/L apply. Alternative 4 would avoid major adverse impacts to fish habitat, recreation, and wetlands. Because these major impacts are concentrated at only three sites (Allegheny L&D No. 7, Montgomery L&D, and Muskingum L&D No. 3), they can be avoided by not developing these sites for hydropower. Mitigation for all target resources would be implemented. A comparatively small decrease in the generating capacity of the basin would result from this alternative. Benefits to recreation would result from development of fishing access at power plant tailrace areas, and socioeconomic benefits would result from increased employment during construction.

The staff believes that a 400-MW coal-fired steam plant or plants would be the most likely non-hydroelectric generating alternative to the proposed hydroelectric projects. The impacts of the coal-fired power plant would involve releases of sulfur dioxide, oxides of nitrogen, and water vapor. The impacts would be site specific, depending upon the dispersive capability of the local atmosphere, other local sources of air pollutants, and regional concentrations of the pollutants released by the unit. Compliance with regulations for the Clean Air Act of 1970, as amended, would ensure that air-quality impacts from unit operation would be analyzed and found to be acceptable. Unit operation would, however, increase regional pollution levels and contribute to air-quality-related problems such as acid rain and regional ozone levels.

The principal nongenerating alternatives to the proposed projects are conservation and load management to reduce energy requirements and to reduce peak demands for capacity. Although environmental impacts of such alternatives are less than those associated with building and operating new hydroelectric units, implementation of such measures has, in many cases, been pushed to the limit of cost-effectiveness. For this reason, the nongenerating alternative cannot be assumed to be available.

The nonhydroelectric generating alternatives and the nongenerating alternatives would allow no development of the upper Ohio River Basin's hydropower potential. Although impacts to the target resources evaluated in this FEIS would be avoided by these alternatives, other impacts to the environment would occur from power generation using other sources if these alternatives were selected.

The no-action alternative would constitute a denial of all the applications for license to construct, operate, and maintain the proposed projects. This alternative would result in the nonuse of potential energy that could be derived by developing the proposed sites and in the consumption of fossil fuel that would be saved if the proposed projects were developed.

Staff has conducted economic analyses for each project, under each of the alternatives. These alternatives would have different spill flows at each site and, therefore, allow various amounts of generation during critical periods. Under Alternative 1, projects at all of the sites would have positive net economic benefits.

Projects at all of the proposed sites would also have positive net economic benefits under Alternative 2. This second alternative would provide approximately 1900 gigawatt-hours (GWh) of energy, 10 GWh less than Alternative 1.

Under Alternative 3, the increased spill requirement at Montgomery L&D would limit the economic benefits at the site and make that project feasible only under a favorable combination of interest rates, construction costs, escalation rates, and other factors. At least one project at all of the other sites would be economically beneficial. The amount of energy available under this third alternative would be approximately 1760 GWh or 150 GWh per year less than with the Alternative 1. Projects at 7 of the 19 sites would have their energy reduced by at least 10 percent under Alternative 3 as compared with Alternative 1. Alternative 3, however, does avoid significant adverse impacts to water quality and subsequently to fisheries and recreation. Staff estimates that the value of the energy lost by Alternative 3 would be worth about 12 million dollars per year at a levelized rate of approximately 8 cents per kilowatt-hour.

however, would avoid major adverse impacts to water quality, fisheries, wetlands, and recreation. This alternative would reduce the total generation available under Alternative 1 by a total of 350 GWh per year. The cost of the energy lost would be approximately 28 million dollars per year.

From its environmental analysis, the staff recommends Alternative 4 as its preferred alternative for development of hydropower projects in the upper Ohio River Basin. Sixteen hydropower projects would be constructed and operated with staff's recommended mitigative measures to avoid or minimize significant environmental impacts. This alternative allows generation of about 82 percent of the power proposed by project applicants but prevents projects from causing DO concentrations low enough to significantly affect aquatic life. Proposed hydropower projects would not be developed at Allegheny L&D No. 7, Montgomery L&D, and Muskingum L&D No.3 to avoid significant adverse impacts to wetlands, fish, and recreation at these sites. The recreational enhancements these three projects could provide cannot compensate for losses of important habitat. However, staff recommends that additional mitigative measures that could reduce impacts of these three projects be studied. The protection of wetlands and fish habitat provided by Alternative 4 is important for maintaining the overall biological integrity of the basin.

1. PURPOSE AND NEED FOR ACTION

1.1 PURPOSE OF ACTION

The proposed action by the Federal Energy Regulatory Commission (FERC) is the licensing of 24 hydroelectric projects at 19 sites (5 sites have competing applications) located in the upper Ohio River Basin in the states of Pennsylvania, West Virginia, and Ohio (Table 1.1-1 and Figure 1.1-1). The projects can be licensed if they can provide energy in an environmentally acceptable manner that is more economically feasible than the least-cost thermal alternative.

Table 1.1-1. Hydroelectric projects with pending FERC license applications evaluated in the DEIS.

Project name, abbreviation	FERC project no.
Allegheny River L&D No. 7, A7	7914-003
Allegheny River L&D No. 4, A4	7909-002
Allegheny River L&D No. 3, A3	4474-003
Allegheny River L&D No. 2, A2	4017-002
Tygart Dam, TD	7307-000 7399-000
Opekiska L&D, OPE	8990-000
Hildebrand L&D, HIL	8654-001
Point Marion L&D, PM	7660-000
Maxwell L&D, MAX	8908-000
Monongahela L&D No. 4, M4	4675-002
Emsworth L&D, EMS	7041-001
Dashields L&D, DAS	7568-001
Montgomery, MONT	2971-002 3490-003
New Cumberland L&D, NC	6901-001 10332-000
Pike Island, PI	3218-001
Willow Island L&D, WI	6902-003 9999-000
Belleville, BEL	6939-001
Gallipolis L&D, GAL	9042-000 10098-000
Muskingum River L&D No. 3, MUSK3	6998-001

FERC staff prepared this environmental impact statement (EIS), as required by the National Environmental Policy Act (NEPA) of 1969 (P.L. 91-190) and FERC regulations, to provide the Commission with descriptions and evaluations of the potentially significant environmental

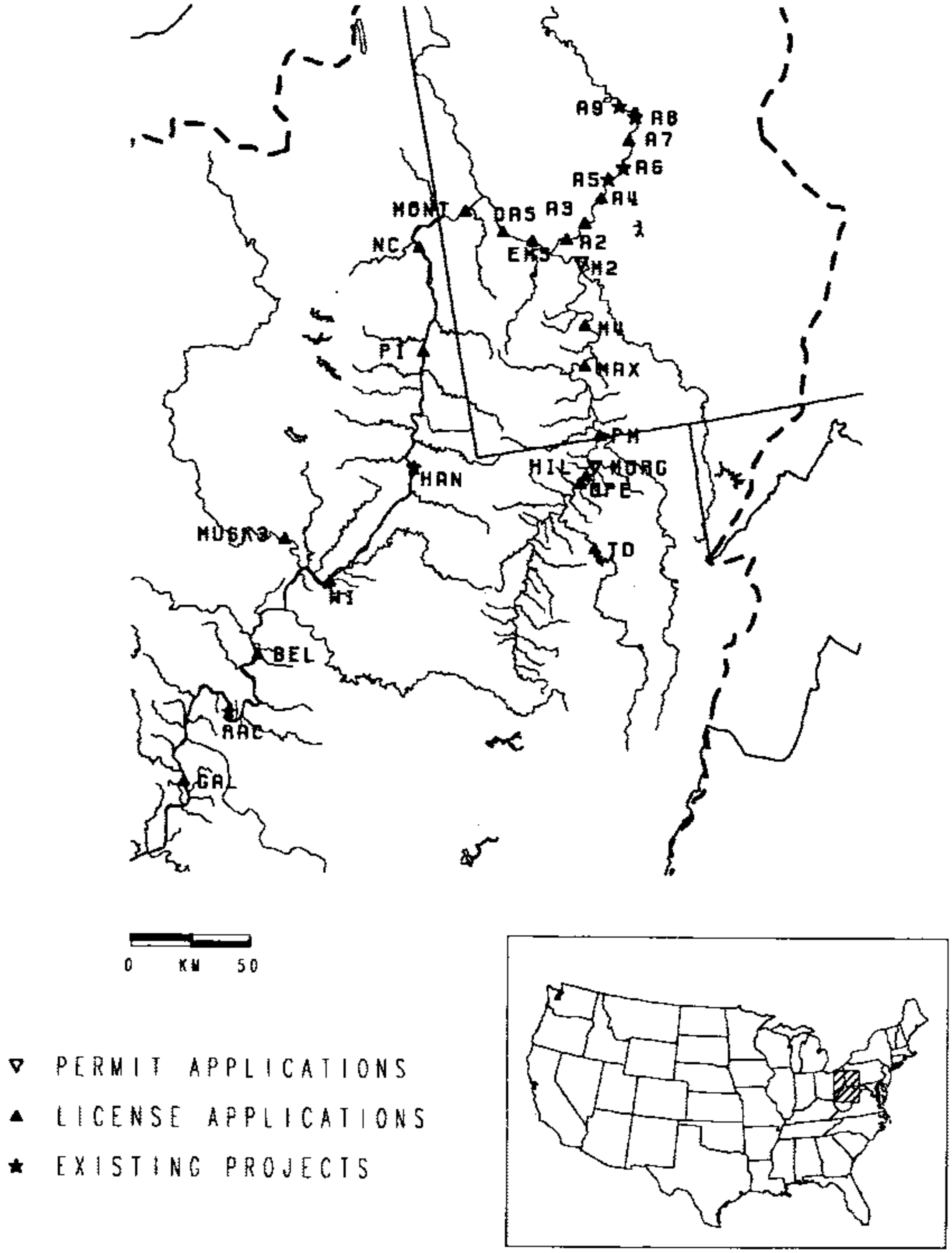


Figure I.1-1. Potential and existing hydroelectric projects evaluated in the FEIS.

impacts associated with the proposed projects. At the request of FERC, the Department of the Army, Corps of Engineers (Corps) agreed to participate as a cooperating agency in preparing this EIS. This final environmental impact statement (FEIS) provides an analysis of the potential site-specific and cumulative environmental impacts from the construction and operation of 24 proposed hydroelectric projects at 19 existing dams on the Allegheny, Tygart, Monongahela, Muskingum, and Ohio Rivers. These projects are located for the most part at locks and dams (L&Ds) constructed and operated by the Corps. These L&Ds were authorized by Congress for navigational purposes, which use must remain their primary function. Issues of primary concern identified during the scoping process include impacts of the projects on water quality, recreational fishing, and navigation. Other resources that were of concern for specific projects include wetlands, wildlife habitat, socioeconomics, archeological and historic sites, and aesthetics. The scope of the study as defined during the scoping process is discussed in Section 1.3.

1.2 NEED FOR POWER

Eighteen of these sites are at navigation L&Ds where power generation would be controlled by river flows and water use for navigation locks. The other site is at Tygart dam (Project Nos. 7307 and 7399), a multipurpose facility on the Tygart River, where storage is maintained for flood control and low-flow augmentation and cannot be regulated to meet power needs. All of the proposed projects would be operated as run-of-the-river plants, producing base-load power. Accordingly, this section is concerned specifically with potential markets for base-load power.

Potential markets for the power produced by the proposed Ohio River Basin projects exist in the states of Ohio, Indiana, Michigan, Kentucky, Virginia, and West Virginia, and the western portions of Pennsylvania and Maryland. Most of the electric utilities serving these eight states, or portions thereof, are located in the East Central Area Reliability Coordination Agreement (ECAR) Region of the North American Electric Reliability Council (NERC). A few are located in the Mid-Atlantic Area Council (MAAC) and in the Virginia-Carolina Power Area (VACAR) of the Southeastern Electric Reliability Council (SERC) Regions of NERC. Staff has relied upon data and information contained in the 1987 annual reports (containing data for the 1986 operating year) prepared by these three regions of NERC. These reports contain quantitative data on projected average annual growth rates for peak demands and annual energy requirements, on existing generating resources, on planned resource expansion, etc. for the planning period being considered.

Data taken from the above-cited reports for 32 specific utilities serving the 8 states containing or immediately surrounding the proposed Ohio River Basin projects have been studied by staff to identify potential markets for the power produced by the projects. These utilities have been grouped according to the states they serve and are listed in Table 1.2-1.

The proposed Ohio River Basin projects are located in the ECAR Region of NERC; and in the April 1987 Coordinated Regional Bulk Power Supply Program Report, ECAR projects average annual growth rates of 1.6 percent for summer peak demand and 1.8 percent for annual energy requirements. Existing generating resources, as of January 1, 1987, include approximately 84,000 megawatts (MW) of coal-fired steam capacity. An additional 5240 MW of coal and 1219 MW of oil-fired combustion turbine capacity are projected for the reported planning period.

It is the staff's opinion that it is most meaningful to consider a limited portion of the total ECAR Region, which includes the eight states that contain or immediately surround the proposed Ohio River Basin projects. These eight states, or portions thereof, and the 32 electric utilities that serve them, are listed in Table 1.2-1. Data for this restricted portion of the ECAR Region, as given in the above-cited Bulk Power Supply Program Report, project the installation of 3651 MW of coal-fired combustion turbine capacity; 696 MW of oil/gas-fired combustion turbine capacity; and 1994 MW of non-utility Independent Power Producer (IPP) capacity, by the 32 utilities listed in Table 1.2-1 during the reported 1987 to 1995 planning period.

The 1994 MW of IPP capacity indicated above includes the projected installation of cogeneration plants, steam plants fueled by solid waste, small hydroelectric projects, and other non-utility sources of electric power. Much of this capacity is not authorized by the utilities in the region and therefore involves a high degree of uncertainty regarding the eventual development and installation of this IPP capacity.

Table 1.2-1. Utilities near the proposed Ohio River Basin projects.

A. Utilities Serving Ohio Markets	
1. Cincinnati Gas and Electric Co.	ECAR [1/]
2. Cleveland Electric Illuminating Co.	ECAR
3. Columbus and Southern Ohio Electric Co.	ECAR
4. Dayton Power and Light Co.	ECAR
5. Ohio Edison Co.	ECAR
6. Ohio Power Co.	ECAR
B. Utilities Serving Indiana Markets	
7. Hoosier Energy Rural Electric Cooperative	ECAR
8. Indiana Michigan Power Co. (AEP)	ECAR
9. Indianapolis Power and Light Co.	ECAR
10. Northern Indiana Public Service Co.	ECAR
11. Public Service Company of Indiana	ECAR
12. Southern Indiana Gas and Electric Co.	ECAR
C. Utilities Serving Michigan Markets	
13. Consumers Power Co. (MECS)	ECAR
14. Detroit Edison Co. (MECS)	ECAR
15. Indiana Michigan Power Co. (AEP)	ECAR
16. Michigan Power Co. (AEP)	ECAR
D. Utilities Serving Kentucky Markets	
17. Big Rivers Electric Corporation	ECAR
18. Kentucky Power Co. (AEP)	ECAR
19. Kentucky Utilities Co.	ECAR
20. Louisville Gas and Electric Co.	ECAR
21. Union Light, Heat and Power Co. (Cincinnati Gas & Electric)	ECAR
22. East Kentucky Power Cooperative	ECAR
E. Utilities Serving Western Maryland Markets	
23. Potomac Edison Co. (APS)	ECAR
F. Utilities Serving Virginia Markets	
24. Appalachian Power Co. (AEP)	ECAR
25. Old Dominion Power Co. (Kentucky Utilities)	ECAR
26. Potomac Edison Co. (APS)	ECAR
27. Virginia Electric and Power Co.	VACAR
G. Utilities Serving Western Pennsylvania Markets	
28. Allegheny Power System	ECAR
29. Duquesne Light Co.	ECAR
30. Pennsylvania Electric Co. (GPU)	MAAC
31. Pennsylvania Power Co. (Ohio Edison Co.)	MAAC
32. Potomac Edison Co. (APS)	ECAR
33. West Penn Power Co. (APS)	ECAR
H. Utilities Serving West Virginia Markets	
34. Appalachian Power Co. (AEP)	ECAR
35. Monongahela Power Co. (APS)	ECAR
36. Potomac Edison Co. (APS)	ECAR
37. Virginia Electric and Power Co.	VACAR
38. Wheeling Electric Co.	ECAR

Table 1.2-1 (concluded).

1/ Abbreviations:
AEP = American Electric Power Co., Inc.
APS = Allegheny Power System, Inc.
GPU = General Public Utilities Corp.
MECS = Michigan Electric Coordinated Systems
MAAC = Mid-Atlantic Area Council
ECAR = East Central Area Reliability Coordination Agreement
VACAR = Virginia - Carolina Power Area of the Southeastern Electric Reliability Council

It is appropriate to state that because the development of hydroelectric capacity has been encouraged at sites which are equally important for reasons other than the generation ofelectric power, such as flood control, irrigation, and river navigation, the proposed hydroelectric developments in the Ohio River Basin represent a component of the projected IPP capacity with a higher degree of certainty. The electricity produced by these facilities generally adds very little additional impact and is produced at a cost below that of other generating resources. Water-entrained energy, which would otherwise be wasted, can be captured to conserve non-renewable primary energy resources and to reduce atmospheric pollution.

Longevity of project operation, a utility concern in the case of some IPP projects, is not a serious concern in the case of hydroelectric IPP facilities constructed at sites having a second important purpose.

Between 400 and 480 MW of base-load capacity from the proposed Basin projects would be useful to regional utilities because the base-load energy produced by these projects would displace energy produced by inefficient coal-fired, load-following units (stacked above the base-load units) by increasing base-load capacity.

1.3 SCOPE OF THE FEIS

The staff prepared an environmental assessment (EA) for the Ohio River Basin (FERC, 1987a) that concludes that the proposed projects would interact with one another in a manner that would contribute to significant cumulative adverse impacts to target resources, which were identified as dissolved oxygen, recreational fishing, and river navigation. From the analysis in the EA, the staff determined that the proposed construction and operation of multiple hydropower projects in the basin warranted the preparation of an EIS to address the site-specific and cumulative environmental impacts of licensing the proposed projects.

The staff's review of existing water quality data and information on other resources indicated that additional information was needed to conduct cumulative and site-specific analyses. Therefore, FERC staff requested that the applicants conduct additional studies and held a meeting on July 20, 1987, with the applicants and their consultants in Pittsburgh, Pennsylvania, to provide guidance on conducting field studies to obtain the necessary information.

Scoping meetings and public hearings to obtain comments on the scope of the FEIS and the issues to be addressed were held by the staff in Pittsburgh, Pennsylvania, on June 11, 1987, and in Huntington, West Virginia, on June 17, 1987. The results of comments made during the scoping process, were published in Scoping Document II (FERC, 1987b), dated August 10, 1987, to identify the issues to be addressed in the EIS. The scoping process also involved a series of formal and informal interactions with applicants, licensees, state and federal agencies, and interested persons. A technical meeting was noticed and conducted on September 17, 1987, in Pittsburgh, Pennsylvania, to allow staff to provide an update of the progress on the draft environmental impact statement (DEIS) and to present the analytical procedures to be used. Informal meetings were also conducted in Grafton, West Virginia, on November 3, 1987, concerning recreational fishing issues, and in Charleston, West Virginia, on December 8 and 9, 1987, concerning fish entrainment issues. The staff has also participated in project site visits and meetings with representatives from the Corps and has provided information at Ohio River Valley Water Sanitation Commission (ORSANCO) technical sessions and meetings related to the status of the EIS studies.

In defining the geographic scope of this study, staff considered the location and licensing status of all existing and potential hydroelectric facilities in the Ohio River Basin

(FERC, 1987a). There are 113 existing and potential hydroelectric projects identified in FERC's Hydroelectric Power Resources Assessment data base as of February 1988, including 24 projects in operation, 17 pending projects that have been issued licenses, 3 pending projects that have been issued license exemptions, 28 projects for which license applications have been accepted, and 41 projects with preliminary permit applications or outstanding peliminary permits (Figure 1.3-1). The highest concentration of projects is in the upper part of the river basin, on the main stem of the Ohio River and its two major tributaries, the Allegheny and Monongahela rivers.

After reviewing the information developed during the scoping process, the staff determined that the projects and cumulative impact study area originally proposed in the Ohio River Basin EA encompass the most concentrated stretch of proposed hydropower development in the Ohio River Basin. Staff believes that including additional proposed projects, as suggested by several commenters, would increase the complexity of the analysis without contributing to an understanding of cumulative impacts. The study area in the FEIS, therefore, includes the river mile (RM) reach of the following rivers: 20 miles of the Tygart Valley River; 128.7 miles of the Monongahela River; 45.7 miles of the Allegheny River; 14.2 miles of the Muskingum River; and, to the pool formed by the Greenup L&D that is located downstream from the pending competing projects at Gallipolis L&D at RM 279.2 on the Ohio River.

In addition to the 19 dams where hydropower projects have been proposed in the upper basin, there are 5 dams with no pending license applications (Monongahela L&D Nos. 2, 3, and 7; Morgantown L&D; and Muskingum River L&D No. 2) and 6 dams where hydropower licenses have been issued by FERC [Allegheny River L&D No. 5 (FERC No. 3671), Allegheny River L&D No. 6 (FERC No. 3494), Allegheny River L&D Nos. 8 and 9 (FERC No. 3021, Hannibal L&D (FERC No. 3206), and Racine L&D (FERC No. 2570)] (Figure 1.1-1). Because these 11 dams have important interactions with the proposed hydropower projects, they are evaluated in the water quality modeling portion of the FEIS. The total number of dams considered in the FEIS is 30, distributed over 500 river miles of the Allegheny, Monongahela, Tygart, Muskingum, and Ohio Rivers.

Since the preparation of Scoping Document II (FERC, 1987b), the competing application at Montgomery L&D (FERC No. 3490) and the competing application at Willow Island L&D (FERC No. 9999) were dismissed. The dismissals are currently under appeal by the applicants. In addition, prior to issuance of the DEIS, an application for a hydropower project at Morgantown L&D (FERC No. 9949) was filed with the Commission. The application was determined to be deficient and the applicant has been informed of these deficiencies. Staff used available information to analyze the contribution to cumulative impacts to water quality and fishery resources in the EIS study area attributed to hydropower development at the Morgantown dam site. At this time, information needed to evaluate all environmental impacts (site-specific and cumulative) associated with hydropower development at Morgantown is not available, and an assessment of these impacts is not included in the present study. Analysis of these impacts will be provided, as needed, in future environmental assessment documents tiered to this EIS.

From the discussions and comments generated during the scoping process, the staff has identified the following issues that are addressed in this FEIS:

1. Impacts on water quality and hydraulics caused by changes in aeration, water depth, currents, and volatilization of pollutants from the rivers.

2. Impacts on fishery resources resulting from changes in dissolved oxygen, altered flow patterns, and turbine-induced fish injury and mortality.

3. Impacts on recreational fishing resulting from changes in fish populations, and the effects of construction, structures, and flow modifications on river access and navigation.

4. Socioeconomic impacts, including effects of construction on the regional labor force, and social and economic effects of construction and operation.

5. Effects of dredge spoil disposal.

6. Impacts on archaeological and historic resources, including disturbance of unknown prehistoric and historic sites during construction and dredge spoil disposal.

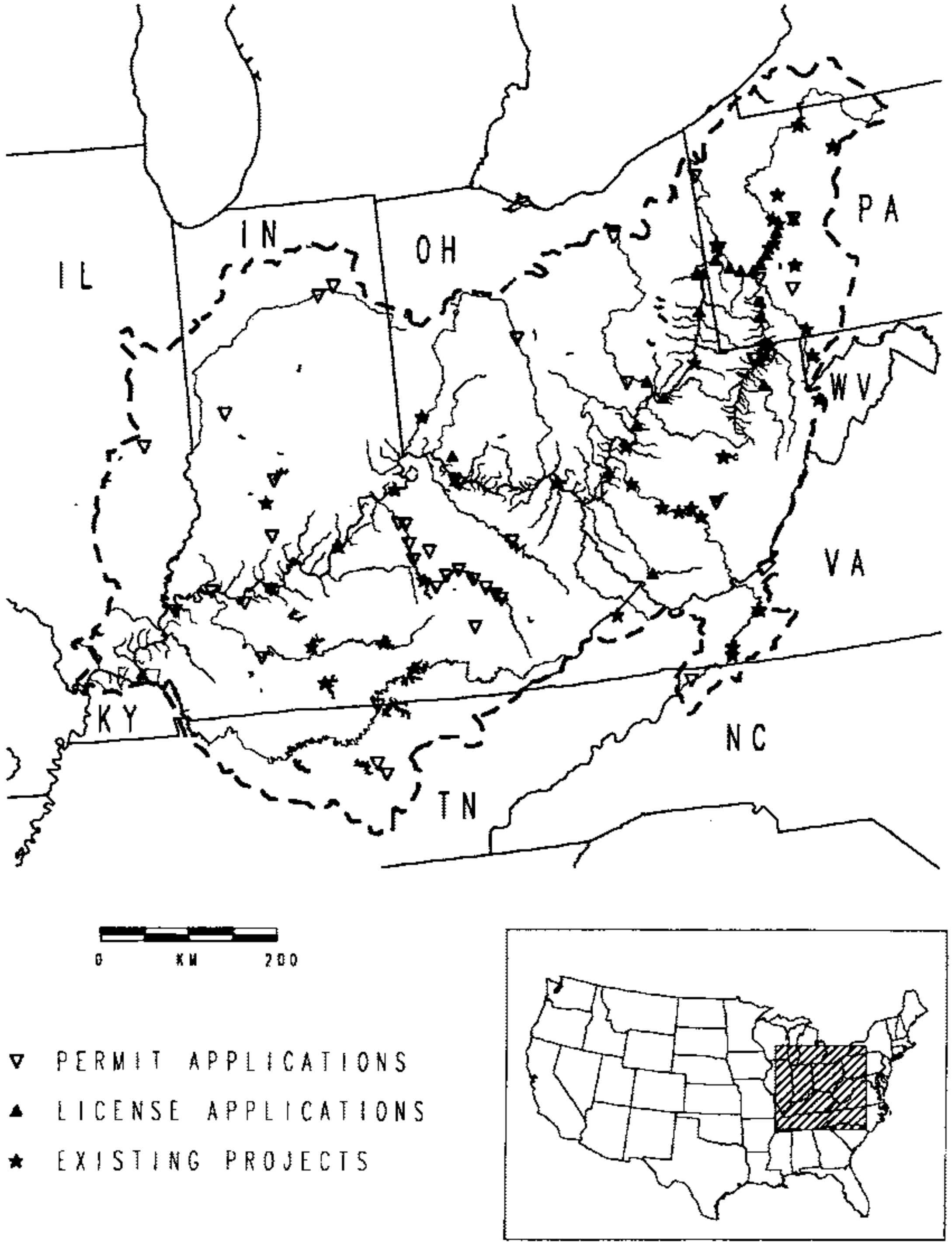


Figure 1.3-1 Potential and existing hydroelectric projects in the Ohio River Basin. Source: Staff analysis of FERC's Hydroelectric Power Resources Assessment data base.

7. Impacts on terrestrial resources, including loss or modification of wetlands and other wildlife habitat from project construction and operation of project facilities, such as transmission lines, access roads, dredge spoil disposal areas, and other facilities.

8. Impacts on aesthetic resources from changes in physical factors contributing to landscape quality.

A draft environmental impact statement (DEIS) was made available to the public on May 10, 1988. Comments on the DEIS received by FERC have been considered by modifying the text or responding in Appendix J of this FEIS.

1.4 PROJECT INTERACTIONS AND CUMULATIVE EFFECTS

Although many of the potential impacts from hydroelectric development in the Upper Ohio River Basin are site specific and do not have the potential for interactions among sites, interactions and cumulative impacts have been identified as a major concern. The primary mechanism for project interactions and cumulative effects is by diversion of flow through turbines at navigation dams and subsequent impacts to water quality, river hydraulics, fish populations, and recreational fisheries.

The proposed actions evaluated in this FEIS are all retrofits of hydroelectric generation capacity into existing dams. With the exception of the Tygart Dam project, all the proposed projects are located at existing, low-head navigation dams. River flow has three ways to pass navigation dams prior to the installation of hydroelectric facilities:

(1) Spillage -- water can spill over the dam crest or through the open gates,

(2) Lockage -- water can be passed through the navigation lock, or

(3) Leakage -- water can leak through the dam, the gates or the lock.

Installation of hydroelectric facilities introduces a new route for water to pass the dam, through the hydroelectric turbine. The diversion of river flow through the turbine results in a reduction in spillage because lockage requirements must still be satisfied and leakage will remain relatively constant. Reduced spillage and the concentration of dam discharge in the turbine's tailrace are the major causes of potential adverse environmental impacts from the proposed projects. These and other potential concerns resulting from hydropower retrofits have been described by Schmitt and Varga (1988).

Reduced spillage and altered tailwater flows initiate a chain of impacts affecting water quality, aquatic biota, and fishery resources (Figure 1.4-1). Water spilled at dams, especially fixed-crest dams, undergoes aeration. In large rivers that receive heavy wasteloads from point-source dischargers, such as the mainstem of the Ohio River, aeration at dams can be an important component of the overall dissolved oxygen budget. Therefore, the loss of some spillage can be a threat to a river's water quality. Reduced spillage can also reduce the upstream water surface elevation because the depth of water flowing over the dam is reduced. This issue of reducing upstream pool elevations is important only at fixed-crest dams; at gated structures, the gates can be operated to maintain a constant upstream pool elevation. During low-flow periods, reduced pool elevations may dewater or degrade aquatic habitat, depending on the magnitude of the elevation change.

A cumulative impact can be described as an environmental change that results from the accumulation and interaction of the effects of one action with the effects of one or more other actions occurring on a common resource (Reed et al., 1984; Stull et al., 1988). The effect on dissolved oxygen (DO) of developing multiple hydroelectric projects has been documented in large river systems (e.g., USEPA, 1985) and is an excellent example of cumulative impacts. As illustrated in Figure 1.4-2(a), the aeration that occurs in spillage can cause discrete jumps in a river's longitudinal profile of DO concentrations. The construction and operation of new hydro projects can eliminate these DO jumps and cause DO concentrations to drop below water quality standards [Figure 1.4-2(b) and (c)]. The combination of reduced aeration at two or more successive dams can aggravate the water quality problems even more, as DO concentrations sag further below a standard for more miles of river [Figure 1.4-2(d)]. These impacts to water quality are cumulative and complex.

Cumulative impacts can be quantified to various degrees, depending on their mode of action and the complexity of their effects. Fortunately, the art of water quality modeling is sufficiently developed that cumulative impacts from reduced spillage and aeration can be predicted relatively well. A simulation model of DO was developed as part of this analysis to address some of the cumulative impact concerns. Other cumulative effects, such as the impacts to fish populations, are much more difficult to quantify. Effects to fish populations result from multiple causes: lower DO, modified habitat, and mortality of fish entrained into hydroelectric turbines (Figure 1.4-1). The response of populations to multiple stresses is difficult to predict because most natural populations have excess reproductive capacity which can compensate for some losses of individuals (e.g., Barnthouse et al., 1984). To the degree possible, cumulative effects are evaluated with quantitative methods in this FEIS. Where they cannot be predicted, they are discussed in qualitative terms, and unknowns and uncertainties are identified.

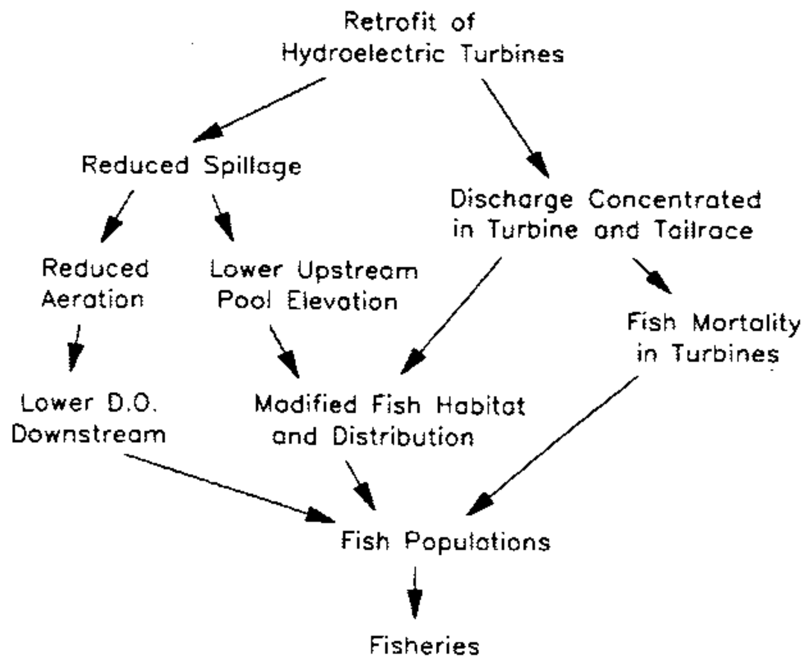


Figure 1.4-1. **Potential impacts resulting from retrofitting hydroelectric facilities at existing navigation dams.**

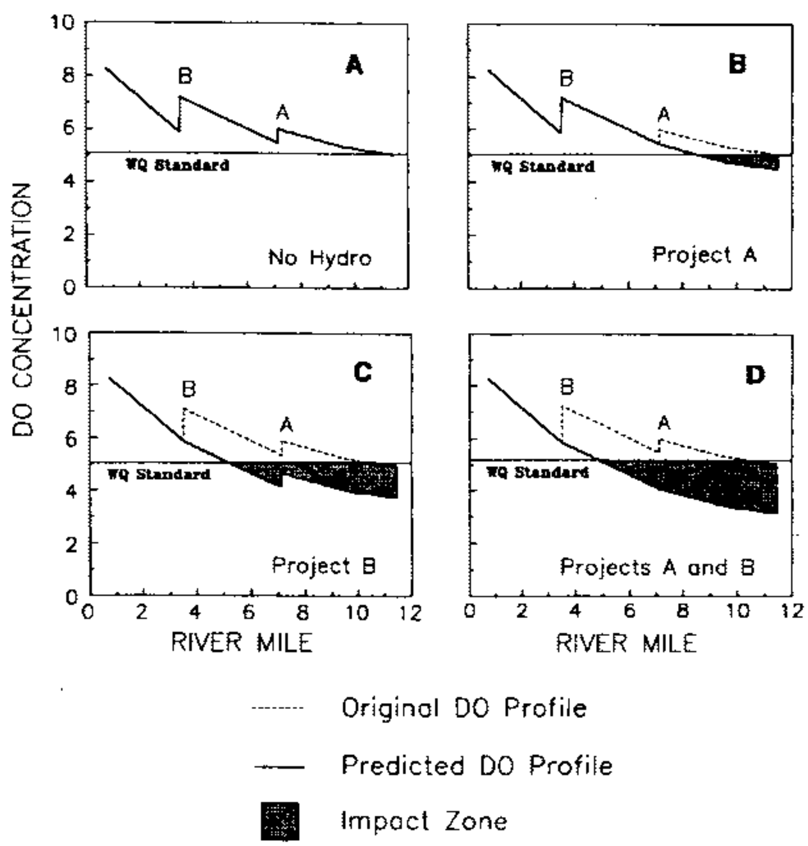


Figure 1.4-2. **Example of cumulative impacts of dissolved oxygen caused by hydroelectric development, reduced spillages, and reduced aeration at dams.**

2. ALTERNATIVES, INCLUDING THE PROPOSED ACTION

The action of licensing multiple hydroelectric projects in the upper Ohio River Basin involves potential trade-offs between new energy production and environmental quality. The alternatives considered in this FEIS were selected to give equal consideration to both power and environmental quality values, in accordance with the Electric Consumers Protection Act of 1986 (P.L. 99-495). These alternatives include licensing up to 19 of the 24 applications for projects as proposed (Section 2.1.1), modifying project design and operation to meet different water quality management strategies (Sections 2.1.2 and 2.1.3), forgoing hydroelectric development at some sites to minimize impacts to target resources (Section 2.1.4), and licensing none of the projects (Section 2.3.4). One nonhydroelectric generation alternative is also considered: the production of an equivalent amount of electricity with a coal-fired power plant (Section 2.2.1).

2.1 HYDROPOWER GENERATING ALTERNATIVES

The scoping process and the environmental impact analyses done for this FEIS indicated that potential change in DO concentrations is one of the most important cumulative impacts of the proposed projects. Decreases in DO concentrations at the proposed projects are directly related to the amount of power generated (Sections 3.2.1 and 4.1.1). It has been found that at dams where the water is aerated, increases in the flow that goes through the turbine to generate power cause reduced spillage and decreases in the DO concentration downstream of the dam. Therefore, a clear trade-off exists between the amount of power generated and the DO concentration. DO concentrations directly affect other important resources such as aquatic life and recreational fishing (Sections 3.2.2 and 3.2.4).

Two operational alternatives were considered to identify ways in which hydroelectric projects could be developed without causing unacceptable changes in water quality. The approach taken to define these alternatives was to maximize total hydroelectric production in the basin, subject to constraints that ensure that water quality criteria are met. Two different criteria were used as constraints: (1) the current ambient DO standards legally required by the states and by the Ohio River Valley Water Sanitation Compact, as administered by ORSANCO (ORSANCO, 1987a), and (2) a stricter management objective that has been promulgated by the U.S. Environmental Protection Agency (USEPA) prohibiting degradation of water quality (USEPA, 1983). In evaluating these alternatives, only spillage was used to manipulate downstream DO concentrations. Mechanical or artificial aeration was not considered, because the technology has not yet been proven to be reliable.

2.1.1 <u>Alternative 1 - Projects as Proposed</u>

This section provides brief descriptions of the hydroelectric facilities for each of the 24 proposed projects and diagrams showing the layout of the principal features of each project. These descriptions are summaries of the more detailed descriptions and engineering drawings of the proposed facilities found in the license applications, additional information filed with FERC, and responses to FERC and other agency comments. Table 2.1.1-1 summarizes certain important project features for all of the proposed projects. The proposed spillages for each project are provided in Table 2.1.1-2.

The staff has studied the economics of the proposed Ohio River projects. The estimated construction costs for the hydroelectric projects were escalated to the midpoint of construction, assuming that the projects would go on line in August 1991. The projected escalation rate for hydropower construction was based on Bureau of Reclamation construction cost indices for the past 5 years.

Operation, maintenance, administrative, and general costs for the hydroelectric plants included in the analysis were based on hydroelectric industry averages. These costs were escalated for the first 10 years of the project life at historic skilled labor rates published by <u>Engineering News-Record Magazine</u>, held constant for the remaining 40 years of the license period, and levelized over the term of the analysis. All of the privately developed projects were assumed to pay the same rate of federal, state, and local taxes.

The economic analysis for the proposed projects is summarized in Table 2.1.1-3. In its analysis, the staff assumed an interest rate of 11 percent for private developers and 9 percent

Table 2.1.1-1. Summary of some project features.

Site	FERC project No.	Feature replaced by powerhouse	Proposed aerator	Turbine Flow 1/ maximum (cfs)	Turbine Flow 1/ minimum (cfs)
Allegheny 7	7914	150 feet of crest	Tailrace aeration	20,100	1,500
Allegheny 4	7909	150 feet of crest	Turbine aeration	20,100	1,500
Allegheny 3	4474	135 feet of crest	Turbine or tailrace aeration	14,000	1,400
Allegheny 2	4017	Shore	Dome diffuser in tailrace	15,200	1,100
Tygart Dam	7307			3,000	450
Tygart Dam	7399		Tailrace sparger 2/	8,200	250
Opekiska (Mon.)	8990	Shore	Tailrace sparger 2/	7,000	1,050
Hildebrand (Mon.)	8654	Weir	Tailrace sparger 2/	6,890	1,050
Morgantown	9949			8,000	1,200
Point Marion (Mon.)	7660	Weir	Tailrace sparger 2/	4,000	600
Maxwell (Mon.)	8908	Shore	None unless required later, unspecified	8,000	800
Monongahela 4	4675	Shore	None unless required later, unspecified	8,000	800
Emsworth	7041	Shore	Turbine or aeration of porous dike 4/	19,000	6,000
Dashields	7568	250 feet of crest	Tailrace aerators 3/	33,500	2,500
Montgomery	2971	100 feet of weir	Turbine aeration	19,000	6,450
Montgomery	3490	100 feet of weir	Mechanical aerators, unknown location	19,000	3,800
New Cumberland	6901	Shore	None	30,500	4,500
New Cumberland	10332	115 feet of gate	Tailrace sparger 2/	52,500	7,500
Pike Island	3218	Shore	To be determined	46,600	6,000
Willow Island	6902	Shore	None	30,500	4,500
Willow Island	9999	140 feet of weir/pile	Tailrace sparger 2/	36,000	2,700
Belleville	6939	189 feet of spillway	None	34,000	5,100
Gallipolis	9042	125 feet of gate	Turbine aeration	44,800	2,500
Gallipolis	10098	125 feet of gate	Tailrace sparger 2/	51,000	8,000
Muskingum 3	6998	Shore	Turbine aeration	7,000	1,000

1/ cfs = cubic feet per second; Mon. = Monongahela
2/ Noah Corp. proposal; forced air into perforated pipes in tailrace.
3/ Air forced through "ring around tailrace perimeter"; apparently attached to downstream end of powerhouse.
4/ Proposal may have been superseded by mechanical aerators.

Table 2.1.1-2. Lockage, leakage, and minimum spill flows for Alternative 1 (projects as proposed) and other dams within the study area.

Dam	FERC No.	Lockage & leakage (cfs)	Spill flow 1/ (cfs)
Allegheny L&D 9	(licensed)		2,250 2/
Allegheny L&D 8	(licensed)		2,250 2/
Allegheny L&D 7	7,914	160	400
Allegheny L&D 6	(licensed)	160	1,000 3/
Allegheny L&D 5	(licensed)	170	1,170 3/
Allegheny L&D 4	7,909	180	400
Allegheny L&D 3	4,474	190	300
Allegheny L&D 2	4,017	190	900
Tygart Dam	7,307	(not applicable)	
Tygart Dam	7,399	(not applicable)	
Opekiska	8,990	230	315
Hildebrand	8,654	430	315
Morgantown	(none)	440	
Point Marion	7,660	540	195
Monongahela L&D 7	(none)	240	
Maxwell	8,908	580	0
Monongahela L&D 4	4,675	540	450
Monongahela L&D 3	(none)	230	
Monongahela L&D 2	(none)	250	
Emsworth	7,041	870	4,000
Dashields	7,568	260	1,000
Montgomery	2,971	1,350	1,050
Montgomery	3,490	1,350	5,700
New Cumberland	6,901	3,250	0
New Cumberland	10,332	3,250	1,600
Pike Island	3,218	840	0
Hannibal	(licensed)	1,180	
Willow Island	6,902	2,290	0
Willow Island	9,999	2,290	1,300
Belleville	6,939	1,800	0
Racine	(licensed)	3,330	
Gallipolis	9,042	2,600	900
Gallipolis	10,098	2,600	0
Muskingum L&D 3	6,998	(unknown)	(seasonal) 4/

1/ Applicants' most recently proposed spill flow, not including lockage or leakage flows, as interpreted by FERC staff. (cfs = cubic feet per second.)

2/ Assumed spill flow at a licensed project where interim spill flows have not been determined.

3/ Interim spill flow requirement at a licensed project.

4/ 2280 cfs from April through June; 1520 cfs from July through March.

Table 2.1.1-3. Economic comparison of proposed hydroelectric projects. 1/

Project	FERC No.	Installed capacity 2/ (kW)	Capital cost 3/ ($ million)	Levelized cost 4/ (mills/kWh)	GWh	Levelized benefits 5/ (mills/kWh)
Allegheny 7	7,914	15,000	29.9	63.2	64.9	17.0
Allegheny 4	7,909	15,000	35.7	64.3	61.1	18.6
Allegheny 3	4,474	12,000	45.5	70.6	71.9	12.3
Allegheny 2	4,017	11,600	38.4	63.4	62.8	19.5
Tygart	7,307	20,000	33.2	42.8	85.3	40.1
Tygart	7,399	75,000	69.7	83.4	104.2	-3.2
Opekiska	8,990	10,000	14.4	64.5	31.5	15.7
Hildebrand	8,654	9,600	13.8	67.1	28.2	13.1
Point Marion	7,660	5,000	9.3	58.2	17.1	24.7
Maxwell	8,908	10,000	15.9	46.7	43.9	36.2
Monongahela 4	4,675	8,250	14.6	61.0	31.5	21.9
Emsworth	7,041	20,000	40.7	49.3	91.1	33.6
Dashields	7,568	25,000	58.4	66.2	96.8	16.7
Montgomery	2,971	20,000	71.4	72.5	119.1	7.7
Montgomery	3,490	20,000	77.4	79.2	99.3	3.7
New Cumberland	6,901	37,000	91.3	58.8	178.9	24.1
New Cumberland	10,332	55,000	122.6	75.7	203.8	4.5
Pike Island	3,218	49,500	98.4	49.8	236.4	33.1
Willow Island	6,902	35,000	97.2	68.4	163.3	14.5
Willow Island	9,999	40,000	107.0	77.0	163.3	3.2
Belleville L&D	6,939	42,000	119.7	47.6	267.8	35.3
Gallipolis L&D	9,042	48,000	104.0	61.1	227.7	19.1
Gallipolis L&D	10,098	62,000	133.0	68.4	251.7	11.8
Muskingum 3	6,998	7,000	16.7	66.0	36.0	14.2
Total 6/		399,950	950		1,910	

1/ Source: Staff

2/ Total estimated costs to place project in operation August 1, 1991, including interest during construction. Construction costs were escalated to midpoint of construction using the applicant's cost of money. Interest during construction for all projects was assumed to be 11 percent for private developments and 9 percent for municipal developments.

3/ 50-year present-worth levelized annual costs based upon 11 percent cost of money for private developments and 9 percent for municipal developments. Annual costs for private developments include insurance; federal, state and local taxes; and operation, maintenance, administration, and general costs escalated for 10 years into the future.

4/ Staff annual generation figures are based on Corps estimates of lockage and leakage and applicant's proposed spill flows.

5/ Net annual benefits based on the levelized value of alternative energy.

6/ Totals include only first filed applications for competing sites.

for municipal developers. In all cases, the discount rate or opportunity cost of money was assumed to be equal to the cost of money.

The levelized annual cost of the hydroelectric project was compared with the levelized cost of producing an equivalent amount of power from a generic coal-fired steam electric plant in the Ohio River Valley. A discussion of alternative energy is contained in Section 1.2.

Current fuel costs were used in staff's economic analysis. Fuel rates were escalated for the first 10 years of operation at rates projected by Energy Information Administration (EIA), held constant for the remaining project life, discounted to 1991 dollars at the opportunity cost of money, and then levelized over the 50-year license period. The levelized fuel values over a 50-year period at three discount rates (9, 11, and 13 percent) has been estimated by staff to be 82.9, 80.2, and 77.9 mills per KWh, respectively. These values are within the range of rates for projects currently under construction in the Ohio River Valley and are reasonable for the proposed projects.

Features common to most of the projects include the following: (1) all the projects are the proposed installation of hydropower at existing navigation dams on large rivers, except the project at Tygart Dam, which is a storage reservoir; (2) all the existing dams, except the Muskingum facility, are operated by the Corps, which will develop with the licensee operating agreements before project operation begins; (3) the proposed powerhouses would be located at the end of the dam opposite the locks; (4) all projects propose to install bulb or propeller turbines, except the competing applications proposed at Tygart Dam; (5) proposed projects would be operated automatically, and/or remotely, with or without operators at the plant at all times (computers would be used to determine whether generation is possible and to set all wicket gates and turbine blade angles to maximize power); and (6) projects would shut down when river flows are either too low (because of insufficient flow) or too high (because of insufficient head). A typical cross section showing the position of project features is shown in Figure 2.1-1. Appendix C contains recent aerial photos of the existing dams.

2.1.1.1 Allegheny River Lock and Dam No. 7 Project (FERC No. 7914)

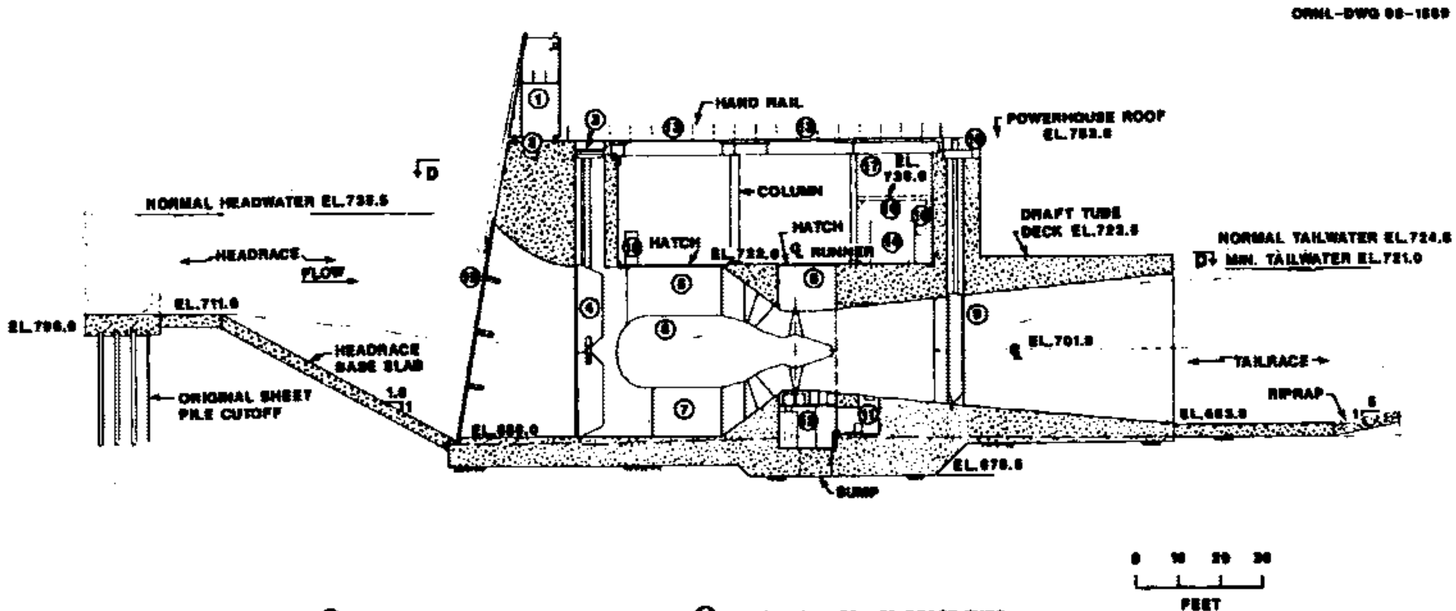
Allegheny Hydropower, Inc., proposes a hydropower project at Lock and Dam (L&D) No. 7 at RM 45.7 on the Allegheny River (A7 in Figure 2.1-2). The project site is located at Kittanning in Armstrong County, Pennsylvania. The project (Figure 2.1-3) would replace about 150 feet of the existing 916-foot-long, fixed-crest dam with a powerhouse that would contain three 5-MW generating units. The powerhouse would be submerged, with the roof at the same elevation as the dam crest. A 25-kilovolt (kV) transmission line about 2.1 miles long would connect the project to the existing Kittanning substation. The applicant estimates that the average annual energy generated by the project would be 70 GWh. Power produced by the project would be sold to the Allegheny Power Services System.

2.1.1.2 Allegheny River Lock and Dam No. 4 Project (FERC No. 7909)

The County of Allegheny, Pennsylvania, proposes a hydroelectric project at L&D No. 4 at RM 24.2 on the Allegheny River (A4 in Figure 2.1-2). The project site is located at the city of Natrona in Allegheny and Westmoreland counties. The project (Figure 2.1-4) would replace approximately 150 feet of the existing 876-foot-long, fixed-crest dam with a powerhouse that would contain three 5-MW generating units. The powerhouse would be submerged, with the roof at the same elevation as the dam crest. A 25-kV transmission line approximately 0.3 miles long would connect the project to the existing Federal Street substation of the West Penn Power Company. The applicant estimates that the average annual energy generated by the project would be 60 GWh. The applicant plans to use some of the power generated and would sell the balance to the Allegheny Power Services System.

2.1.1.3 Allegheny River Lock and Dam No. 3 Project (FERC No. 4474)

The Borough of Cheswick and the Allegheny Valley North Council of Governments jointly propose a hydroelectric project at L&D No. 3 at RM 14.5 on the Allegheny River (A3 in Figure 2.1-2). The project site is located at Acmetonia, Pennsylvania, in Allegheny County. The project (Figure 2.1-5) would remove a 135-foot-long section of the existing 1436-foot-long, fixed-crest dam to form the entrance to the proposed headway channel and install a powerhouse on the north bank of the river that would contain two 6-MW generating units. A 135-foot-wide headrace channel would be excavated. Crest gates would be installed along 1171 feet of the existing spillway. No crest gates would be installed along a 130-foot section of the dam



1. TRASH RACK RAKE
2. TRASH CHANNEL
3. GATE DOGGING DEVICE
4. UPSTREAM GATE
5. GENERATOR ACCESS
6. BULB UNIT
7. BULB SUPPORT PIER
8. TURBINE PIT
9. DOWNSTREAM GATE
10. DOWNSTREAM GATE OPERATOR
11. ACCESS GALLERY TO DRAFT TUBE
12. EQUIPMENT GALLERY
13. HATCH COVER
14. POWER TRANSFORMER
15. CIRCUIT BREAKER
16. TRANSFORMER VAULT
17. AUXILIARY FLOOR
18. COOLING WATER TANK
19. TRASH RACK

Figure 2.1-1. Cross-section showing typical project features. (Source: Modified from (Exhibit F-4) Borough of Cheswick and Allegheny Valley North Council of Governments, 1984)

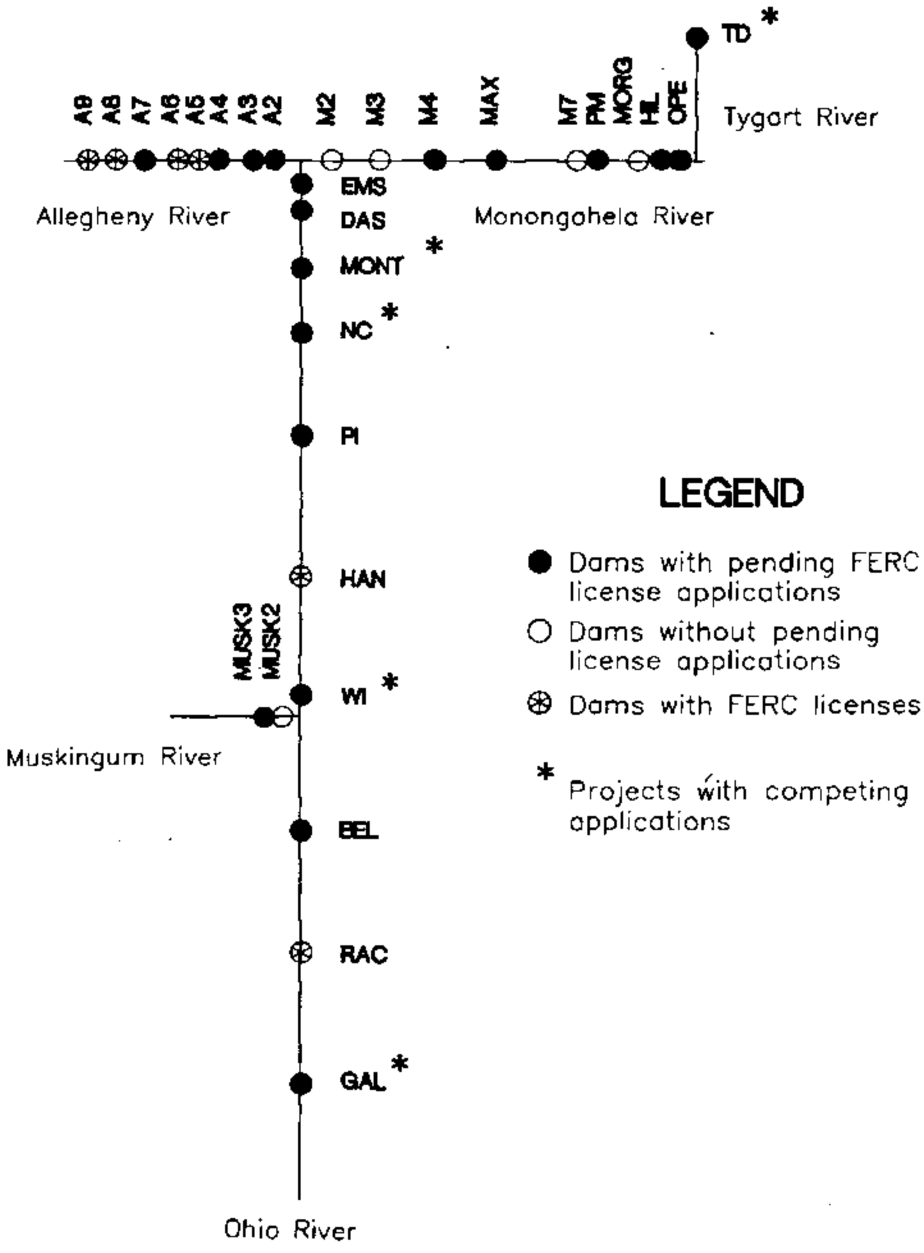


Figure 2.1-2. Schematic representation of projects within the study area. (Table 1.1-1 gives project names and FERC project numbers for each of the abbreviations used in this figure.)

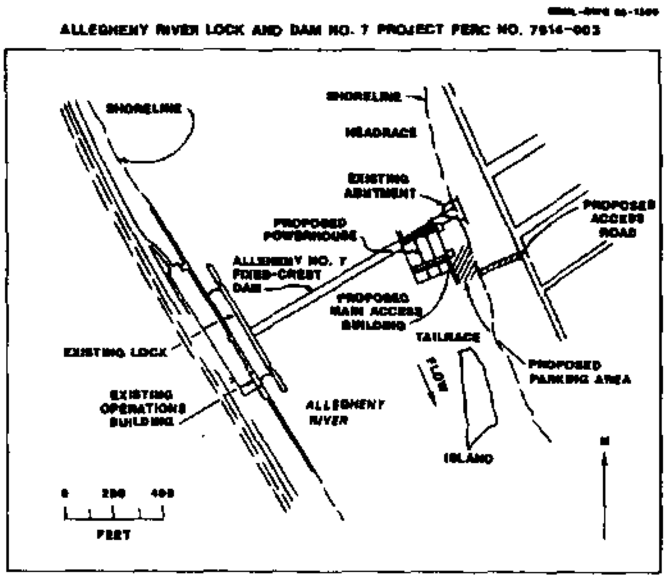


Figure 2.1-3. Layout diagram for the Allegheny Lock and Dam No. 7 Project (FERC No. 7914). Source: Modified from Exhibit G, Allegheny Hydropower, Inc. 1984.

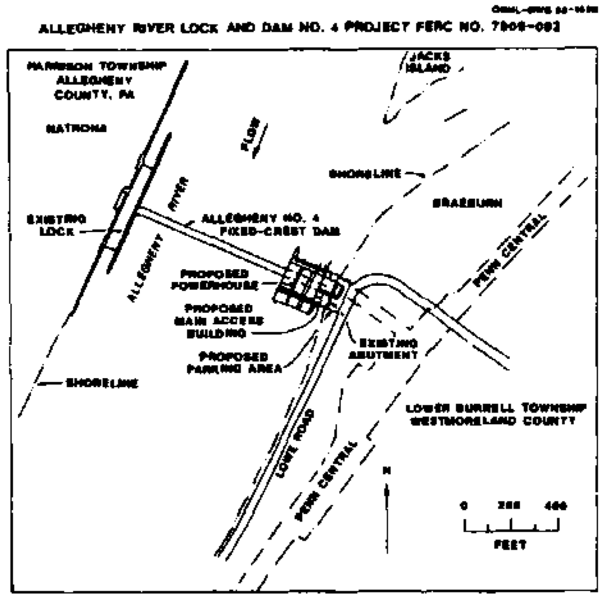


Figure 2.1-4. Layout diagram for the Allegheny Lock and Dam No. 4 Project (FERC No. 7909). Source: Modified from Exhibit F, County of Allegheny, 1984.

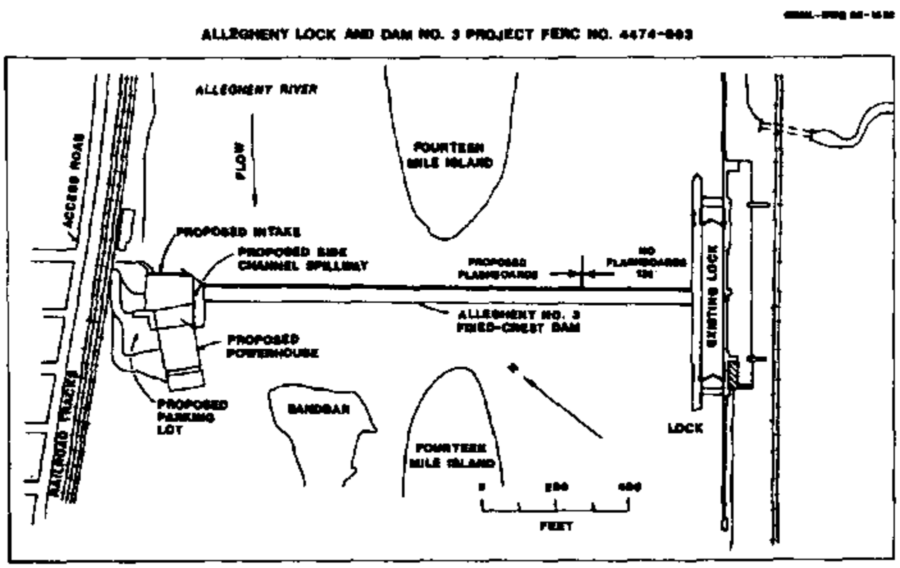


Figure 2.1-5. Layout diagram for the Allegheny Lock and Dam No. 3 Project (FERC No. 4474). Source: Modified from Exhibit 2-A, Borough of Cheswick and Allegheny Valley North Council of Governments, 1984.

closest to the lock to allow 300 cubic feet per second (cfs) of water to spill during normal operation. The proposed headway channel would include a new 142-foot side-channel spillway that would pass water during flood flows, replacing some of the spillway capacity removed by the powerhouse. A 13.8-kV transmission line approximately 1 mile long would be built from the project to the Harwick Substation. The applicant estimates that the average annual energy generation from the proposed project would be 61 GWh.

2.1.1.4 Allegheny River Lock and Dam No. 2 Project (FERC No. 4017)

The City of Pittsburgh, proposes a hydroelectric project at L&D No. 2 at RM 6.7 on the Allegheny River (AZ in Figure 2.1-2). The project site is located near Sharpsburg in Allegheny County, Pennsylvania. The project (Figure 2.1-6) would install a powerhouse in the right abutment (facing downstream) of the existing 1393-foot-long, fixed-crest dam; none of the existing crest would be removed. The powerhouse would contain two 5.8-MW generating units. An 800-foot-long headrace channel with a bottom width of 85 feet and a 425-foot-long tailrace channel, with a bottom width of 100 feet, would be excavated. A new road 20 feet wide by 1700 feet long would be built to provide access to the powerhouse and a tailrace fishing area. Project facilities would be located primarily in O'Hara Township, Pennsylvania, with the exception that a proposed parking lot would be in the Borough of Sharpsburg. A 60-foot-long, 23-kV transmission line would connect the proposed project to an existing substation. The applicant estimates that the average annual energy generated by the project would be 61 GWh to be used by the applicant to operate nearby city facilities, such as a water plant and maintenance shop; the balance of the power generated would be sold to Duquesne Light Company.

2.1.1.5 Tygart Dam Project (FERC No. 7307)

The City of Grafton, West Virginia, proposes a hydroelectric facility at Tygart Dam on the Tygart Valley River [151.4 RMs upstream of Pittsburgh on the Monongahela River (22.7 miles upstream of the confluence of the Tygart River and the West Fork River)] (TD in Figure 2.1-2). Although the Tygart River is shown on U.S. Geological Survey (USGS) topographic maps as the Tygart Valley River, it is referred to in this EIS as the Tygart River for brevity. The project site is near the town of Grafton in Taylor County, West Virginia. A powerhouse containing two 10-MW Kaplan turbines would be located on the right abutment 325 feet downstream from the dam (Figure 2.1-7). A 14.75-foot-diameter, 350-foot-long penstock would be installed in an existing 15-foot-diameter penstock, would originate about 90 feet from the opening of the existing penstock, and would extend to a bifurcation into two 12-foot-diameter pipes leading to the turbines. A tailrace channel would be excavated from the powerhouse to the river and would be directly downstream of the existing stilling basin. The tailrace would be about 75 feet wide at the powerhouse and 50 feet wide 175 feet downstream. A 138-kV powerline would also be constructed to transmit power generated to a 138-kV line owned by Monongahela Power Company about 1 mile west of the dam. Average annual energy output would be about 85 GWh, almost all of which would be sold to the Monongahela Power Company. This project competes with FERC No. 7399.

2.1.1.6 Tygart Dam Project (FERC No. 7399)

Noah Corporation, Aiken, South Carolina, proposes a hydroelectric generating facility at the same site as competing project FERC No. 7307 (Section 2.1.1.5). The project would include extensions connected to two existing 15-foot-diameter penstocks, a power plant built downstream of the dam beside the stilling basin, and a tailrace discharging into the river downstream of the stilling basin (Figure 2.1-8). The powerhouse would contain one 35-MW and two 20-MW generating units. A 138-kV transmission line 2400 feet long on federal property and 4400 feet long on private property would connect the project with an existing Monongahela Power Systems line owned by the Allegheny Power Systems, to which power would be sold. The applicant estimates that the average annual energy generated by the three turbines would be 144 GWh.

2.1.1.7 Opekiska Lock and Dam Project (FERC No. 8990)

Noah Corporation, Aiken, South Carolina, proposes to construct and operate a hydropower project at the Opekiska L&D at RM 115.4 on the Monongahela River (OPE in Figure 2.1-2). The existing dam is gated, with a submerged discharge. The project site is near Opekiska in Monongalia County, West Virginia. Construction would consist of an intake headrace excavated

ORNL-DWG 88-1581

ALLEGHENY RIVER LOCK AND DAM NO. 2 PROJECT FERC NO. 4017-002

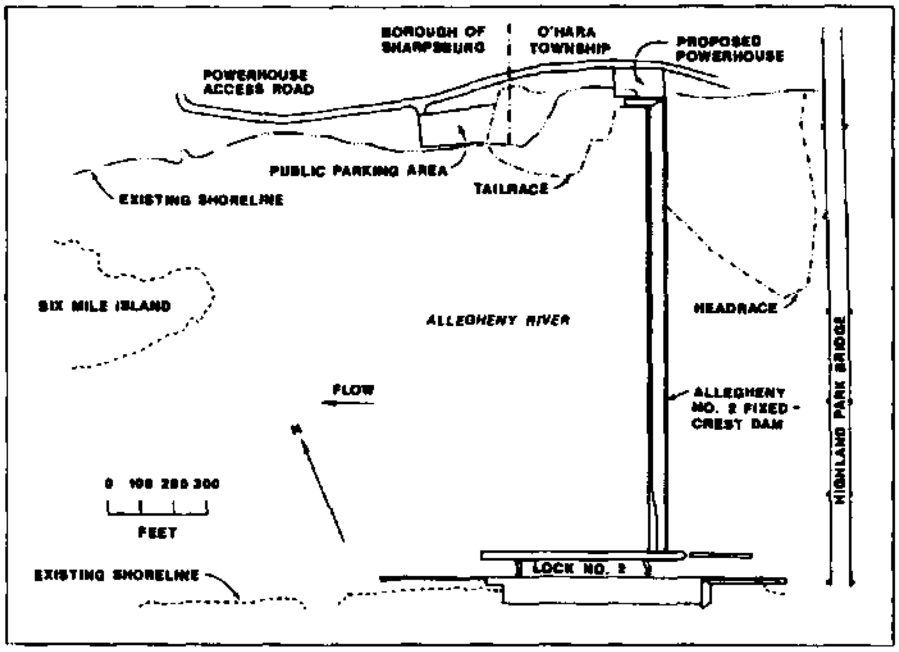


Figure 2.1-6. Layout diagram for the Allegheny Lock and Dam No. 2 Project (FERC No. 4017). Source: Modified from Exhibit F, City of Pittsburgh, 1984.

ORNL-DWG 88-1582

TYGART DAM PROJECT FERC NO. 7307-000

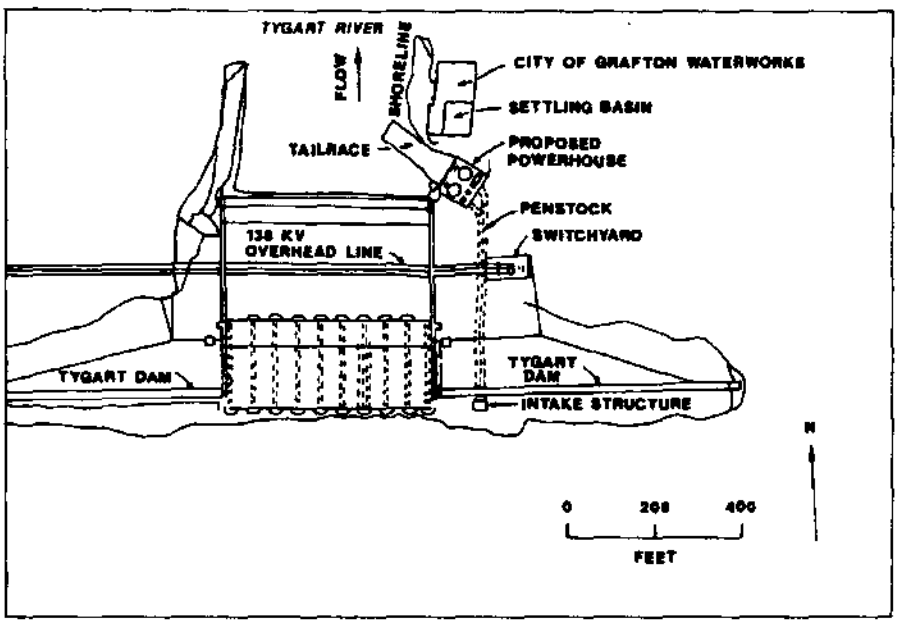


Figure 2.1-7. Layout diagram for the Tygart Dam Project (FERC No. 7307). Source: Modified from City of Grafton, 1983.

in the upstream embankment, a waterway constructed through the existing abutment, a powerhouse beside or just downstream of the dam, and a tailrace constructed in the bank for discharge to the river (Figure 2.1-9). A 10-MW propeller turbine with an average annual energy generation estimated by the applicant to be about 35 GWh would be installed in the powerhouse. The tailrace would be 50 feet wide and 25 feet downstream of the tailwater at its lowest point. A transmission line 4400 feet long with a 100-foot-wide corridor would be needed to connect the project with a 23-kV line owned by Monongahela Power Company. Power would most likely be sold initially to the West Penn Power Company.

2.1.1.8 <u>Hildebrand Lock and Dam Project (FERC No. 8654)</u>

Noah Corporation of Aiken, South Carolina, proposes a hydroelectric project at Hildebrand L&D at RM 108.0 on the Monongahela River near the town of Hildebrand in Monongalia County, West Virginia (HIL in Figure 2.1-2). The Commission rejected the application initially, but because the applicant has appealed this decision, the project is included in this EIS. Hildebrand Dam has six underflow gates whose discharge is not submerged and a fixed-crest weir at each end of the dam. The project would involve construction of a powerhouse downstream of the dam, near the abutment, with one 9.6-MW generating unit; a waterway through one of the two existing fixed weirs, part of which would be removed; and a 50-foot-wide tailrace along the riverbank (Figure 2.1-10). A 23-kV transmission line 2420 feet long would connect the project to a substation owned by Monongahela Power Company, which would purchase the power generated. The applicant estimates the average annual energy produced by the project would be 33 GWh.

2.1.1.9 <u>Point Marion Lock and Dam Project (FERC No. 7660)</u>

The Borough of Point Marion, Pennsylvania, and Noah Corporation of Aiken, South Carolina, jointly propose a hydroelectric project at the Point Marion L&D (Monongahela L&D No. 8) at RM 90.8 on the Monongahela River (PM in Figure 2.1-2). The existing dam is gated, with a discharge that is not submerged; it also has one fixed-crest weir. The project site is located near the town of Point Marion in Fayette County, Pennsylvania. Construction of a waterway through the fixed-crest weir of the dam, a powerhouse downstream of the fixed weir, a 50-foot-wide tailrace, and 75 feet of new transmission line would be required (Figure 2.2-11). The powerhouse would contain one 4-MW propeller turbine. The tailrace would discharge into the existing channel along the shoreline. All power generated would be sold to Allegheny Power System or an interconnected utility and would be transmitted by 1 mile of new line overbuilt on existing West Penn Power Company poles except for 75 feet of line needed to reach the existing line. The applicant estimates that the average annual energy generated by the project would be 20 GWh.

2.1.1.10 <u>Maxwell Lock and Dam Project (FERC No. 8908)</u>

The Borough of Brownsville, Pennsylvania, the Washington County Board of Commissioners, Pennsylvania, and Pennsylvania Renewable Resources, Inc., of New York, New York, jointly propose a hydroelectric project at Maxwell L&D at RM 61.2 on the Monongahela River (MAX in Figure 2.1-2). Maxwell is a gated dam, with a submerged discharge. The project site is located in Centerville Township, Washington County, Pennsylvania. Construction plans call for a headrace channel, an intake structure, a tailrace, a powerhouse, and a transmission line (Figure 2.1-12). The powerhouse would be constructed in the left bank adjacent to the dam. Major construction modifications would be removal of part of the bulkhead wall in the left dam abutment, removal of 65 feet of spillway training wall on the left abutment where the powerhouse would be located, and excavation into the river bank for the tailrace from the powerhouse toward the river. Excavation at the river bank would also be required for the headrace channel. The tailrace channel would be 80 feet wide at the powerhouse and 100 feet wide at a distance of 60 feet downstream. Two 5-MW turbines would be installed in the powerhouse, with an average annual energy output estimated by the applicant to be approximately 45 GWh. A 1.5-mile-long, 15-kV transmission line would be constructed directly north from the powerhouse switchyard to an existing 25-kV line owned by West Penn Power Company, the most probable purchaser of power.

2.1.1.11 <u>Monongahela Lock and Dam No. 4 Project (FERC No. 4675)</u>

The Borough of Charleroi, Pennsylvania, the Washington County Board of Commissioners, Pennsylvania, and Pennsylvania Renewable Resources, Inc., New York, New York, jointly propose a hydroelectric project at L&D No. 4 at RM 41.5 on the Monongahela River (M4 in Figure 2.1-2). The project site is near the town of Charleroi in Washington County, Pennsylvania (Figure 2.1-13). The existing dam is gated, with a submerged discharge, and also has a

ORNL-DWG 88-1562

TYGART DAM PROJECT FERC NO. 7399-001

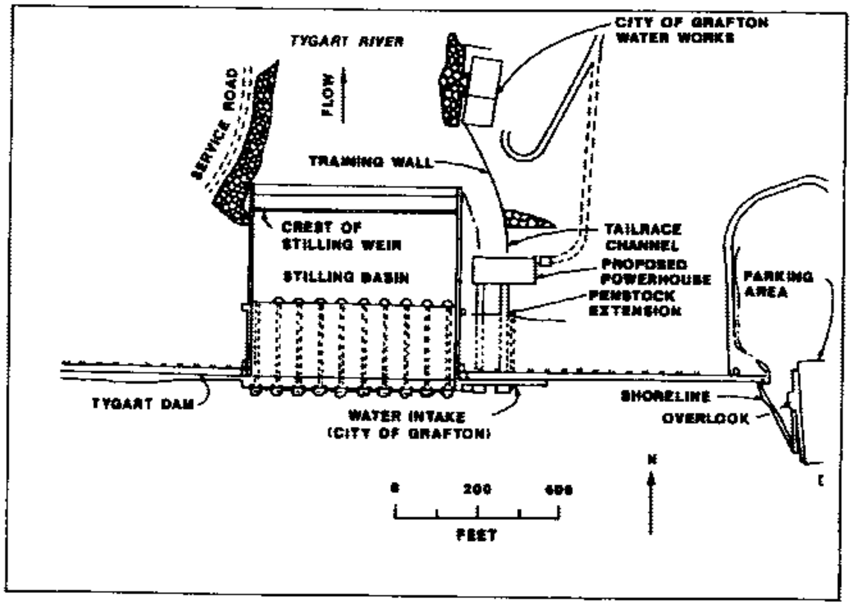


Figure 2.1-8. Layout diagram for the Tygart Dam Project (FERC No. 7399). Source: Modified from Exhibit F-2, Noah, Corp., 1983.

ORNL-DWG 88-1564

OPEKISKA LOCKS AND DAM PROJECT FERC NO. 8990-000

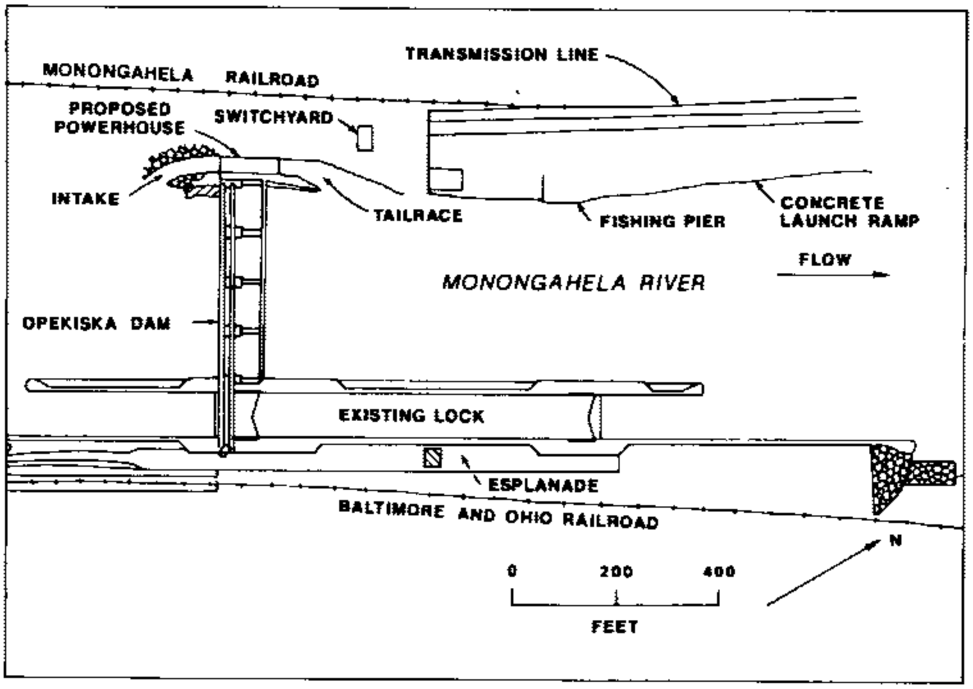


Figure 2.1-9. Layout diagram for the Opekiska Lock and Dam Project (FERC No. 8990). Source: Modified from Exhibit G-2, Noah Corp., 1985.

ORNL-DWG 88-1585

HILDEBRAND LOCK AND DAM PROJECT FERC NO. 8654-001

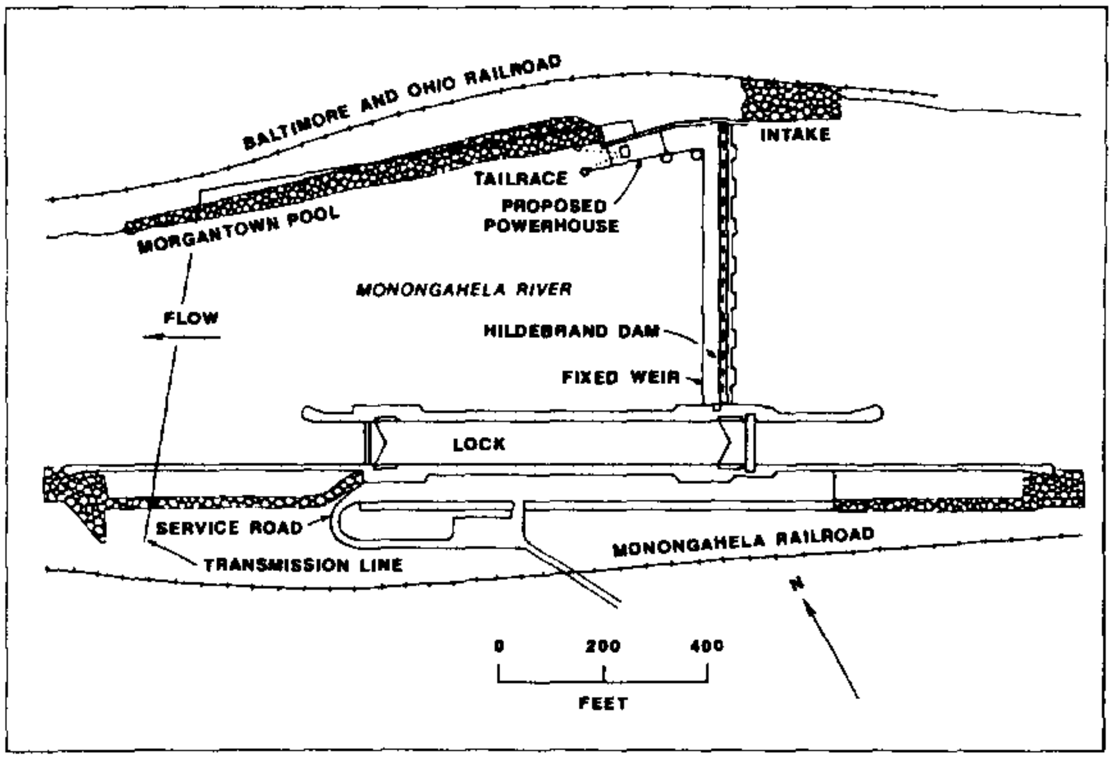


Figure 2.1-10. Layout diagram for the Hildebrand Lock and Dam Project (FERC No. 8654). Source: Modified from Exhibit F-1, Noah Corp., 1985.

ORNL-DWG 88-1586

POINT MARION LOCK AND DAM PROJECT FERC NO. 7660-000

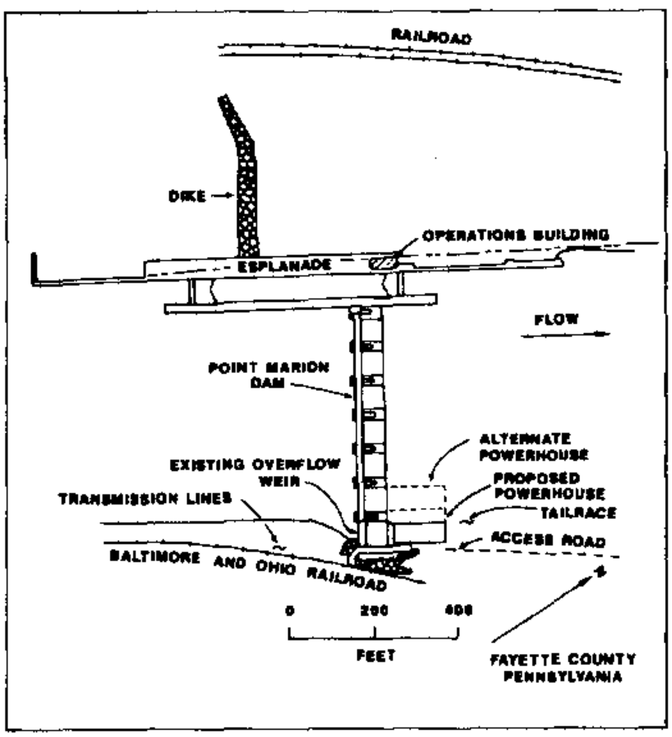


Figure 2.1-11. Layout diagram for the Point Marion Lock and Dam Project (FERC No. 7660). Source: Modified from Exhibit F-1, Borough of Point Marion and Noah Corp., 1983.

ORNL-DWG 88-1587

MAXWELL LOCK AND DAM PROJECT FERC NO. 8908-000

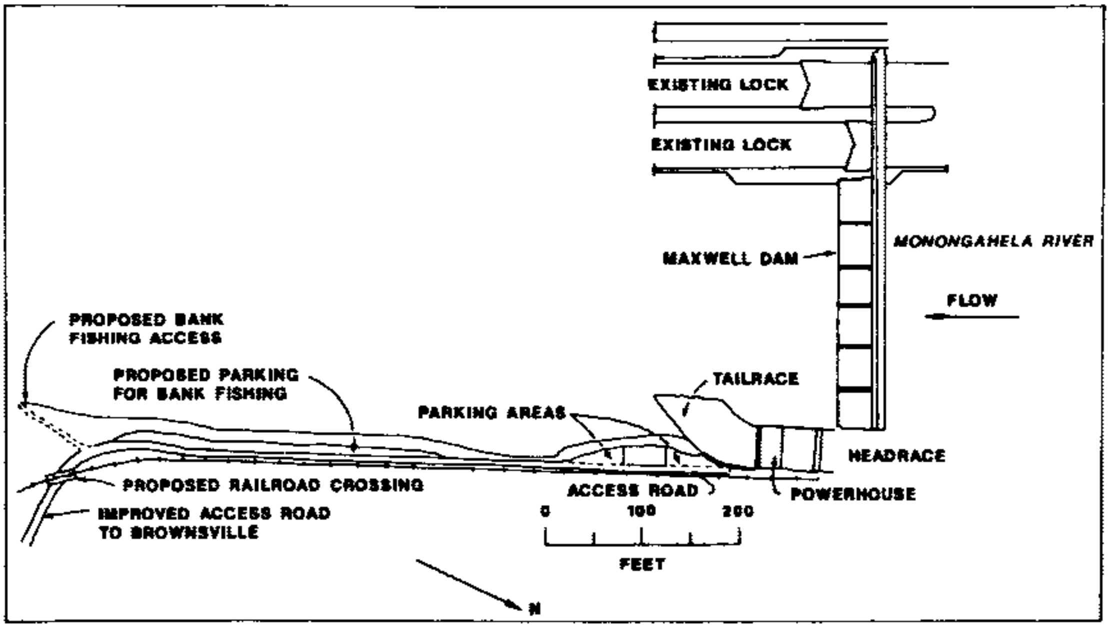


Figure 2.1-12. Layout diagram for the Maxwell Lock and Dam Project (FERC No. 8908). Source: Modified from Exhibit F, Borough of Brownsville, Washington County Board of Commissioners, and Noah Corp., 1985.

MONONGAHELA LOCK AND DAM NO. 4
FERC NO. 4675-000

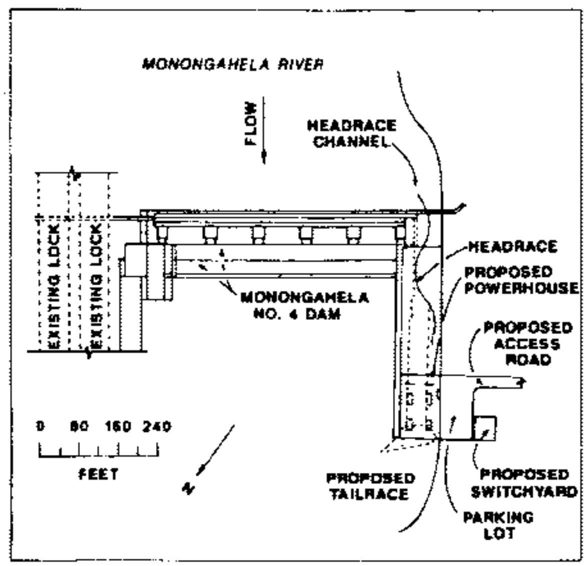


Figure 2.1-13. Layout diagram for the Monongahela Lock and Dam No. 4 Project (FERC No. 4675). Source: Modified from Exhibit F, Borough of Charleroi, Washington County Board of Commissioners, and Pennsylvania Renewable Resources, Inc. 1984.

fixed-crest weir. A powerhouse would be constructed in the left bank 150 feet downstream of the dam and would contain two 4.125-MW turbines. Part of the bulkhead wall in the left dam abutment would be removed and a canal constructed leading to the powerhouse. Additional excavation in the river bank would be needed for the headrace and tailrace. The tailrace outlet channel would be 80 feet wide at the powerhouse and extend to 100 feet in width, 60 feet downstream; total length would be 160 feet. An access road to the powerhouse and a 3000-foot-long, 13.8-kV transmission line leading to a West Penn Power Company substation would also be constructed. The applicant estimates that the average annual energy generated by the project would be about 35 GWh and the power would be sold to the West Penn Power Company.

2.1.1.12 Emsworth Lock and Dam Project (FERC No. 7041)

Potter Township, Monaca, Pennsylvania, proposes a hydroelectric project at the Emsworth L&D at RM 6.2 on the Ohio River (EMS in Figure 2.1-2). The project site is located between the Borough of Emsworth and Neville Island in Allegheny County, Pennsylvania. There are two dams of similar design, one on the main channel on the north side of Neville Island and the other on the back channel on the south side of the island. The proposed power facilities would be built on Neville Island around the abutment of the main channel dam (Figure 2.1-14). The existing main dam, the back channel dam on the opposite side of Neville Island, and the two locks on the right side of the main dam would not be altered by the project. Emsworth Dam is gated, with discharge that is not submerged. Project features include a porous rock dike about 1,800 feet long parallel to the river bank that would form a forebay about 2000 feet long; an intake that would consist of an open channel about 250 feet long; and a powerhouse that would contain four 5-MW generating units. A short open channel would discharge into the river immediately downstream of the dam, and a 500-foot-long porous rock dike would direct discharges to the center of the river. A 34.5- or 69-kV transmission line about 1800 feet long would connect the project to an existing substation owned and operated by the Duquesne Light Company. The applicant estimates that the average annual energy generated by the project would be 105 GWh and would be sold to the Duquesne Light Company.

2.1.1.13 Dashields Lock and Dam Project (FERC No. 7568)

The County of Allegheny, Pennsylvania, proposes a hydropower project at the Dashields L&D at RM 13.3 on the Ohio River (DAS in Figure 2.1-2). The project site is located near Sewickley, Pennsylvania, in Allegheny County. The project would replace about 250 feet of the existing 1585-foot-long, fixed-crest dam and spillway with a submerged powerhouse adjacent to the abutment of the dam on the right side of the river opposite the existing locks (Figure 2.1-15). The roof of the powerhouse would be at the same elevation as the dam crest. Five 5-MW generating units would be installed. A 69-kV transmission line about 2.2 miles long would connect the proposed project to an existing Duquesne Light Company substation. The applicant estimates that the average annual energy generated by the project would be 100 GWh and would be sold to the Duquesne Light Company.

2.1.1.14 Montgomery Lock and Dam Project (FERC No. 2971)

Allegheny Electric Cooperative, Inc., Harrisburg, Pennsylvania, proposes a hydroelectric project at the Montgomery L&D at RM 31.7 on the Ohio River (MONT in Figure 2.1-2). The project site is located near the Borough of Industry and the community of Ohioview in Beaver County, Pennsylvania. Montgomery dam is gated, and the gate discharge is not submerged. There are also fixed-crest weirs at either end of the dam. The proposed project would replace one of these weirs, between pier 11 and the abutment pier at the northern end of the existing 1379-foot-long dam (Figure 2.1-16). Two 10-MW generating units would be installed. The intake channel would be approximately 250 feet wide and 400 feet long, while the tailrace would be about 120 feet long with a maximum width of 120 feet. A 138-kV transmission line, 2.8 miles long, would connect the project to an existing Duquesne Light Company 138-kV transmission line. The applicant estimates that the average annual energy generated by the project would be 125 GWh. The applicant plans to use the power to displace a portion of power it currently purchases. This project competes with FERC No. 3490.

2.1.1.15 Montgomery Project (FERC No. 3490)

Potter Township, Monaca, Pennsylvania, proposes a hydroelectric project at the Montgomery L&D on the Ohio River at RM 31.7. The project would be located at the same site as competing project FERC No. 2971 (Section 2.1.1.14). The proposed project would include construction of a porous rock dike upstream of the dam, an open intake channel, and a powerhouse downstream of the dam, as well as a step-up substation and transmission line (Figure 2.1-17). The porous

ORNL-DWG 86-1601

EMSWORTH LOCK AND DAM PROJECT FERC NO. 7041-001

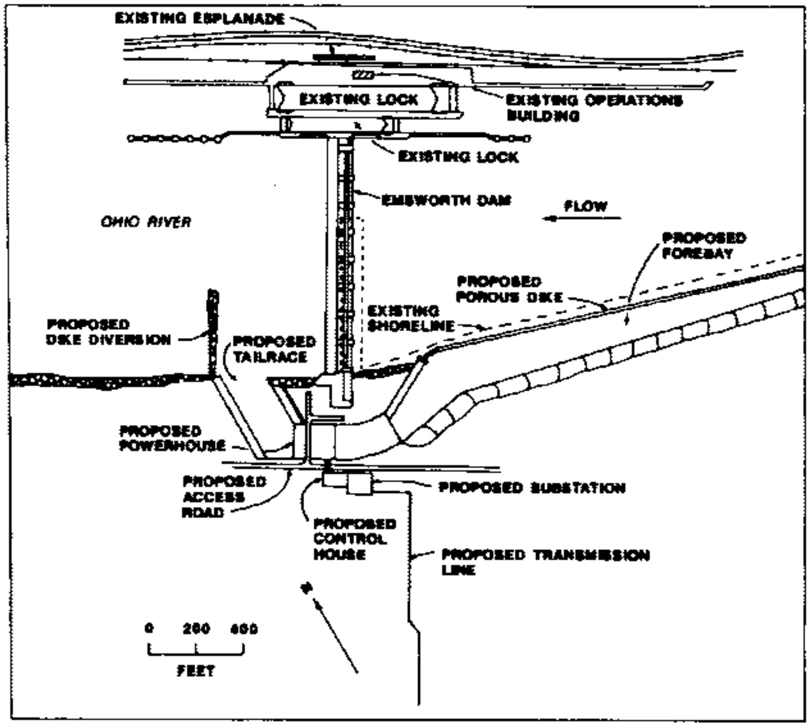


Figure 2.1-14. Layout diagram for the Emsworth Lock and Dam Project (FERC No. 7041). Source: Modified from Exhibit G, Potter Township, 1985.

ORNL-DWG 86-1590

DASHIELDS LOCK AND DAM PROJECT FERC NO. 7568-001

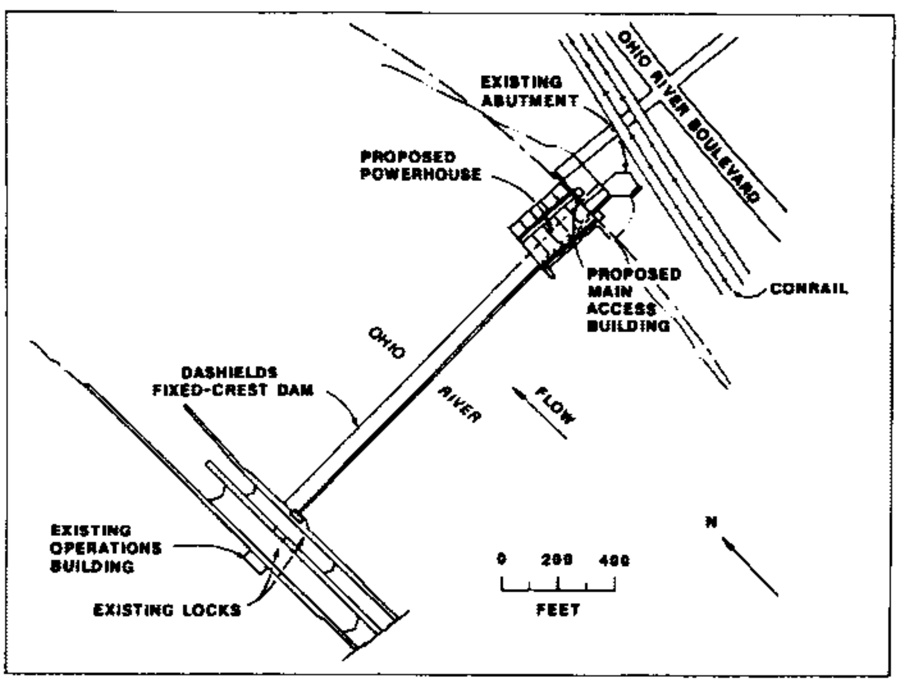


Figure 2.1-15. Layout diagram for the Dashields Lock and Dam Project (FERC No. 7568). Source: Modified from Exhibit G-1, Allegheny County, 1983.

ORNL-DWG 85-1979

MONTGOMERY LOCKS AND DAM PROJECT FERC NO. 2971-002

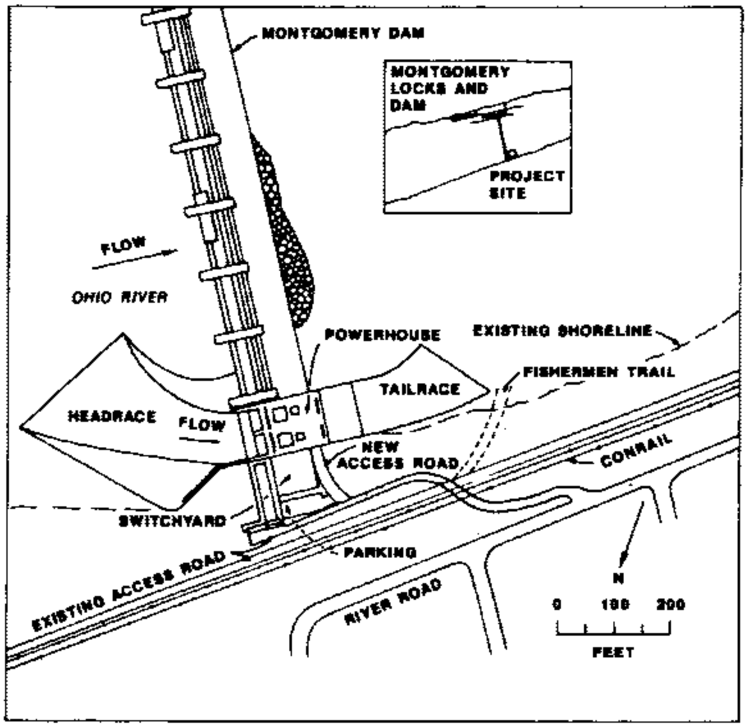


Figure 2.1-16. Layout diagram for the Montgomery Locks and Dam Project (FERC No. 2971). Source: Modified from Exhibit F, Allegheny Electric Cooperative, 1984.

ORNL-DWG 85-1978

MONTGOMERY LOCK AND DAM PROJECT FERC NO. 3490-003

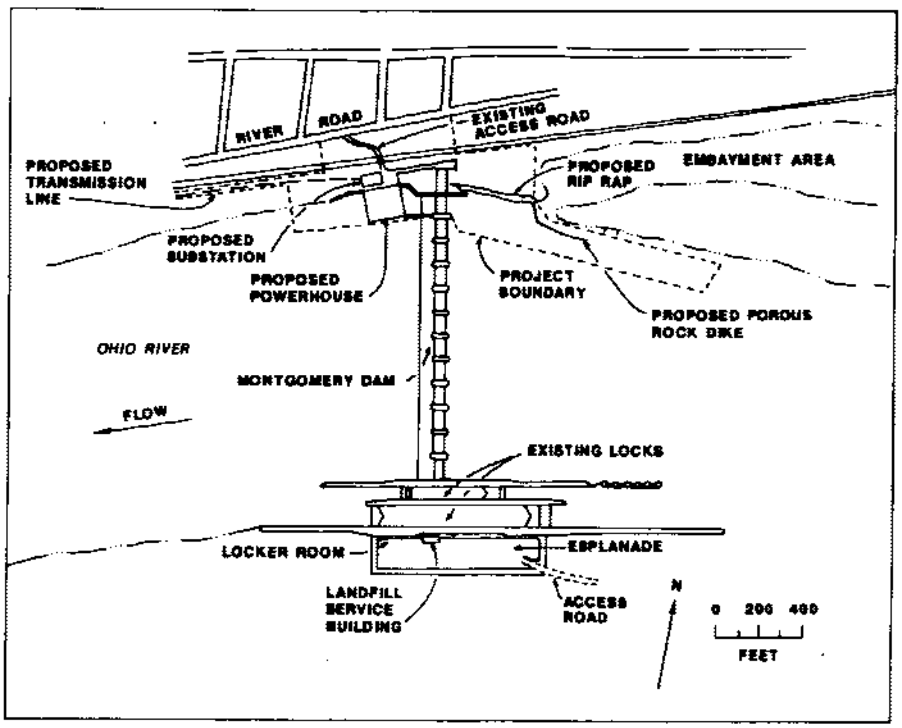


Figure 2.1-17. Layout diagram for the Montgomery Lock and Dam Project (FERC No. 3490). Source: Modified from Potter Township, 1986.

dike would be approximately 400 feet in length; the open intake channel would be 100 to 150 feet wide and 80 feet long from the existing dam to the powerhouse. The powerhouse would be situated adjacent to the river bank about 200 feet downstream of the 1379-foot-long dam. The powerhouse would contain three or four turbines with a total rated capacity of 20 MW. The transmission line would be either 34.5 kV or 69 kV and would be about 18,850 feet long, connecting the project to the existing Duquesne Light Company system. The applicant estimates the average annual energy generated by the project would be 127 GWh and would be sold either to Duquesne Light Company or West Penn Power Company.

2.1.1.16 New Cumberland Lock and Dam Project (FERC No. 6901)

The City of New Martinsville, West Virginia, proposes a hydroelectric project at the New Cumberland L&D at RM 54.4 on the Ohio River (NC in Figure 2.1-2). The project site is located near the town of New Cumberland in Hancock County, West Virginia. The New Cumberland dam is gated, and the discharge is submerged except during very low flows. The proposed facility would be located at the abutment end of the existing 1413-foot-long dam (Figure 2.1-18). Project features include a 600-foot-long intake channel; a powerhouse containing two 18.5-MW generating units, a 649-foot-long tailrace; a switchyard; and a 1000-foot-long, 138-kV transmission line connecting the project to an existing 138-kV transmission line owned by the Monongahela Power Company. A switching station would be constructed at the location of the interconnection with the existing transmission lines. The applicant estimates that the average annual energy generated by the project would be about 166 GWh. Power from the project would either be used directly by the city or sold to the Monongahela Power Company or a municipal utility. This project competes with FERC No. 10332.

2.1.1.17 New Cumberland Hydroelectric Development Project (FERC No. 10332)

WV Hydro, Inc., Aiken, South Carolina, proposes a hydroelectric project at the New Cumberland L&D at RM 54.4 on the Ohio River. The project would be located at the same site as competing project FERC No. 6901 (Section 2.1.1.16). The powerhouse would be built downstream of the existing dam and would have three 19.3-MW generating units (Figure 2.1-19). A 138-kV transmission line would extend about 1000 feet to the east, where it would intersect an existing 138-kV transmission line owned by Monongahela Power Company. The applicant estimates that the average annual energy generated by the project would be 232 GWh. Power would be sold to the Monongahela Power Company.

2.1.1.18 Pike Island Project (FERC No. 3218)

The City of Orville, Ohio, proposes a hydroelectric project at the Pike Island L&D at RM 84.2 on the Ohio River (PI in Figure 2.1-2). The existing dam is gated, with a submerged discharge. The project site is located near Tiltonsville in Belmont County, Ohio. The proposed facility would replace a short section of an existing retaining wall currently used to protect a small fishing access point on the right abutment of the existing 1306-foot-long dam (Figure 2.1-20). The powerhouse would contain three 16.5-MW generating units. The proposed intake structure would be 155 feet wide, and the proposed tailrace would be 350 feet long by 160 feet wide. A 138-kV transmission line, 8600 feet long, would connect the project to the existing Ohio Power Company's Tiltonville substation. The applicant estimates that the average annual energy generated would be 244 GWh, which would be used to help meet its total system requirements.

2.1.1.19 Willow Island Lock and Dam Project (FERC No. 6902)

The City of New Martinsville, West Virginia, proposes a hydroelectric project at Willow Island L&D at RM 161.7 on the Ohio River (WI in Figure 2.1-2). The existing dam is gated, with a submerged discharge. The project site is located near Willow Island in Pleasants County, West Virginia. The powerhouse would be built into the existing shoreline and would contain two 17.5-MW generating units (Figure 2.1-21). A 980-foot-long approach channel, with widths varying from 122 to 320 feet, and an 865-foot-long exit channel, with widths varying from 114 to 190 feet, would be excavated. A 138-kV transmission line, 1.6 miles long, would connect the project to an existing substation owned by the Monongahela Power Company. This project competes with FERC No. 9999.

2.1.1.20 Willow Island Project (FERC No. 9999)

The City of St. Marys, West Virginia, proposes a hydroelectric project at the Willow Island L&D at RM 161.7 on the Ohio River. The project would be located at the same site as competing

ORNL-DWG 88-1577

NEW CUMBERLAND LOCK AND DAM PROJECT FERC NO. 6901-001

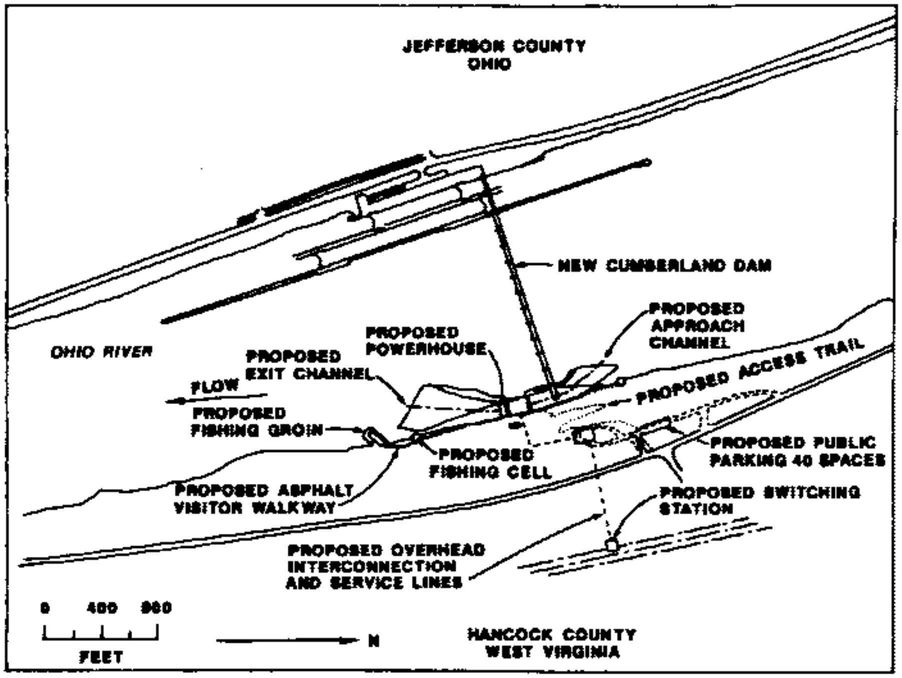


Figure 2.1-18. Layout diagram for the New Cumberland Lock and Dam Project (FERC No. 6901). Source: Modified from Exhibit E, Figure 3, City of New Martinsville, 1985.

ORNL-DWG 88-1578

NEW CUMBERLAND LOCKS AND DAM PROJECT FERC NO. 10332-000

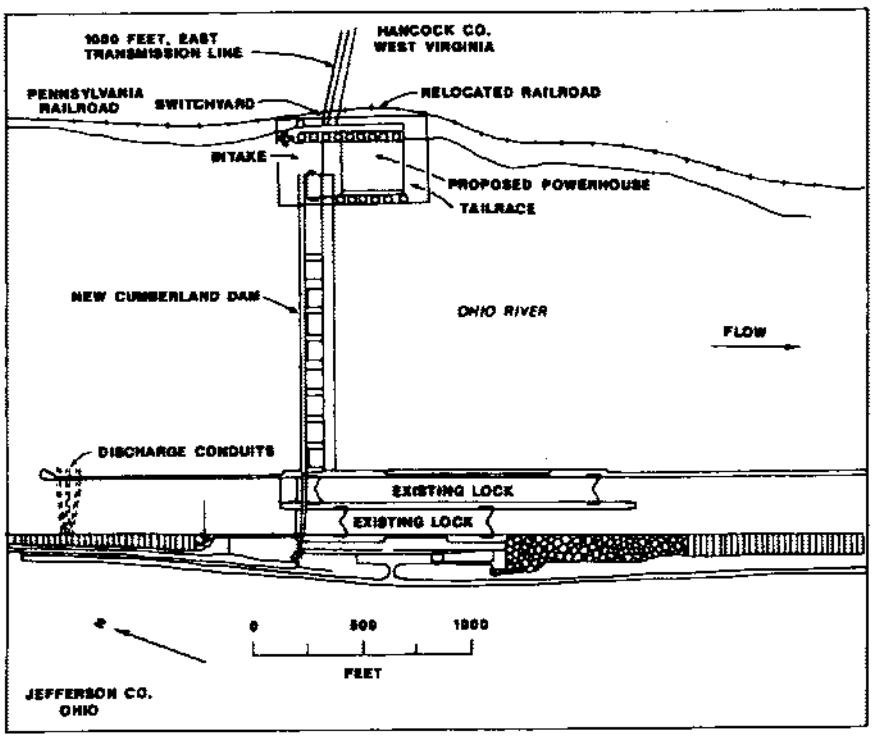


Figure 2.1-19. Layout diagram for the New Cumberland Lock and Dam Project (FERC No. 10332). Source: Modified from Exhibit G-1, WV Hydro, Inc., 1987.

ORNL-DWG 88-1575

PIKE ISLAND LOCKS AND DAM PROJECT FERC NO. 3218-001

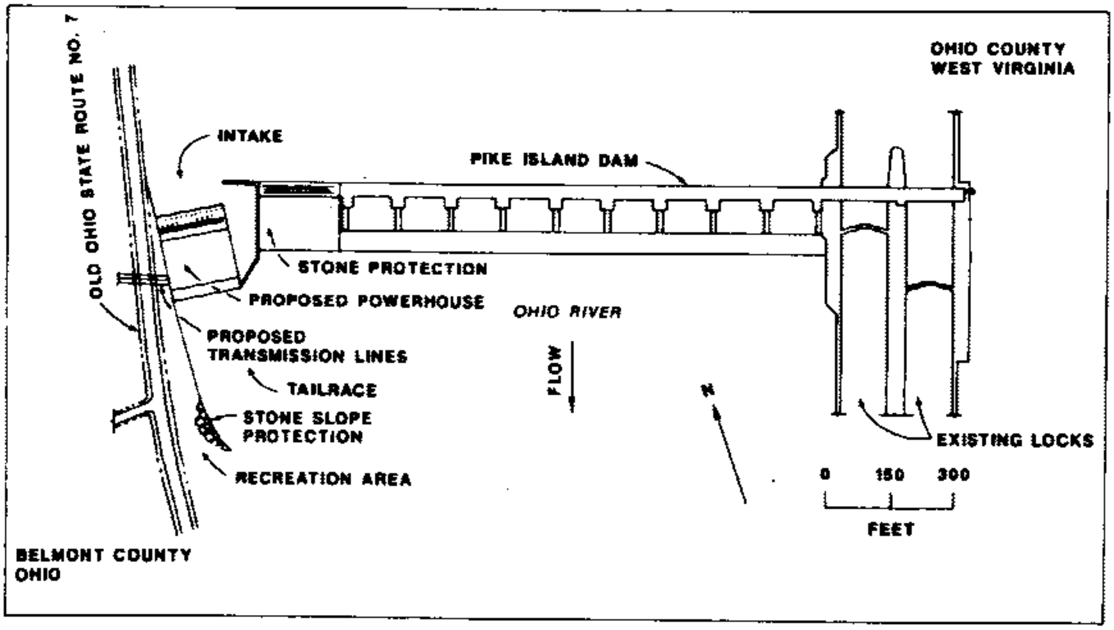


Figure 2.1-20. Layout diagram for the Pike Island Locks and Dam Project (FERC No. 3218). Source: Modified from Exhibit F, City of Orrville, 1982.

WILLOW ISLAND LOCK AND DAM PROJECT FERC NO. 6902-003

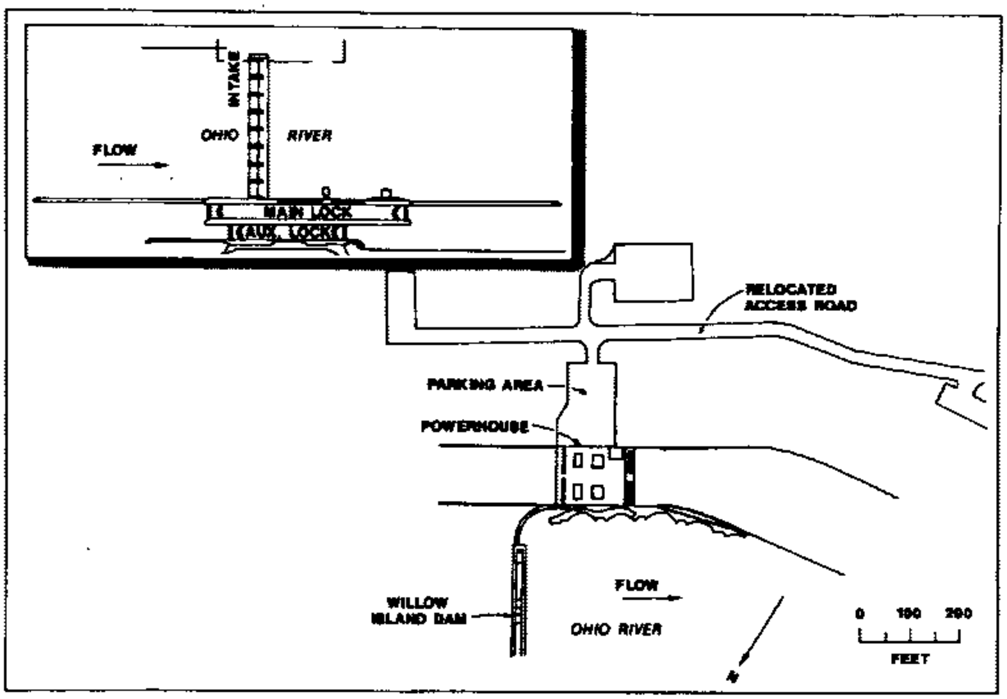


Figure 2.1-21. Layout diagram for the Willow Island Lock and Dam Project (FERC No. 6902). Source: Modified from City of New Martinsville, 1985.

project FERC No. 6902 (Section 2.1.1.19). The powerhouse would be located immediately downstream of the existing dam, would replace about 140 feet of the existing weir and pilings, and would contain two 20-MW generating units (Figure 2.1-22). The approach channel would be 140 feet wide and 22 feet deep; the 140-foot-wide tailrace would discharge directly into the river channel. A 138-kV transmission line, 5000 feet long, would connect the project to an existing Monongahela Power Company substation. The applicant estimates that the average annual energy generated by the project would be 181 GWh and expects the power would be sold to Allegheny Power Systems, Inc.

2.1.1.21 Belleville Project (FERC No. 6939)

The City of Jackson, Ohio, proposes a hydroelectric project at the Belleville L&D at RM 203.9 on the Ohio River (BEL in Figure 2.1-2). The existing dam is gated, with a submerged discharge. The project site is located in Wood County, immediately downstream of Parkersburg, West Virginia. The power plant would be located approximately 175 feet to the left and downstream of the existing 1017-foot-long dam (figure 2.1-23). The powerhouse would contain two 21-MW generating units. An intake channel would be excavated along the left (east) bank and would be about 500 feet long. The proposed tailrace channel would extend approximately 550 feet downstream from the powerhouse. A 138-kV transmission line, approximately 11.9 miles long, would connect the project to the existing Washington Bottom Substation, which is owned and operated by the Monongahela Power Company. The applicant estimates that the average annual energy generated by the project would be 253 GWh and plans to use the generation to serve the needs of its existing and future customers.

2.1.1.22 Gallipolis Lock and Dam Project (FERC No. 9042)

Gallia Hydro Partners proposes a hydroelectric project at the Gallipolis L&D at RM 279.2 on the Ohio River (GAL in Figure 2.1-2). The project site is located near Gallipolis in Gallia County, Ohio. The powerhouse would replace one 125-foot gate at the west end of the existing 1116-foot-long dam, and would contain two 24-MW generating units (Figure 2.1-24). The approach channel would be about 400 feet long, and the exit channel would be about 460 feet long. A paved access road, 20 feet wide by 130 feet long, would be built to connect the project to State Highway No. 7. A new 69-kV transmission line approximately 3 miles long would connect the project to the existing Apple Grove substation of the Appalachian Power Company. The applicant estimates that the average annual energy generated by the project would be 231 GWh. The power generated would be sold to the Allegheny Power System. This project competes with FERC No. 10098 (Section 2.1.1.23).

2.1.1.23 Gallipolis Development Project (FERC No. 10098)

The City of Pt. Pleasant, West Virginia, and WV Hydro, Inc., Aiken South Carolina, jointly propose a hydroelectric project at the Gallipolis L&D at RM 279.2 on the Ohio River. The project would be located at the same site as competing project FERC No. 9042 (Section 2.1.1.22). The project would proceed in two phases; initially, two 23.5-MW generating units would be installed downstream of Gate 8; later, two 12.5-MW units would be installed in the riverside lock after new locks are constructed by the Corps in 1996 (Figure 2.1-25). The powerhouse would consist of two float-in powerhouse modules for the first phase of construction. The Phase I portion of the project would create a waterway that would extend through the existing dam; the intake to the waterway would be formed by removing the existing gate between piers 8 and 9. The tailrace would be about 125 feet wide. The 138-kV transmission line would be 1.7 miles long and would connect the project to an existing 138-kV line owned by the Appalachian Power Company. The applicant estimates that the average annual energy generated by the project would be 293 GWh (upon completion of the entire project). The power generated would be sold to Virginia Electric Power Company (VEPCo).

2.1.1.24 Muskingum River Lock and Dam No. 3 Project (FERC No. 6998)

The Upper Mississippi Water Company, Inc., proposes a hydroelectric power plant at the Muskingum River L&D No. 3 (RM 14.2), which belongs to the Ohio Department of Natural Resources (MUSK3 in Figure 2.1-2). The lock and dam are located in Washington County, Ohio, near Lowell, Ohio, and about 15 miles upstream from the confluence with the Ohio River at Marietta, Ohio. The proposed project (Figure 2.1-26) would involve constructing a powerhouse downstream of the abutment end of the dam, installing two 3.5-MW turbines, building intake and tailrace channels, dredging upstream and downstream channels, and providing access to the power plant and dam

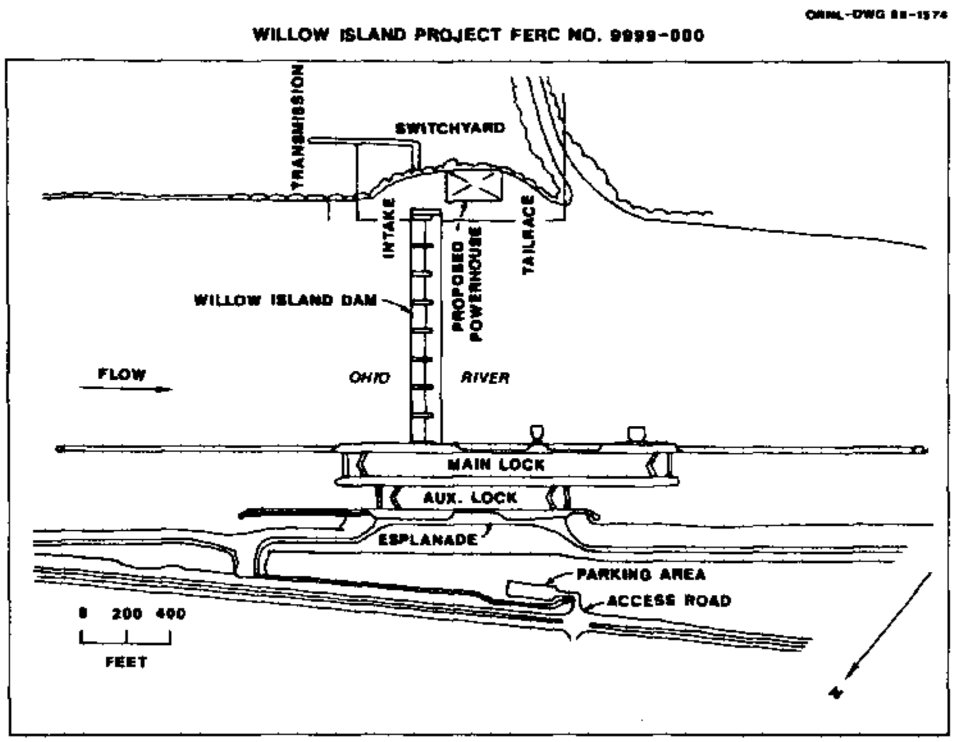


Figure 2.1-22. Layout diagram for the Willow Island Project (FERC No. 9999). Source: Modified from Exhibit G-2, City of St. Marys, 1986.

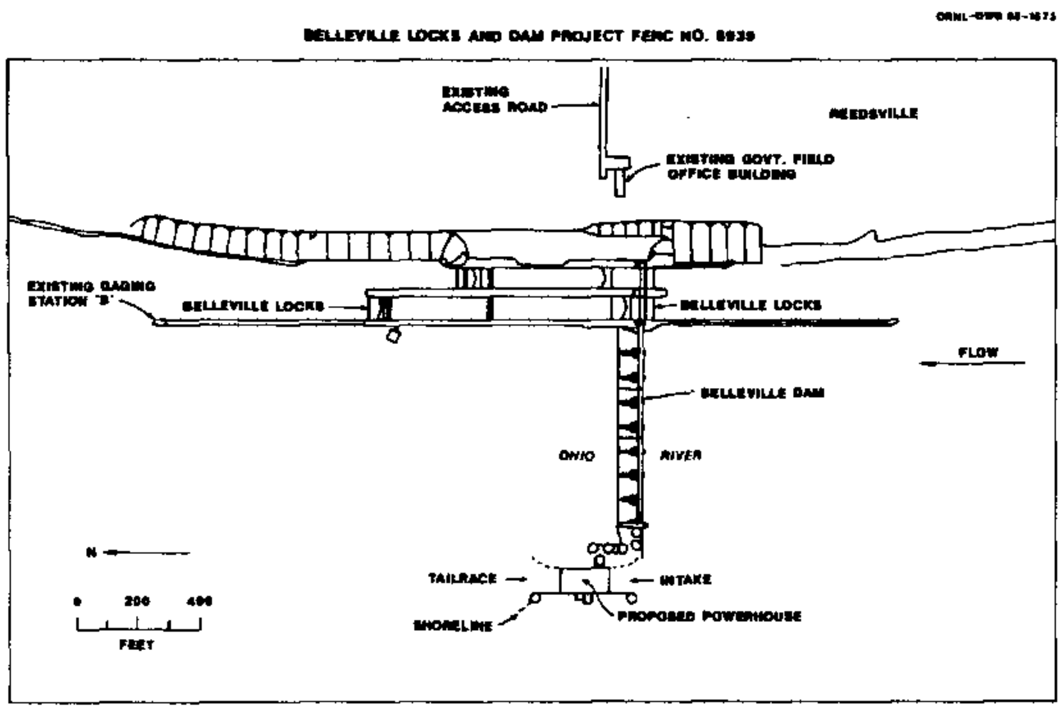
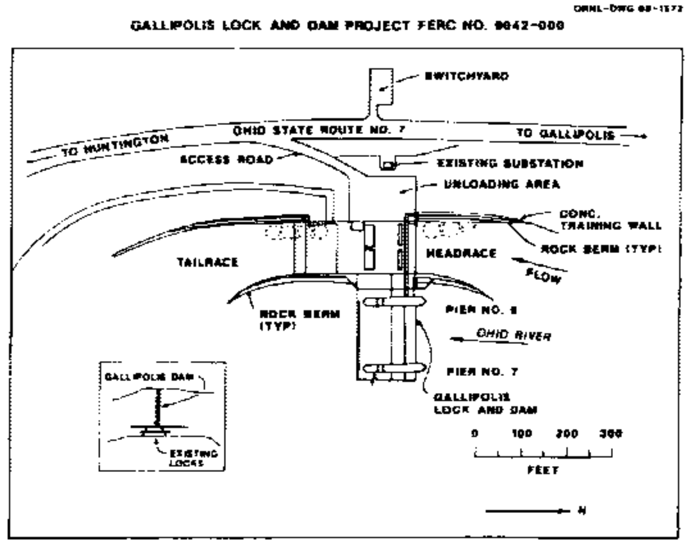


Figure 2.1-23. Layout diagram for the Belleville Locks and Dam Project (FERC No. 6939). Source: Modified from Exhibit F, City of Jackson, 1983.

Figure 2.1-24. Layout diagram for the Gallipolis Lock and Dam Project (FERC No. 9042). Source: Modified from Exhibit F, Gallia Hydro Partners, 1985.



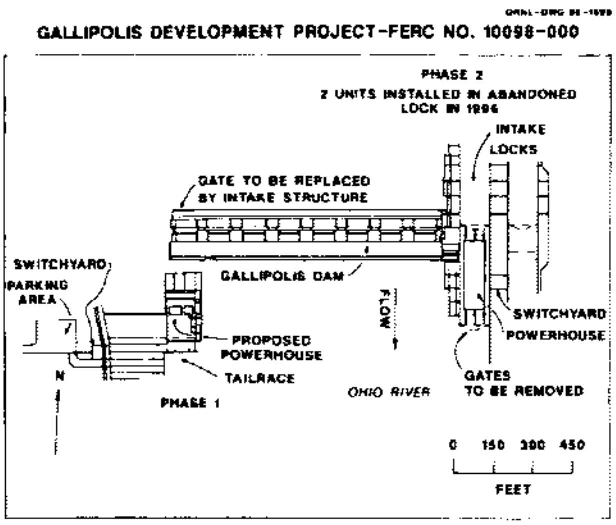
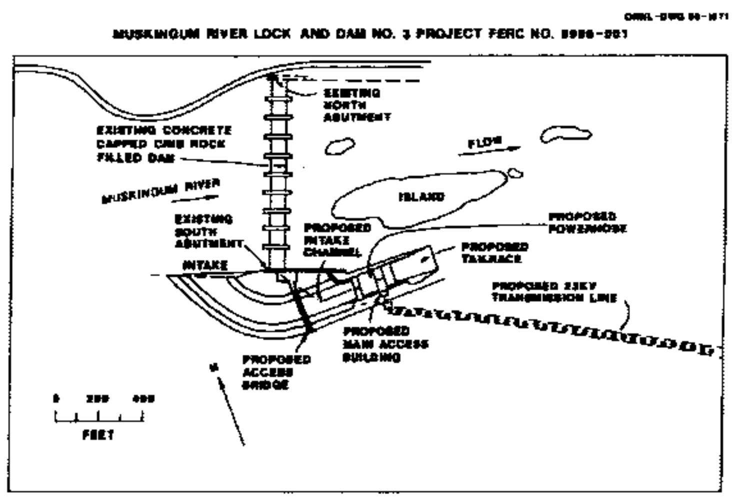


Figure 2.1-25. Layout diagram for the Gallipolis Development Project (FERC No. 10098). Source: Modified from Exhibit F, City of Point Pleasant and WV Hydro, Inc., 1986.

Figure 2.1-26. Layout diagram for the Muskingum Lock and Dam No. 3 Project (FERC No. 6998. Source: Modified from Exhibit G, Upper Mississippi Water Co., Inc., 1984.



The intake channel would be 700 feet long and 100 feet wide; the tailrace would be approximately 200 feet long and 200 feet wide. Power output is estimated by the applicant to be about 50 GWh and would be used entirely within the Monongahela Power Service System, for which a 23-kV transmission line 4,500 feet long would be constructed.

2.1.2 Alternative 2 - Project Operation to Meet Dissolved Oxygen Standards

This alternative would require modified flow regulation at proposed projects to provide greater aeration by increased spillflows and thus avoid violations of the states' DO standard of 5 milligrams per liter (mg/L). Only aeration via spillage is considered to increase downstream DO concentrations. Using a simulation model described in Appendix B, spillage requirements are estimated that would ensure that DO will not drop below the 5-mg/L standard, except when and where that standard would be exceeded under existing conditions. By enforcing this standard, this alternative would provide the minimal water quality mitigation required by existing laws. However, it would still allow some reduction in DO concentrations at locations where the standard is currently met. It was determined from simulation results that the DO standard could be satisfied if no generation were allowed at six sites (eight projects) when Ohio River flows dropped below 9000 cfs at the USGS gauging station at Sewickley, Pennsylvania, during the high-temperature season of July through October (Section 4.2.1). The eight projects whose generation would be constrained during this critical period are all in the middle of the study area and are located at the following six sites: Allegheny L&D No. 2, Emsworth, Dashields, Montgomery, New Cumberland, and Pike Island (Figure 1.1-1). By ensuring complete spillage at these six locations during low-flow periods, this alternative would maintain sufficient waste assimilative capacity in the Ohio River to handle the high wasteloads from point-source dischargers in the Pittsburgh area. The applicant's proposed spill flows are acceptable when Ohio River flows at Sewickley are greater than 9000 cfs (Table 2.1.2-1).

Table 2.1.2-1. Percent of time with no generation for Alternative 2 (projects operated to meet water quality standards) at sites where no generation would occur during critical conditions. 1/

Project	FERC No.	Percent of time with no generation	
		July-Oct	Annual
Allegheny L&D 2	4,017	51	17
Emsworth	7,041	61	27
Dashields	7,568	51	17
Montgomery	2,971	51	20
Montgomery	3,490	54	23
New Cumberland	6,901	51	20
New Cumberland	10,332	61	28
Pike Island	3,218	51	18

1/ Critical conditions are defined as when Ohio River flows at the Sewickley gauge are less than 9000 cfs during the months of July through October.

2.1.3 Alternative 3 - Project Operation to Meet Antidegradation Criteria

The third alternative would require further modifications to project operations to prevent degradation of current water quality conditions. Levels of DO that would harm aquatic biota could not occur more frequently than they do without hydropower development. Scoping comments from several resource protection agencies requested that the proposed hydropower projects be licensed so they "maintain existing conditions" of water quality, or comply with antidegradation policies. EPA's antidegradation policy, which is to be implemented by each state, is:

> Where the quality of waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the

intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located (40 CFR Part 131.12; see USEPA, 1983).

Because proposed hydropower generation at many of the navigation dams would result in decreased aeration, strictly maintaining existing aeration rates would severely limit generation. Instead, the staff has defined this alternative as licensing of hydropower with sufficient mitigation to prevent any additional DO impacts on aquatic life.

The most fundamental problem with the concept of licensing projects to maintain existing conditions is that insufficient data are available to define existing DO conditions throughout the system. At seven points in the study area, ORSANCO DO monitors have provided a base of historic concentration measurements; however, data from these monitors are sufficient only to describe local conditions, not conditions throughout the basin. For instance, staff has used data from the DO monitor just downstream of Dashields dam at Ohio RM 15.2 to develop an historic DO concentration distribution (Figure 3.5-2). Other historic data and results of the water quality modeling done for the DEIS show that DO concentrations just upstream of Dashields are generally much different from those downstream of the dam because of dam aeration. This information also shows that DO concentrations at the downstream end of the pool below Dashields are generally lower than at the monitor. At several of the proposed hydropower sites, continuous monitors were operated for parts of at least one year. Data from these monitors, however, are also inadequate to describe existing conditions because (1) the monitors operated for an insufficient length of time to describe the full range of historic conditions; (2) the monitors suffered frequent data loss and inaccuracies; and (3) the concentrations measured by the instruments, which typically have been mounted on lock walls, do not necessarily represent the average DO concentration across the width of the river.

Without sufficient information to define existing DO concentrations, only two potential approaches are apparent to meet a strict definition of antidegradation (i.e., maintaining dam aeration rates equal to those occurring without the hydropower projects). The first is not to develop hydropower projects at any dam that currently provides significant amounts of aeration. Although this approach would maintain existing DO conditions by prohibiting hydropower development that would alter dam aeration, it would result in the loss of hundreds of gigawatt-hours of generation, much of which could have been produced at times of the year when DO concentrations do not limit aquatic life. The second approach would be to (1) develop a model of below-dam DO deficits as a function of above-dam deficits (and possibly other parameters) for the dams before hydropower development, as was done for the water quality model described in Section 4.1.1; and (2) require developers to provide sufficient artificial aeration (using compressed air or similar techniques) to maintain the same below-dam DO concentrations that the dam would provide without hydropower. This second approach has been suggested by several hydropower developers. However, artificial aeration at bulb turbines would be expensive, and the reliability or even feasibility of mechanical aeration has not yet been demonstrated (Section 4.1.1). It would not be prudent to rely on unproven technology such as artificial aeration at bulb turbines to maintain water quality. Neither of these two approaches of strictly maintaining existing DO conditions is a good, reliable trade-off of environmental and power generation objectives.

The existing data clearly indicate that during much of the year, including the high-flow seasons when most power production could occur, DO concentrations throughout the Ohio River Basin are high enough that they do not limit aquatic organisms (Section 3). A better antidegradation objective is to develop criteria that would allow hydropower generation but prevent DO deficits that would impact aquatic life from occurring more frequently than they do under existing conditions without hydropower. This objective could be met by (1) determining a "no-effects" DO concentration that, if maintained, would not limit the survival, growth, or distribution of aquatic organisms; and (2) requiring spillage at dams sufficient to prevent DO concentrations from being below this "no-effects" concentration as a result of hydropower generation. Under existing conditions, DO concentrations occasionally fall below standards. By requiring hydropower projects to cease operations when generation would cause DO concentrations to fall below the "no-effects" concentration, the projects would be prevented from causing DO impacts to aquatic life from occurring more frequently than they do under existing conditions.

The third licensing alternative would, therefore, require aeration spillage at hydropower projects in sufficient amounts to maintain the "no-effects" DO concentration and to allow no reduction in aeration when DO concentrations are below this threshold. The "no-effects" level for DO is considered to be 6.5 mg/L for the purposes of the EIS analysis (Section 4.3). This definition would allow hydropower generation when DO concentrations do not limit aquatic life and prevent additional DO impacts to aquatic life. The final spillage values specified under this alternative were selected to maximize the total annual production from new hydroelectric projects under consideration in this assessment, while maintaining the desired DO concentrations. The use of the optimization model to determine the spill flows is described in Appendix B.

As in the previous alternative, critical and noncritical periods of the year were distinguished in defining spillage requirements. For the purposes of meeting the antidegradation criteria, the critical period of the year is defined as extending from July through October, the lowest flow and highest water temperature months of the year. The spillage requirements for this alternative are given in Table 2.1.3-1. It is recommended that these spill flows be subject to temporary modification if needed for water quality management.

Table 2.1.3-1. Minimum spill flows for Alternative 3 (projects operated to meet antidegradation criteria) and Alternative 4 (projects selected to minimize impacts to all target resources).

Project	FERC No.	Spill flow (cfs) Critical 1/	Spill flow (cfs) Non-critical 2/
Allegheny L&D 7 3/	7,914	500	500
Allegheny L&D 4	7,909	8,000	1,000
Allegheny L&D 3	4,474	1,000	1,000
Allegheny L&D 2	4,017	7,000	1,000
Tygart Dam	7,307	(not applicable)	
Tygart Dam	7,399	(not applicable)	
Opekiska	8,990	0	0
Hildebrand	8,654	1,500	500
Point Marion	7,660	1,500	500
Maxwell	8,908	500	500
Monongahela L&D 4	4,675	500	500
Emsworth	7,041	8,000	4,000
Dashields	7,568	14,000	4,000
Montgomery 3/	2,971	16,000	4,000
Montgomery 3/	3,490	16,000	4,000
New Cumberland	6,901	15,000	4,000
New Cumberland	10,332	15,000	4,000
Pike Island	3,218	6,000	4,000
Willow Island	6,902	0	0
Willow Island	9,999	0	0
Belleville	6,939	0	0
Gallipolis	9,042	0	0
Gallipolis	10,098	0	0
Muskingum L&D 3 3/	6,998	2,280 4/	1,520

1/ Spill flows, not including lockage and leakage, during the critical season. The critical season is defined as the months of July through October.

2/ Spill flows at all times except the critical season.

3/ This project would not be developed under Alternative 4.

4/ Spill flows at Muskingum L&D No. 3 are those recommended by the USFWS for protection of the pink mucket pearly mussel. the critical season for Muskingum L&D No. 3 is during the months of April, May, and June.

2.1.4 Alternative 4 - Projects Selected to Minimize Impacts to All Target Resources

The fourth alternative would, like Alternative 3, provide protection of aquatic resources from decreases in DO and would also reduce impacts to other target resources. This protection would be accomplished by developing hydropower at 16 of the 19 sites; these 16 proposed projects would have no significant adverse impacts on wetlands, terrestrial resources, recreation, and fish populations. The three sites at which hydropower development would not be developed because of significant adverse impacts on target resources are Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3. Spillage requirements at all other locations would be the same as in Alternative 3.

2.2 NONHYDROELECTRIC GENERATING ALTERNATIVE

The staff believes that the 400-plus MW of base-load capacity that would be available from the 19 proposed Ohio River Basin sites would be useful in replacing generation from the less efficient steam units. Adhering to this opinion and recognizing that projections of base-load capacity additions for the 32 utilities studied by staff forecast the addition of 3651 MW of coal-fired steam capacity, it is further the opinion of staff that a coal-fired steam plant, or plants, would be the most likely nonhydroelectric alternative to the proposed Ohio River Basin projects. This assumes, of course, that all "likely to be available" IPP facilities, of all types, have been included in regional resource projections for the 1987 to 1995 regional planning period.

2.2.1 Coal-Fired Power Plant

To replace the 400-plus MW of electrical capacity of the proposed hydropower developments, alternative power production techniques could be employed. A coal-fired unit of approximately 400-MW capacity could supply the energy, but it is uncertain whether a new power plant of this small size would be built. However, a unit of this size could be added to an existing facility within the region, and this development is assumed. The analysis is based upon information contained in a Fish and Wildlife reference document (Dvorak et al., 1978). The values are reasonable, but site-specific variations would occur.

The unit would most likely be constructed at an existing facility, and it would comply with all present environmental regulations. In this analysis, a pulverized coal burner, with a thermal efficiency of 38 percent is assumed. Pollution control equipment employed includes baghouses for particulate control, low excess-air burners to minimize formation of oxides of nitrogen, limestone scrubbers for sulfur dioxide control, and cooling towers to reduce impacts to aquatic communities.

The coal unit would be added to a facility within the region, using coal from either Pennsylvania or West Virginia. Sufficient underutilized mining capacity to supply the facility exists in the region, so coal mining impacts would be site specific, depending upon the source of the coal. Compliance with all coal mining regulations is assumed.

The unit would be constructed at an existing facility, using existing transmission facilities. Land use impacts at the power station are assumed to be limited to previously disturbed areas, with no new land acquisitions for the unit required. The unit would occupy approximately 4 additional acres for coal storage and handling, 2 acres for the power production and generation facilities, and 8 acres for cooling towers.

2.2.2 Other Nonhydroelectric Generating Alternatives

An aggregate of nonhydropower IPP facilities that are adapted to base load dispatch, cost-effective, and reliably available would also serve well as nonhydroelectric generating alternatives. These alternatives have already been recognized in foregoing sections. The two outstanding candidates in this class are cogeneration facilities and steam plants fueled by the combustion of solid waste.

Solar energy has made its principal contribution to the need for electric capacity and energy by conserving energy. Solar space heating and solar water heating are currently recognized as cost-effective technologies making substantial contributions to conservation efforts. The use of solar energy for the generation of electric power either by photovoltaic technology or by solar-energy-"fired" steam-electric technology is, at this time, not commercially feasible except in locations where utility power is not available or where cost is a secondary consideration.

Geothermal energy from existing reservoirs along the border between Virginia and West Virginia is unsuited as a primary energy source for the generation of electric power. Reservoir temperatures are too low for this purpose.

Wind power is being commercially exploited in favorable areas of the country. The cost-effectiveness of wind-power generation depends upon the availability of wind having suitable characteristics and the cost of utility electric power, with which it must compete. Geographical location of a wind-power site determines both. There are also adverse environmental impacts. Wind-powered electric generating facilities, in the ECAR Region, are not being developed at this time.

Alternative nonhydroelectric generation technologies which are still in the research and development (R&D) stage or which, for one reason or another, are not ready for commercial exploitation, will not be discussed.

2.3 NONGENERATING ALTERNATIVES

The principal nongenerating alternatives to the proposed Ohio River Basin projects are conservation and load management to reduce energy requirements and to reduce peak demands for capacity. Efforts and incentives to promote both have come from state and federal agencies and from utilities. Efforts have been aggressive and effective. Both utilities and utility customers are well aware of the financial benefits that accrue from the related programs. Conservation and load-management programs are being carefully studied and when considered to be costeffective, are implemented. Implementation has, in many cases, been pushed to the limit of costeffectiveness.

Utilities, in their projections of the impacts of conservation and load-management programs, reflect these impacts in their projections of peak demands and annual energy requirements.

2.4 NO-ACTION ALTERNATIVE

The no-action alternative would constitute a denial of all the applications for license to construct, operate, and maintain the proposed projects. This alternative would result in the nonuse of potential energy that could be derived by developing the proposed sites and the consumption of fossil fuel that would be saved if the proposed projects were developed. In general, the no-action alternative would result in no change or a continuation of existing trends for the target and other resources discussed in this FEIS. Potential beneficial effects of the proposed projects, however, would not be realized. Such beneficial effects would include improvement of existing DO conditions at Opekiska, potentially aerating rivers using turbine aeration if the technology proves to be feasible, avoiding impacts from power generation facilities (e.g., coal-fired power plants) that would be built instead of the hydropower projects, increases in employment, and development of proposed recreational tailrace fishing facilities at some of the projects.

2.5 COMPARISON OF ALTERNATIVES

There are significant trade-offs between power development and environmental quality among the four hydroelectric generating alternatives considered in this FEIS. The estimated annual energy production of the projects as proposed (Section 2.1.1) would be 1910 GWh of hydroelectricity. The other three hydroelectric generating alternatives would produce successively less energy (Figure 2.5-1); the second, third, and fourth alternatives would produce 99 percent, 92 percent, and 82 percent of the energy from the projects as proposed. The differences among the first three alternatives are directly related to less generation during critical periods of the year (July to October) when higher spillage is required to maintain acceptable DO levels in the river. Hydroelectric generation during the noncritical time of the year would be essentially constant except for the fourth alternative. Compared with the projects as proposed, the cost of attaining the antidegradation criteria for water quality (Section 2.1.3) is to forego generation of approximately 150 GWh of hydroelectricity. By not approving the development of three projects in the fourth alternative (Section 2.1.4) production of approximately 350 GWh of hydroelectricity would be foregone. Although this is a

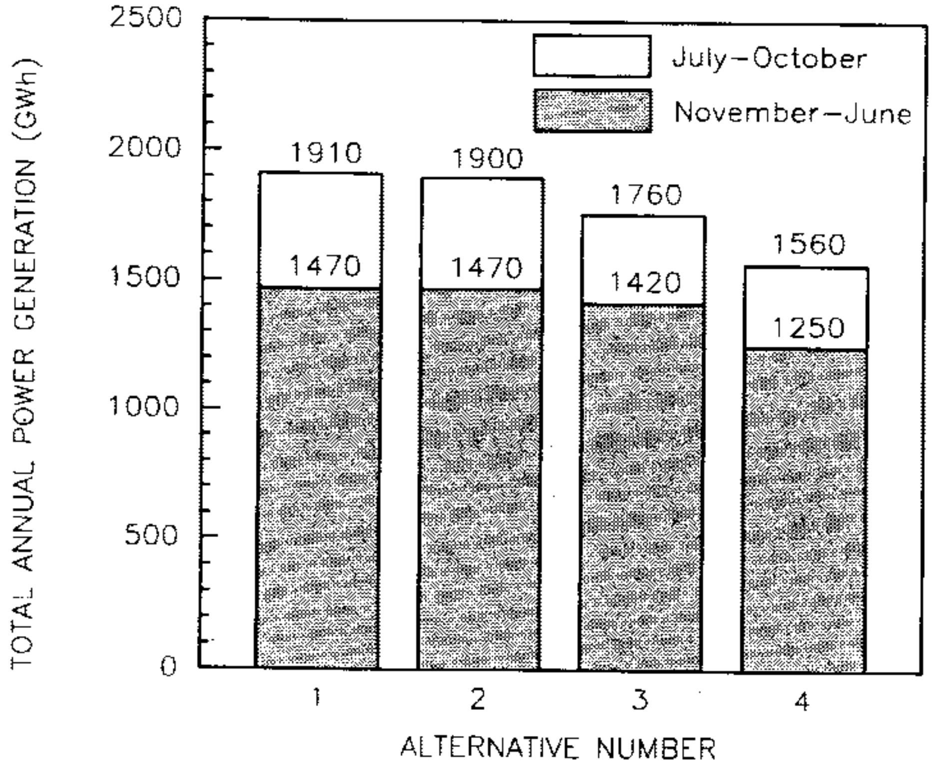


Figure 2.5-1. Hydroelectric generation under Alternatives 1 to 4.

significant amount of new energy that would not be produced, there are significant adverse environmental impacts to fish, wildlife, and recreation that could be avoided under the fourth alternative.

The environmental impacts under the four hydroelectric alternatives are summarized in relative terms in Figure 2.5-2. Relative impact values are assigned to each combination of alternative, project, and affected resource, distinguishing among four levels of impact: no significant concern, minor impacts, moderate impacts, and major impacts. The basis and details for these impacts are presented in Sections 4 and 5.1. Significant adverse impacts to water quality, fish, wetlands, and recreation are predicted at a large number of sites under Alternatives 1 and 2 (Figure 2.5-2). Under Alternative 3 (projects operated to meet the antidegradation criteria); significant adverse impacts to fish, wetlands, and recreation are still predicted at three sites: Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3. These remaining impacts are related to the proximity of islands and other unique habitat types at the proposed projects. Although adverse impacts to water quality could be minimized by spillage requirements, hydropower development would still redistribute dam discharges in such a way as to adversely impact the important environmental resources associated with these islands. Alternative 4 would eliminate all significant adverse impacts. The moderate and minor impacts that would remain under Alternative 4 are associated primarily with potential mortality of fish during passage through hydroelectric turbines and with new construction in densely populated areas. The staff believes that the remaining impacts under Alternative 4 could be controlled and minimized with appropriate mitigation. Because Alternative 4 would minimize impacts to target resources and allow annual production of approximately 1560 GWh of new hydroelectricity, the staff recommends it as the preferred alternative. Further details of the staff's recommendations are presented in Section 5.

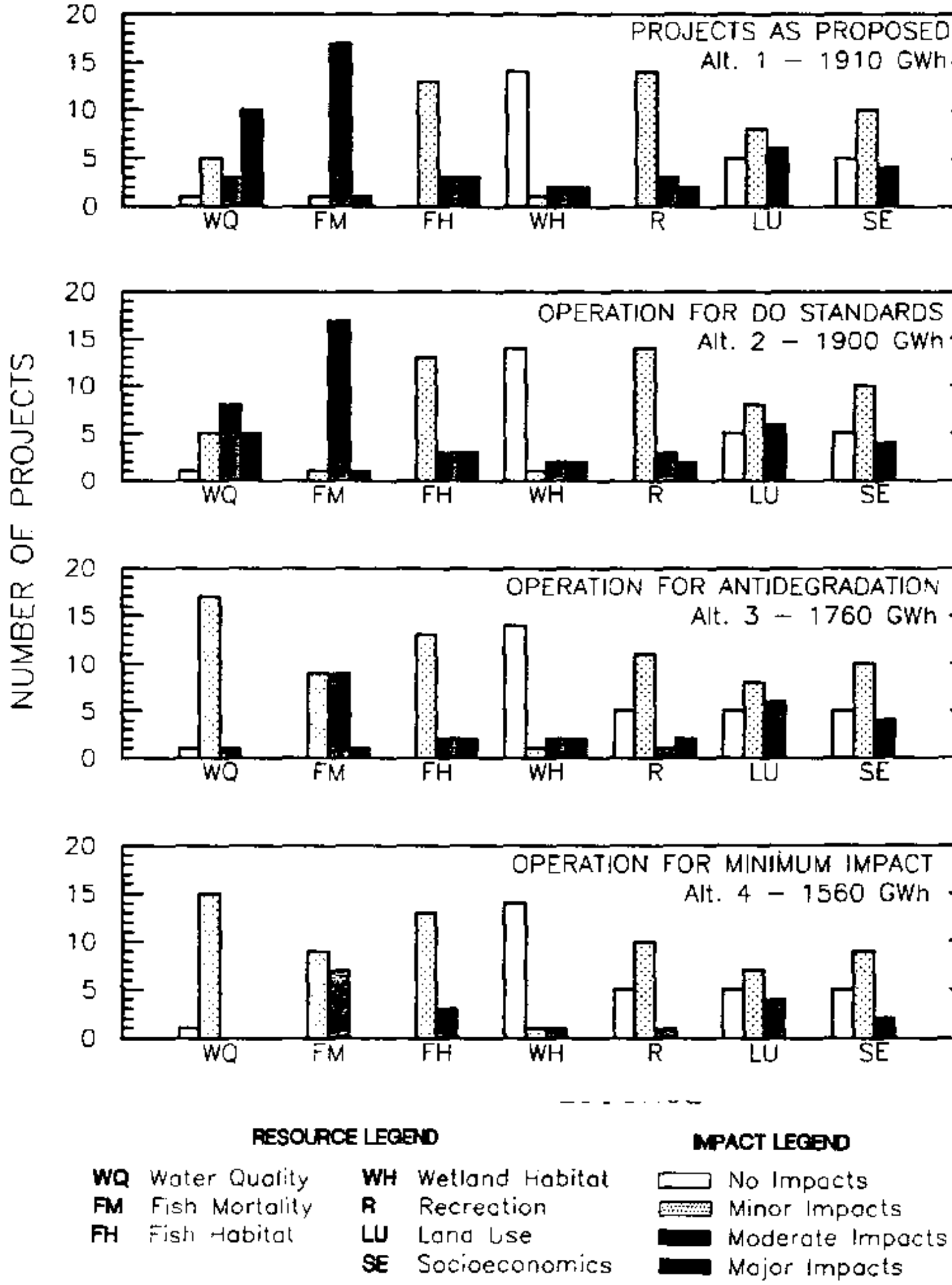


Figure 2.5-2. Summary of impacts for the four alternatives.

3. AFFECTED ENVIRONMENT

The purpose of this section is to describe the environment potentially affected by the proposed actions, in sufficient depth for understanding environmental impacts analyzed in Section 4. Section 3.1 presents an overview of regional environmental resources addressed in this study, Section 3.2 provides a general discussion of each of the target resources (i.e., those identified during the scoping process as being of particular concern to the assessment of possible cumulative impacts from the proposed actions), and Sections 3.3 through 3.6 describe the potentially affected resources for each of the major river sections.

3.1 REGIONAL RESOURCES

3.1.1 General Setting

The study area encompasses a major part of the upper Ohio River Basin that is bounded at the northeast by L&D No. 7 on the Allegheny River near Kittanning, Pennsylvania; at the southeast by Tygart Dam on the Tygart Valley River (a tributary of the Monongahela) near Grafton, West Virginia; and at the southwest by Gallipolis L&D, south of Gallipolis, Ohio. Project sites are located on the Allegheny, Monongahela, Tygart Valley, Ohio, and Muskingum rivers in the states of Pennsylvania, West Virginia, and Ohio.

The study area is located in the Appalachian Plateau Physiographic Province (Fenneman, 1948; Hunt, 1974), which is characterized by narrow flood plains and deeply indented stream valleys. Exposed rocks are primarily Permian and Pennsylvanian in age, and most of the rock strata are shale, sandstone, siltstone, limestone, and coal. Upstream of Pittsburgh, the topography exhibits moderate to strong relief because of erosion of the uplifted plateau. Along the river corridor, the relief remains essentially uniform. Downstream of Pittsburgh, the river is characterized by well-developed floodplains and numerous meanders. Groundwater is generally readily available adjacent to the rivers and is recovered from fluvioglacial sediments.

Alluvial soils along most rivers in the upper Ohio River Basin consist of glaciofluvial fill or medium-coarse grained sand and gravel, while the flood plain soils are commonly loams. The Monongahela is unglaciated and its bottom materials do not consist of glaciofluvial aggregates. Soils are classified as Ultisoils, which are generally used for farming, woodland, and pasture, and Inceptisols, which are generally used for pasture, silage corn, small grain, and hay.

The climate of the basin is continental, with marked contrasts in temperature and moisture. Average annual temperature is about 54^{o}F for the basin as a whole, with summers being warm and humid and winters being relatively cold. The average frost-free period varies from 145 days in the north part of the study area to 180 days in the south. Mean minimum temperatures occur in January, with mean maximum temperatures occurring in July. Annual precipitation also varies considerably, with extremes ranging from 20 inches to 72 inches. The heaviest amounts of precipitation usually occur in June or July, with the minimum amounts occurring in October. Although heavy snowfalls may occur, they are usually followed by gradual thawing periods. Damage from flooding has been reduced along the rivers by the construction of numerous flood-control dams built by the Corps.

3.1.2 Land Use

As indicated by the data in Table 3.1.2-1, forests are the most common land use in the study area, covering 61 percent of the land area. Agricultural lands, including cropland and grazing land, are the next most common uses, with each occupying about 10 percent of the land area. About 7 percent of the study area is occupied with urban land uses, primarily residential. In spite of the region's reputation as a mining center, mining activities occupy only about 2 percent of the land area.

Allegheny County, Pennsylvania, at the confluence of the Allegheny, Monongahela, and Ohio rivers, is the urban center of the study area. Urban land uses, which are generally found in all parts of the county where slopes and other conditions allow, occupy almost one-third of the land area. Only about one-third of the county is used for forestry and agriculture, a much lower proportion than anywhere else in the study area.

Table 3.1.2-1. Land use by river basin. 1/

Area	Allegheny County	Ohio River Basin	Allegheny River Basin	Monongahela River Basin	Total Study
		Percent Land Use 2/			
Rural land use 3/					
Cropland	3.4	9.4	14.1	9.9	9.9
Grazing	1.8	11.3	5.5	12.8	10.3
Forest	28.7	68.0	53.3	63.4	61.4
Mining 4/	2.0	1.9	2.6	1.4	1.9
Urban land use 2/					
Total Urban	31.3	5.2	7.0	4.5	7.4
Residential	22.2	3.5	5.6	3.2	5.3
Other Urban	9.2	1.8	1.3	1.2	2.1

1/ Data are for the counties that would be affected by the proposed hydropower projects and include only portions of the total drainage basins.

2/ U.S. Department of Agriculture, 1982.

3/ Compiled by staff from the following sources: Anderson et al., 1976; Buckeye Hills-Hocking Valley Regional Development District, 1981; McColloch and Lessing, 1980; Kaschak, N. G., Director, Jefferson County, Ohio Regional Planning Commission, 1988, personal correspondence; Southwestern Pennsylvania Regional Planning Commission, 1980; and Greene County, Pennsylvania, Planning Commission, n.d..

4/ Because the data were compiled from diverse sources, the columns do not total to 100.0 percent.

Parts of the upper Ohio River Basin form the western portion of the study area and include the counties of Jefferson, Belmont, Washington, Meigs, and Gallia, in Ohio; Hancock, Brooke, Ohio, Pleasants, Wood, Jackson, and Mason in West Virginia; and Beaver in Pennsylvania. Overall, this portion of the basin is overwhelmingly rural, with forests and agriculture covering almost 90 percent of the land area. This area is the most heavily forested portion of the study area, and forests are particularly extensive in the southern portion. Agricultural use occurs primarily in the flat floodplains of the Ohio River and tributary streams (Brooks and McCamic, 1978) and is about evenly divided between cropland and grazing land. Urban land, which generally occurs in a rather linear fashion along the Ohio River (Brooks and McCamic, 1978; BEL-O-MAR Regional Council and Interstate Planning Commission, n.d.), occupies somewhat less of the area than in the other basins. The northern portion of the basin is considerably more urbanized than the southern part, with major urban concentrations occurring around Steubenville, Ohio, Wheeling, West Virginia, and Aliquippa, Pennsylvania. In the southern portion, a smaller concentration of urban use occurs in the Marietta, Ohio/Parkersburg, West Virginia area.

The southernmost portion of the Allegheny River Basin is also within the study area and includes the counties of Armstrong and Westmoreland, Pennsylvania. Forestry and agriculture dominate the land of these counties, but to much less an extent than in other portions of the study area. About 53 percent of the area is forested, and about 20 percent is used for agriculture. Among agricultural uses, cropland is much more common than grazing land. Urban uses account for a somewhat higher portion of the land area than in the affected parts of the Ohio and Monongahela basins (probably because both counties in this basin are close to Pittsburgh). The urban development is mainly concentrated in the river valley, and follows a general pattern of industrial uses lining the river banks, commercial uses forming a strip just inland of the industrial, and residential areas filling the remaining portion of the valley further inland (Allegheny County, Pennsylvania, 1984).

Part of the Upper Monongahela River Basin forms the southern portion of the study area and includes the counties of Washington, Greene, and Fayette in Pennsylvania; and Monongalia, Marion, Taylor, Harrison, and Barbour in West Virginia. Forests cover approximately 63 percent of this area and are especially prevalent in the southern part. This basin has a higher proportion of land devoted to agricultural uses than any other portion of the study area. In the northern portion of the area, agricultural lands are about evenly split between cropland and grazing, while grazing is clearly more common in the southern portion. The basin has a lower percentage of land in urban uses than does any other part of the study area. The pattern of urban development is also different in that it does not occur in linear fashion along major waterways. Instead, the development is concentrated around the cities of Morgantown, Fairmont, and Clarksburg, with smaller, isolated concentrations occurring in outlying areas.

The waters of the Ohio River and its major tributaries are used for power generation, public water supply, industrial supply, fish and wildlife habitat, recreation, and navigation. Commercial navigation is maintained along the rivers in the study area by a series of locks and dams operated by the Corps. Operation of the locks and dams requires maintenance of a 9-foot-deep navigation channel. Additional locks and dams are also in operation along tributaries to the Ohio River, such as those on the Allegheny and Monongahela Rivers. These locks and dams allow commercial navigation to reach the coal fields of West Virginia and Pennsylvania (USEPA, 1985).

3.1.3 Water Quality

Water quality in the Ohio River Basin is monitored and managed by the Ohio River Valley Water Sanitation Commission (ORSANCO), as well as by individual states' resource agencies. ORSANCO collects extensive data and conducts studies and surveys on the Ohio River and tributaries. Baseline water quality information and information sources are presented for each river in Sections 3.3 through 3.6.

Although ORSANCO has not yet conducted conclusive statistical analyses of historic data to demonstrate significant water quality improvement, evidence of recent improvement in water quality includes recolonization of the rivers by pollution-intolerant fish species (Section 3.1.4); increases in recreational fishing use of the rivers; and the appearance of large algae growths where previously algae populations had been severely limited by acid mine drainage. A recent analysis of long-term trends in water quality measured by the U.S. Geological Survey (USGS) showed that improvement in dissolved oxygen (DO) concentrations occurred frequently at stations in the Ohio River Basin (Smith et al., 1987). Studies conducted by the Ohio River Ecological Research Program indicate that changes in fish populations are related to improvements in water quality in the Ohio River (Van Hassel et al., 1988; Reash and Van Hassel, 1988).

A number of water quality parameters continue to be of concern in the basin. Water temperatures are elevated because there are many power plants and other industries that discharge heated water. High water temperatures reduce DO concentrations and inhibit growth of some fish species. DO concentrations well below saturation occur, especially in summer when flows are low, because major point and nonpoint sources of biochemical oxygen demand (BOD) exist; BOD includes organic and nitrogenous compounds that biodegrade rapidly, resulting in reduced DO concentrations. There are areas where pH remains low because acid mine wastes still are discharged.

A major emphasis of recent ORSANCO monitoring is on toxic compounds such as heavy metals, cyanide, phenolics, trihalomethanes, and volatile organic compounds. These toxic compounds generally occur at low concentrations but their toxicity makes them of concern for drinking water supplies and for protection of aquatic life. The concentrations of some compounds, such as cyanide and phenolics (ORSANCO, 1986a), have decreased in the 1980s but could increase if industries in the basin are revived. ORSANCO recently summarized the results of their Toxics Control Program, which monitors sources and concentrations of toxics (ORSANCO, 1987b). The Program monitors concentrations of 10 heavy metals, 16 volatile organic compounds (14 priority pollutants plus bromochloromethane and trichlorofluoromethane), cyanide, and phenolics. In addition, fish tissues are monitored every other year for pesticides and polychlorinated biphenyls. Copper and zinc have been detected in over 90 percent of water samples. Organic compounds that are most commonly detected include chloroform (in over 70 percent of samples), and tetrachloroethylene and 1,1,1-trichloroethane (each found in about 30 percent samples). Chloroform concentrations exceed the 10^{-5} cancer risk in 3 percent of samples and exceed the 10^{-7} cancer risk in 73 percent of samples.

A 1987 ORSANCO survey of wastewater facilities (ORSANCO, unpublished data) shows that 92 percent of 1608 municipal treatment facilities in the Ohio River Basin have secondary or better treatment (secondary treatment removes most of the organic wastes that decrease DO concentrations). Of the 579 industrial treatment facilities, 82 percent have adequate treatment capacity. The survey shows that there continue to be significant improvements in wastewater treatment in the basin.

3.1.4 Aquatic Ecology

3.1.4.1 General

The mainstem rivers of the upper Ohio River Basin that are included in this EIS are characterized by low gradients and slow water velocity. The original rivers have been modified by navigation impoundments so that they have little rapidly moving water remaining at normal flow volumes except below the dam discharges and around obstructions such as channel islands (Figure 3.1.4-1). The predominant habitat is channelized, deep, open water that is called riverine lower perennial as modified by impoundments (Cowardin et al., 1979). Backwater zones around river islands and the submerged mouths of tributaries are scarce and valuable because these areas offer shallow-water habitats for spawning and rearing of fishes. The remnants of rapid-water habitat that supported a diversity of fast-water species previously occurred throughout the river system are now concentrated below the discharges of the navigation dams. The exception to this characterization is the Tygart Reservoir, a storage reservoir with an annual drawdown cycle for flood control and downstream flow augmentation, and its rapidly flowing tailwater. This and other unique or sensitive areas are discussed more fully by target resources (Section 3.2) or river (Sections 3.3 through 3.6).

Fish communities of the upper Ohio River system are increasing in their percentage of game species as the system overcomes historic degradation, largely from industrialization and acid mine drainage (Lachner, 1956; ORSANCO, 1962; Preston and White, 1978; USEPA, 1979; Jernejcic, 1982; USEPA, 1985; USFWS, 1986; Pearson and Krumholz, 1984; ESE, 1987; ORSANCO, unpublished data, 1987; and fish surveys by the applicants). Prized game species such as walleye, sauger, largemouth bass, smallmouth bass, spotted bass, white bass, and channel catfish that were once rare now occur commonly and are the preferred catch of sports anglers. Other valued and long-absent species such as paddlefish are moving, largely from the lower Ohio River, to colonize previously degraded habitats. There is one truly migratory fish, the American eel, that occurs throughout the study area and migrates downstream as adults to spawn in the ocean and upstream as juveniles. Gamefish are also being stocked into the region, either to reestablish once-present species (e.g., walleye in Tygart pool and tailwater) or as new introductions (e.g., striped bass, hybrid between striped bass and white bass, and northern pike). Carp remain the dominant species by weight in the more urban and industrialized sections. The fishery resource is thus considered by the natural resource agencies to be valuable at present and to be improving to the point that provision should be made to provide conditions suitable to establish valued species thought to once occupy the region. Fish species of the region and their importance as gamefish, their usual adult habitats, and spawning habitats and timing, are shown in Figure 3.1.4-2. An expanded summary of target resource species is given is Section 3.2.

The most valued habitat for the recreational fishery of the upper Ohio region (based on angler use per unit area) is the high-current, rocky-substrate, dam tailwater. Here, the most prized species are walleye, sauger, white bass, smallmouth bass, and channel catfish. This habitat is susceptible to alteration by hydropower development through depletion of DO and spatial rearrangement of flows.

Backwaters at the margins of the main, channelized navigation pools are the next most valued habitat, where largemouth bass, spotted bass, smallmouth bass, and bluegill predominate. These backwaters are the non-navigable sides of islands and the flooded mouths of tributary streams. The pool edges and backwaters upstream of fixed-crest dams are susceptible to dewatering if hydropower development reduces the depth of water flow over the dam crests (Section 4.1.5). However, new pool edges would be created even though the pool area would be reduced.

Freshwater mussels, once abundant in the free-flowing Ohio River but reduced in both species diversity and numerical abundance by pollutants and impoundments, have shown a resurgence (Taylor, 1980; Tolin and Schettig, 1983a, b). A number of species thought lost from the system have been rediscovered, and more complete surveys are expected to demonstrate the occurrence of even more of the extirpated species.

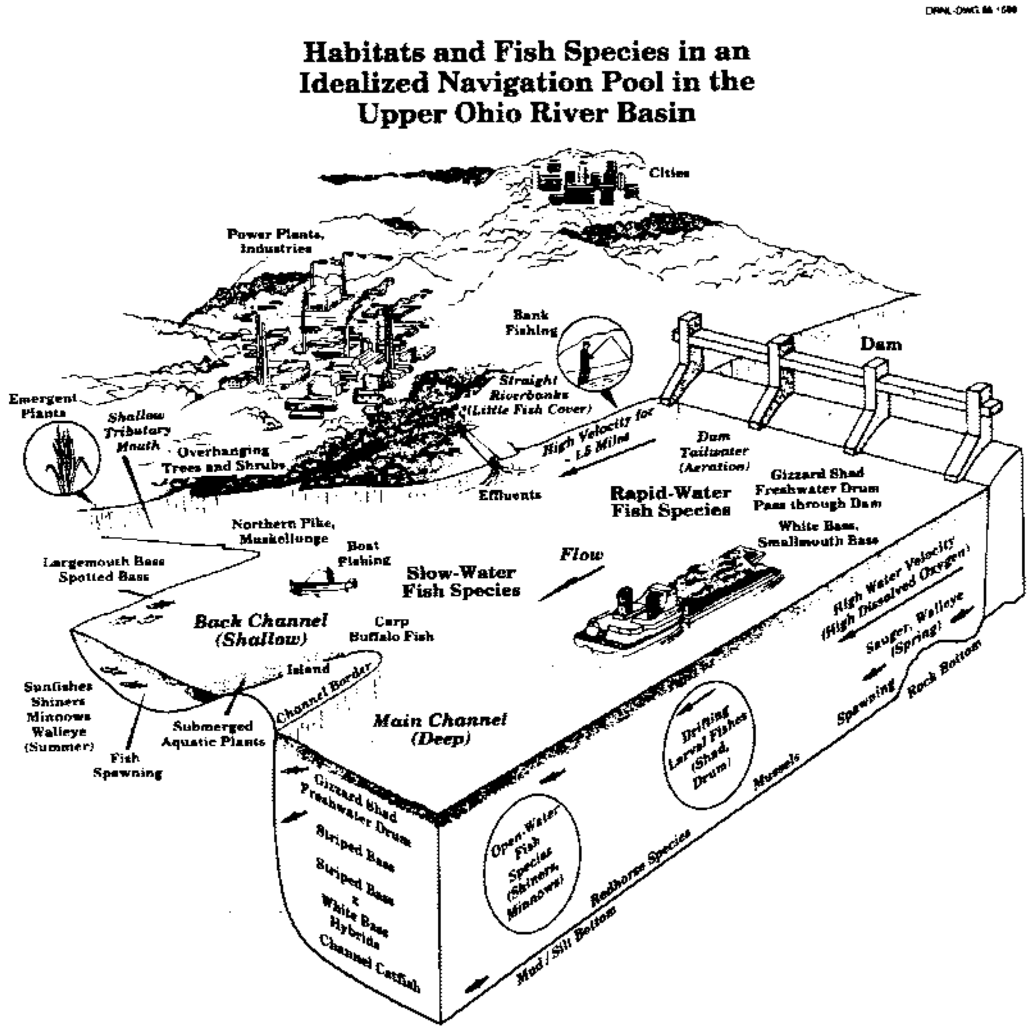


Figure 3.1.4-1. Habitats and fish species in an idealized navigation pool.

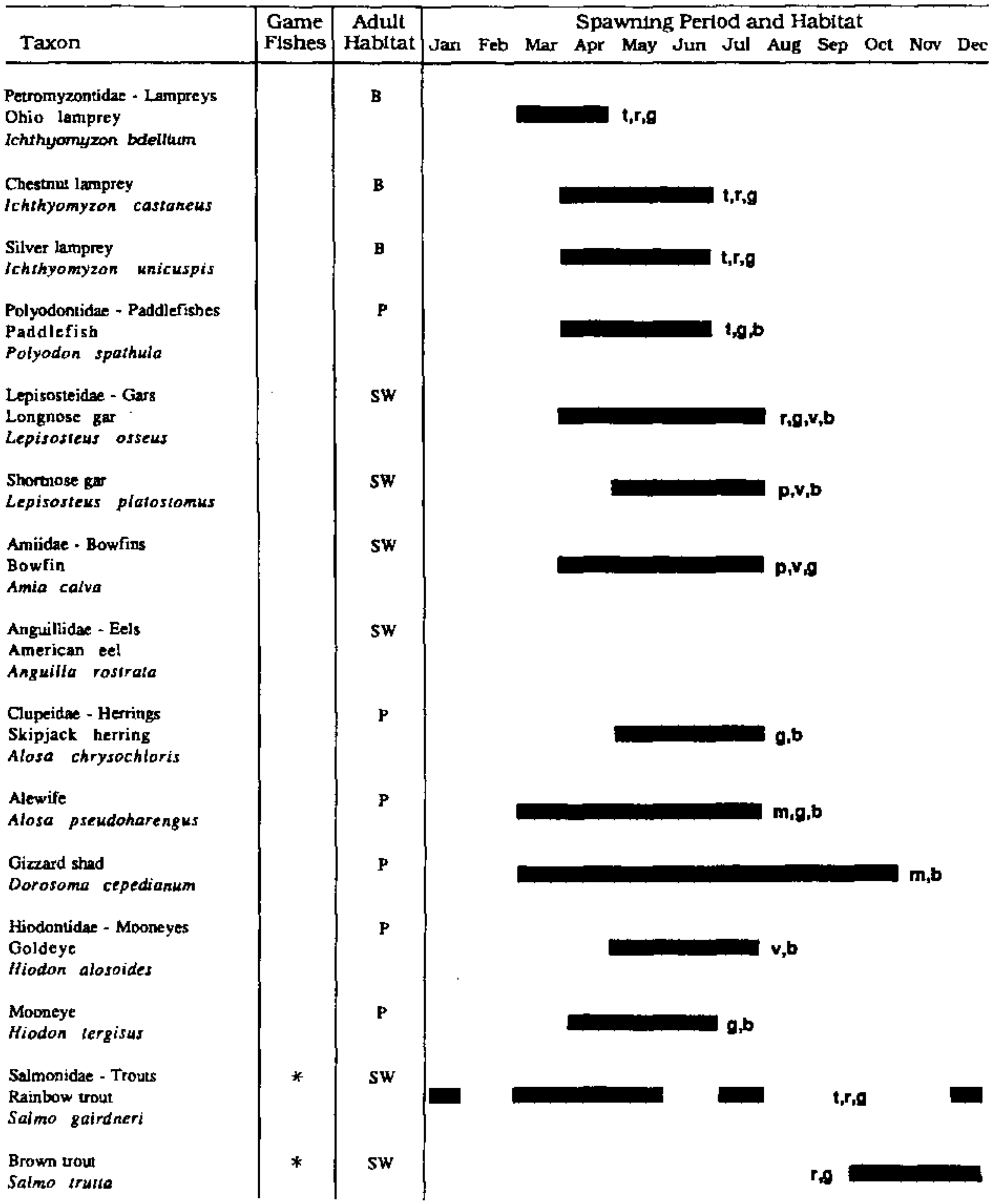


Figure 3.1.4-2. Fishes occurring in the Allegheny, Monongahela, and upper Ohio Rivers, with principal adult habitats, spawning periods, spawning habitat, and spawning type indicated. B = benthic (bottom dwelling), P = pelagic (openwater dwelling), SW = shallow water dwelling, C = midchannel, M = river margin, t = tributaries, p = pools, r = riffles, g = gravel, v = vegetation, b = broadcast spawner, * = game species. Modified from EPA 1985.

Taxon	Game Fishes	Adult Habitat	Spawning Period and Habitat
Esocidae - Pikes		SW	
Redfin pickerel *Esox americanus americanus*			v,b
Grass pickerel *Esox americanus vermiculatus*		SW	m,v,b
Northern pike *Esox lucius*	*	SW	v,b
Muskellunge *Esox masquinongy*	*	SW	v,b
Tiger Muskie	*	SW	
Cyprinidae - Minnows & Carps		B	
Central stoneroller *Campostoma anomalum*			r,g
Goldfish *Carassius auratus*		SW	v,b
Carp *Cyprinus carpio*		SW	v,b
Silverjaw minnow *Ericymba buccata*		SW	r,g
Speckled chub *Hybopsis aestivalis*		SW	b
Bigeye chub *Hybopsis amblops*		SW	t,g,v
Streamline chub *Hybopsis dissimilis*		SW	t,p,r,g
Silver chub *Hybopsis storeriana*		SW	t,g,v,b
River chub *Nocomis micropogon*		SW	g
Golden shiner *Notemigonus crysoleucas*		P	v,b
Popeye shiner *Notropis ariommus*		SW	t,p,g
Emerald shiner *Notropis atherinoides*		P	g,b

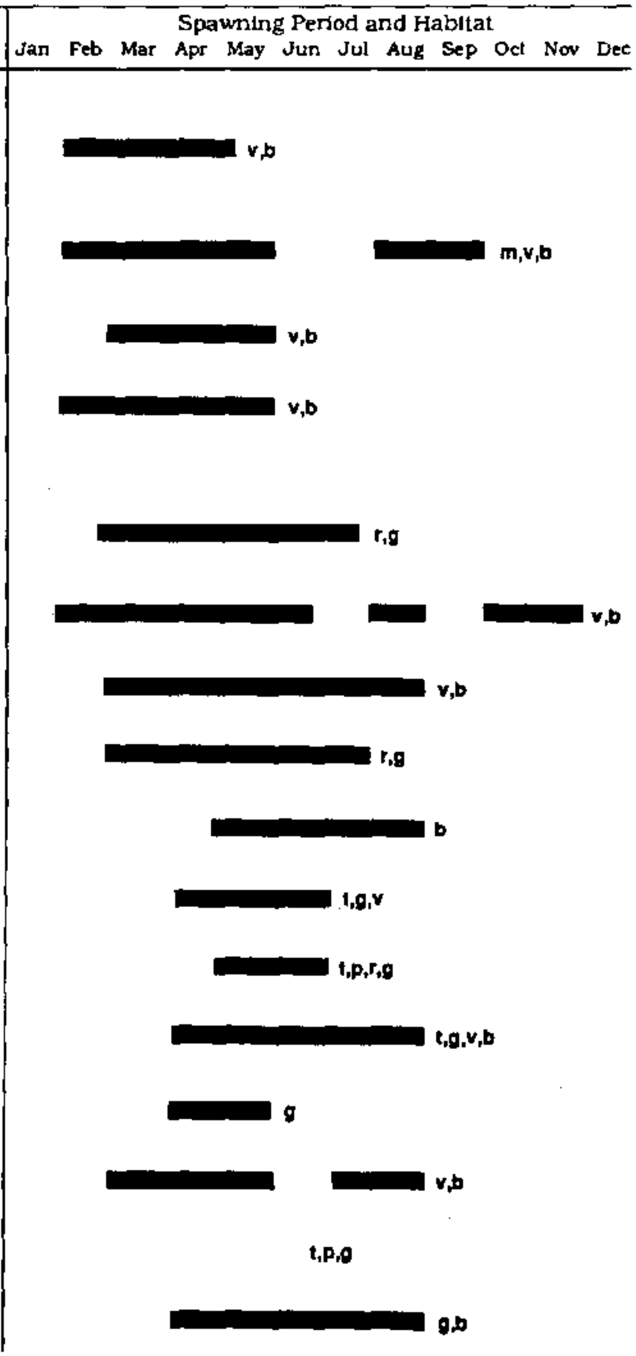


Figure 3.1.4-2 (continued).

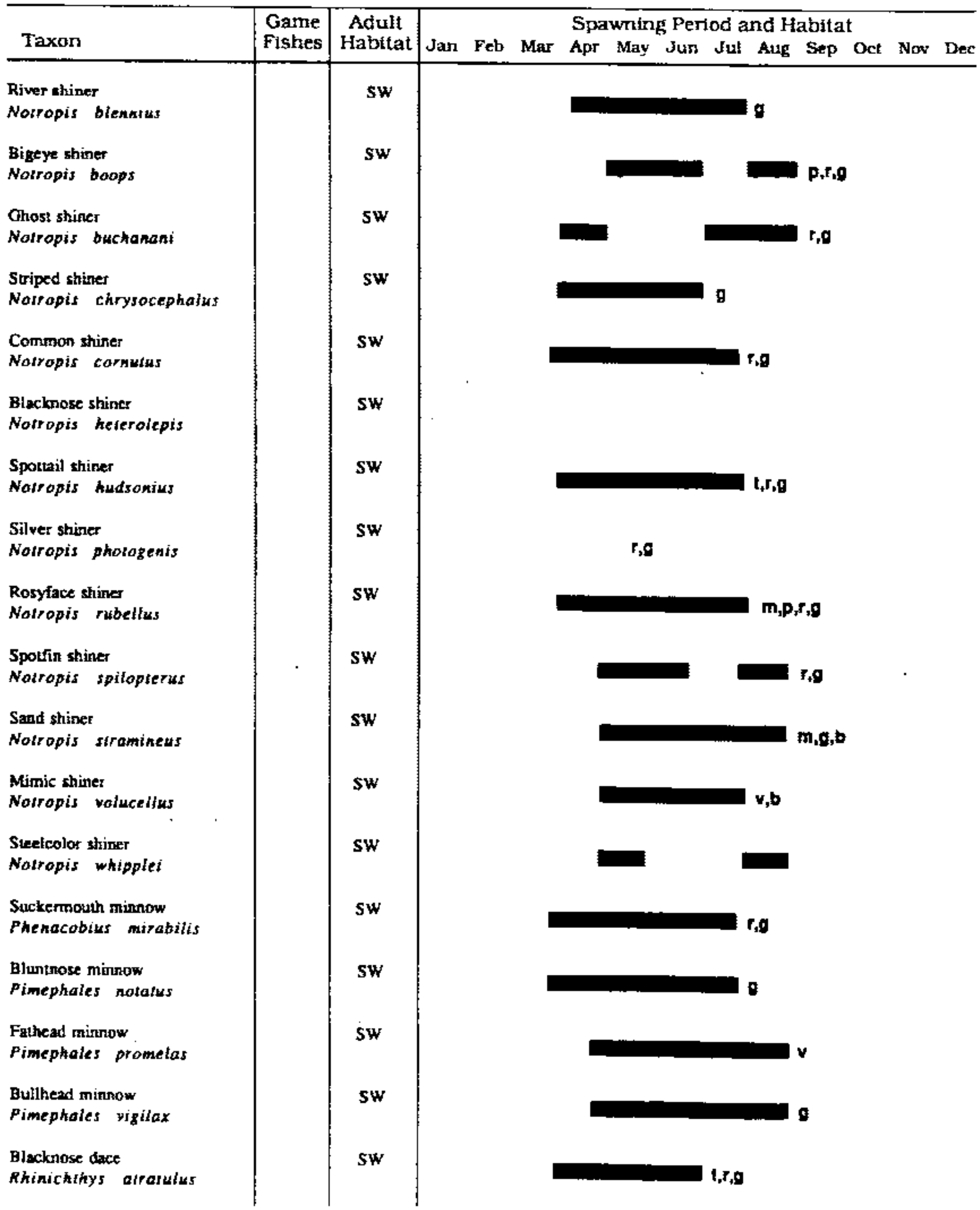


Figure 3.1.4-2 (continued).

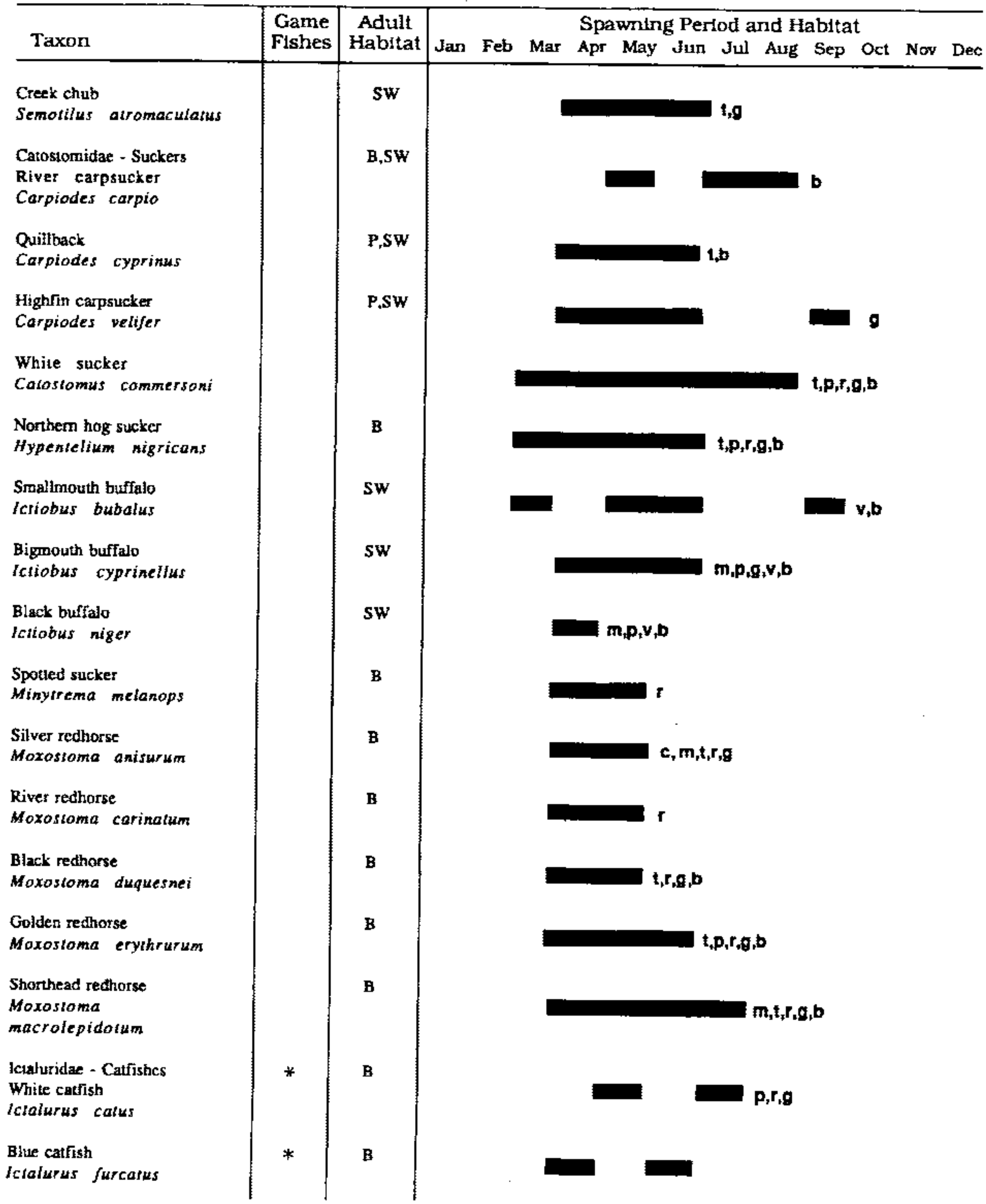


Figure 3.1.4-2 (continued).

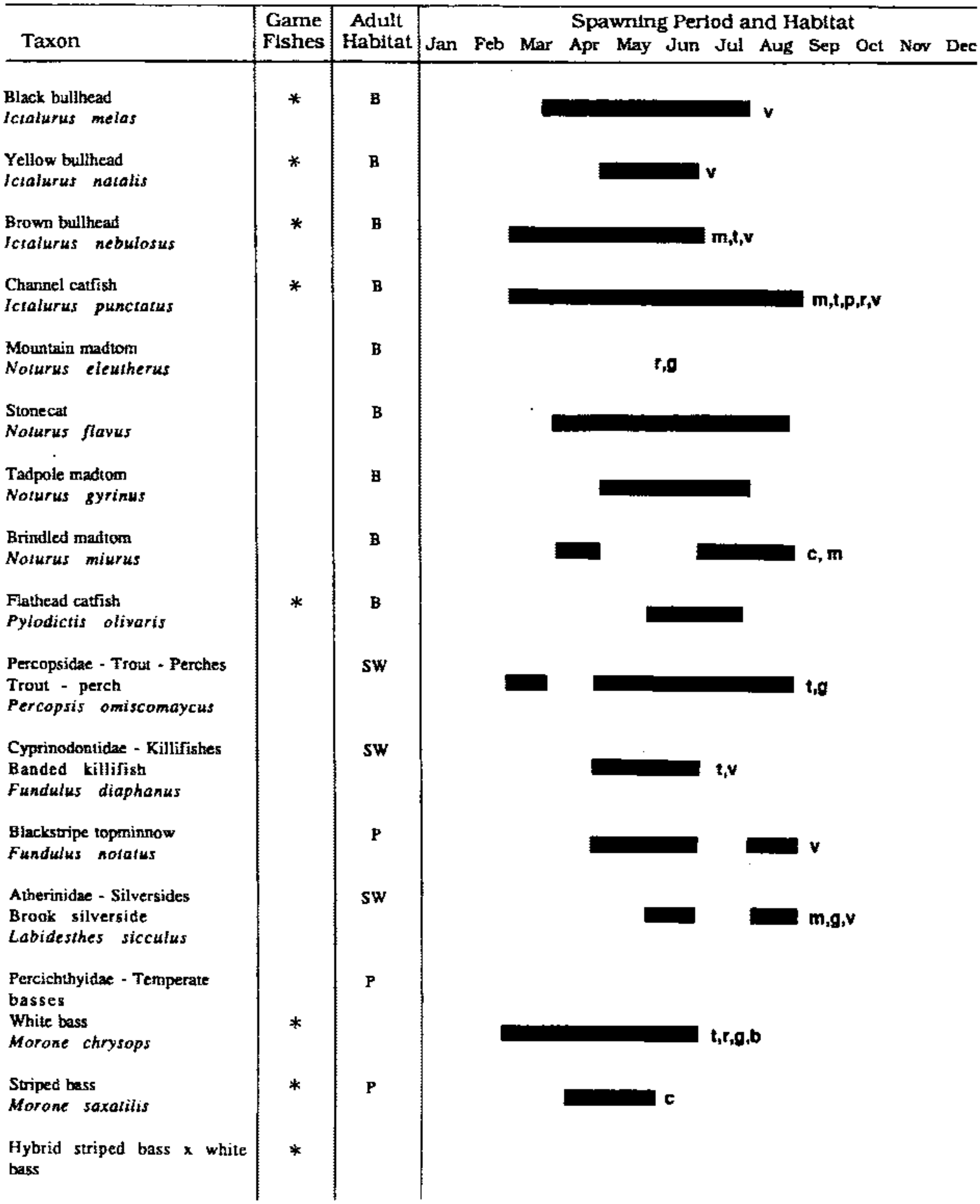


Figure 3.1.4-2 (continued).

Taxon	Game Fishes	Adult Habitat	Spawning Period and Habitat (Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec)
Centrarchidae - Sunfishes		SW	
Rock bass *Ambloplites rupestris*	*		g,v
Green sunfish *Lepomis cyanellus*	*	SW	g
Pumpkinseed *Lepomis gibbosus*	*	SW	g,v
Warmouth *Lepomis gulosus*	*	SW	v
Orangespotted sunfish *Lepomis humilis*	*	SW	
Bluegill *Lepomis macrochirus*	*	SW	g
Longear sunfish *Lepomis megalotis*	*	SW	m,t,g
Redear sunfish *Lepomis microlophus*	*	SW	g,v
Smallmouth bass *Micropterus dolomieui*	*	SW	m,p,g,v
Spotted bass *Micropterus punctulatus*	*	SW	
Largemouth bass *Micropterus salmoides*	*	SW	g,v
White crappie *Pomoxis annularis*	*	SW	g,v
Black crappie *Pomoxis nigromaculatus*	*	SW	v
Percidae - Perches		SW,B	
Greenside darter *Etheostoma blennioides*			t,r,v
Rainbow darter *Etheostoma caeruleum*		SW,B	r,g
Fantail darter *Etheostoma flabellare*		SW,B	p,r,g
Johnny darter *Etheostoma nigrum*		SW,B	
Orangethroat darter *Etheostoma spectabile*		SW,B	t,r,g

Figure 3.1.4-2 (continued).

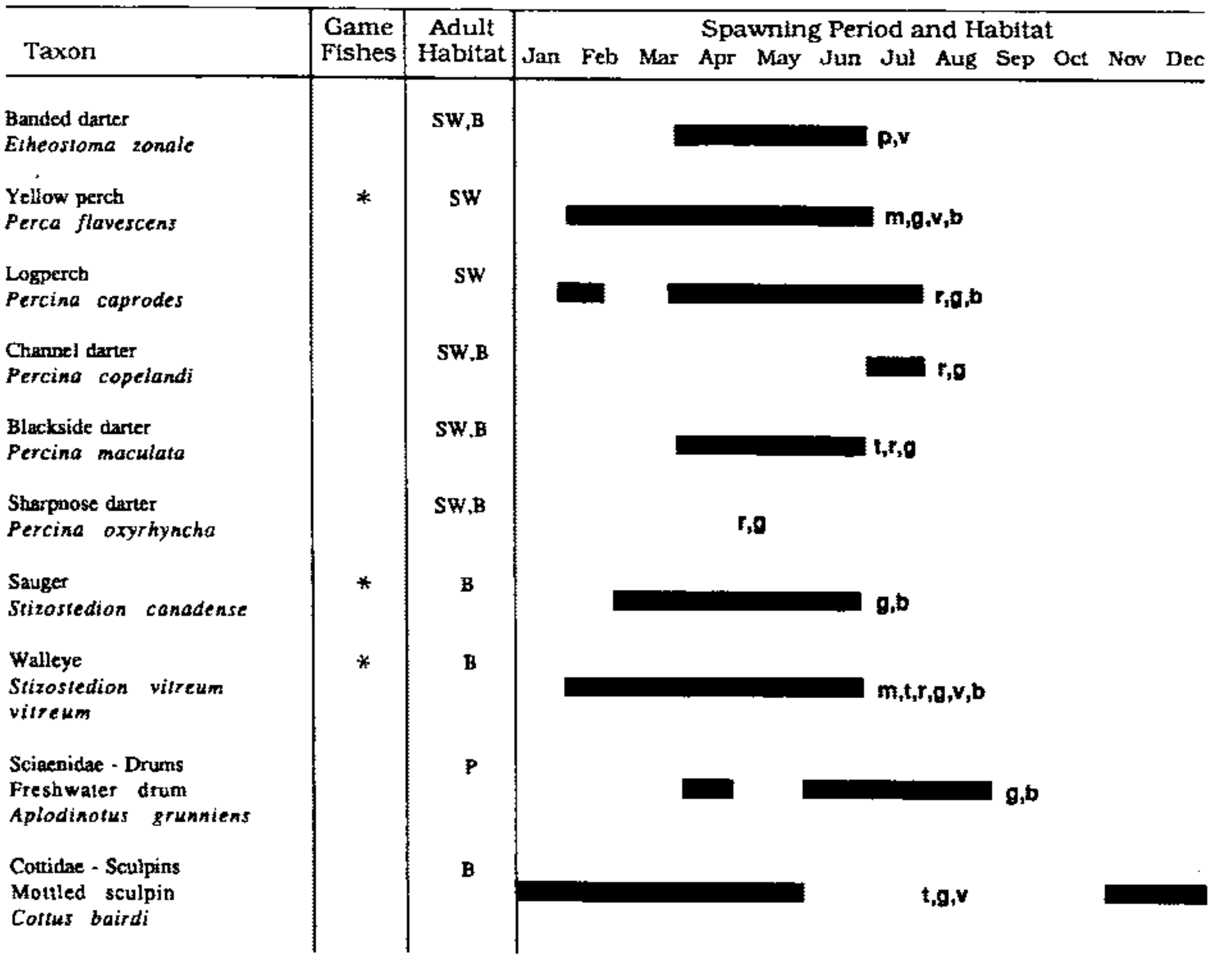


Figure 3.1.4-2 (concluded).

Taylor (1980) reported 27 living mussel species in the reach from Pittsburgh to Greenup Dam (Table 3.1.4-1). In a later study, Taylor (letter to T. Mayberry, Corps, Huntington District, Huntington, West Virginia, May 21, 1982) found two additional species, and Tolin and Schettig (1983a, b) added another. Recent surveys in the Greenup pool below the Gallipolis Dam identified additional species there, including one (the pink mucket pearly mussel, Lampsilis abrupta) that is on the federal endangered species list (letter to James Keany, FERC, from Charles J. Kulp, USFWS, dated September 28, 1987; Tolin et al. 1987; Zeto et al. 1987; Section 3.1.6). This endangered species (sometimes given the scientific name Lampsilis orbiculata) is also found in several locations in the lower Muskingum River (Stansbery, 1985). Appendix I provides more detailed information on this endangered mussel. The nonnative clam species, the Asiatic clam (Corbicula) has recently spread throughout the upper Ohio River system.

Despite a recent resurgence of some species, the riverine mussel habitat has been permenantly and irreversibly altered from a rapidly flowing river habitat to a more pool-like environment. A new mussel fauna may become established, but its composition will not be the same as prior to impoundment for navigation. Habitat for shallow, swift-water species no longer exists except at the tailwaters of dams, sites that have been difficult to survey. Species that composed the vast shell beds of a century ago, the mucket (Actinonaias ligamentina carinata), elephant's ear (Elliptio crassidens crassidens), and pink mucket pearly mussel (Lampsilis abrupta) are now rare or extinct.

The current distribution of mussels varies in the Ohio River (no extensive surveys have been conducted in the Allegheny and Monongahela; Taylor, 1980; Tolin and Schettig, 1983a,b). Greenup, Gallipolis, Racine, Belleville, and Hannibal pools all contained fairly active mussel populations. Beds were found around islands and along shorelines. Belleville pool was the most productive in total numbers and diversity of species; Belleville pool is much less industrialized than other reaches. Willow Island pool had a scanty population and Pike Island, New Cumberland, and Montgomery pools were essentially devoid of mussel life. No mussels were found in the first 90 miles below Pittsburgh, although the Asiatic clam was found there.

All of the active mussel beds have been found in the pool sections of the river, although little attention seems to have been given to surveying the dam tailwaters. The 14 to 18-foot depth is optimal for the brailling sampling technique, and this was the zone where mussels were found most abundantly (Tolin and Schettig, 1983a,b). Should the rapid-water species remain in the river, it is likely that they would be found in the tailwater zones near the dams. The federally endangered pink mucket pearly mussel was located 13 miles downstream of the Gallipolis dam, near river mile (RM) 292 and in the lower Muskingum River. The USFWS recommends special attention be given to potential populations of mussels in three reaches of the Ohio River, RM 280 to 305, Gallipolis Dam to the confluence of the Guyandotte River; RM 204 to 218, Belleville Dam to the toe of Buffington Island; and RM 172 to 184, between the confluences of the Muskingum River and the Little Kanawha River (Section 3.1.6).

The terrestrial and aquatic habitats associated with the islands of the upper Ohio River Basin have been recognized and documented by state, federal, and private resource agencies as extremely valuable to fish and wildlife resources, outdoor recreation and enjoyment, and scientific and natural heritage interests (Tolin and Schettig, 1983a,b). They are, however, vulnerable to changes in water elevation and flow dynamics, both of which are potential effects of hydropower development.

The often complex interspersion of bottomland and riparian habitats and deep and shallow aquatic habitats makes island areas highly suited for numerous fish and wildlife species (Section 3.1.5). Islands are fairly undeveloped compared with the general past and current uses of the river shoreline and floodplain. The deep and shallow water aquatic habitats around islands and their backwater channels are major fish and freshwater mussel production areas. The often undisturbed island shorelines, especially the heads and back channels, are favored sport fishing areas.

Many islands once present in the upper Ohio River system are no longer present because of flooding, sand and gravel operations, or erosion (e.g., 14 of the 49 in West Virginia present in the early 1900s no longer exist) (Tolin and Schettig, 1983a,b). The natural values of a few have been lost by being heavily urbanized (e.g., Brunot, Davis, Neville islands), although the altered shorelines and aquatic habitats retain some value. The islands and their associated aquatic habitats are thus a diminishing resource.

Table 3.1.4-1. Mussel species identified as living in the Ohio River between Pittsburgh and Greenup Dam (compiled by FERC staff from Taylor, 1980; Tolin and Schettig, 1983a,b; letter to T. Mayberry, US Army Corps of Engineers, Huntington District, Huntington, WV. May 21, 1982; letter to James Keany, FERC, from Charles J. Culp USFWS, dated September 28, 1987).

Species	Rare	Frequent	Abundant
Actinonaias ligamentina carinata (mucket)	x		
Amblema plicata plicata (three ridge)			x
Anodonta imbecillis (paper pond shell)	x		
Anodonta grandis grandis (floater)	x		
Anodonta grandis corpulenta (floater)	x		
Cyclonaias tuberculata (purple warty back or purple pimple back)	x		
Elliptio crassidens crassidens (elephant's ear)	x		
Fusconaia ebena (ebony shell)	x		
Fusconaia maculata maculata (long solid)	x		
Fusconaia flava (Wabash pigtoe)		x	
Lampsilis abrupta (pink mucket pearly mussel) 1/	x	x	
Lampsilis radiata luteola (fat mucket)		x	
Lampsilis teres form teres (slough sand shell or yellow sand shell) 2/	x		
Lampsilis ventricosa (pocketbook)	x		
Lasmigona complanata (white heel splitter)		x	
Lasmigona costata (fluted shell)	x		
Lasmigona compressa (creek heel splitter)	x		

Table 3.1.4-1. (continued)

Species	Rare	Frequent	Abundant
Leptodea fragilis (fragile paper shell)			x
Ligumia recta (black sandshell)	x		
Magnonaias nervosa (washboard)	x		
Obliquaria reflexa (three-horned warty back or three horn)		x	
Obovaria subrotunda (?)	x		
Plagiola lineolata (butterfly) 2/	x		
Plethobasus cyphus (bullhead)	x		
Pleurobema cordatum (pigtoe) 3/	x		
Potamilus alatus (pink heel splitter)			x
Potamilus ohioensis (fragile heel splitter or papershell) 4/		x	
Quadurla quadrula (maple leaf)			x
Quadrula metanerva (monkeyface) 5/	x	x	
Quadrula nodulata (?) 2/	x		
Quadrula pustulosa pustulosa (pimple back or warty back)		x	
Strophitus undulatus undulatus (squaw foot)	x		
Toxolasma parvus (liliput shell)	x		
Truncilla donaciformis (?)	x		
Truncilla truncata (deertoe)	x		

Table 3.1.4-1. (concluded)

Species	Rare	Frequent	Abundant
Uniomerus tetralasmus (pond horn)	x		
Villosa iris iris (rainbow shell)	x		

1/ Found only in Greenup pool; federally listed.

2/ Found only in Greenup pool; listed by Ohio.

3/ Found in Greenup, Gallipolis, Racine, and Hannibal pools; listed by Ohio.

4/ Found only in Racine and Belleville pools; listed by Ohio.

5/ Found only in Greenup and Belleville pools; listed by Ohio.

The following sections provide more specific discussion of the major aquatic habitat types of interest in the study area.

3.1.4.2 Channelized Deep Water

Channelized deep water is the predominant habitat, with slowly moving, well-mixed, open water deeper than the 9-foot minimum navigation channel and occasionally much deeper. Depths can be greatest just upstream of the dams but also in submerged natural deep holes in the original river bed or where there has been sand and gravel dredging. Because the navigation pools are run-of-the-river, they do not generally undergo thermal or chemical stratification. Exceptions can occur downstream of thermal electric power stations, such as in the Opekiska pool on the Monongahela River (Section 3.4.2). Bottom materials are often hard-packed silt or sand/gravel mixtures that are remnants from the higher glacial flows.

Open channel river reaches are dominated by forage fish species, including gizzard shad, freshwater drum, and emerald shiners. Wide-ranging fishes such as striped bass, hybrids between striped bass and white bass, American eel, sauger, and walleye are transients in this zone. Only the American eel is of an ocean migratory stock (catadromous, i.e., spawning at sea and living its life in fresh water). These are the species most susceptible to entrainment through powerhouses.

3.1.4.3 Shallow Water

Shallow water habitats occur along the channel margins, in tributary mouths, and around islands. These habitats are especially important at the gravel bars (shoals) below certain dams (Allegheny Nos. 7, 3, and 2; Emsworth; Muskingum 3). Channel margins are often precipitous, either naturally or from dredging and erosion-preventing riprap. River islands found in the Allegheny and Ohio rivers, however, have characteristic shapes both above and below the waterline, depending on their location in the river, that create characteristic and valuable aquatic habitats (Tolin and Schettig, 1983a,b). These shapes have remained relatively constant since island formation during extreme high water ice melt periods at the end of the last glacial period (Reid, 1961) that affected the Allegheny and Ohio rivers (the Monongahela River is unglaciated). Island shapes can be expected to remain relatively constant without destructive human uses such as persistent water level change or major changes in the direction of river currents. Islands subjected to significant flooding when navigation dams were created seem to have reached a physical equilibrium unless affected by gravel dredging, which has induced accelerated erosion (Tolin and Schettig, 1983a,b).

Islands in the main channel area of a straight reach of river tend to be teardrop shaped, with the rounded end upriver; those situated in a bend or near the main shoreline usually are crescent shaped. Below the water surface, islands tend to have large, round, shallow fronts (upstream) of gravel and cobbles and narrow, pointed toes (downstream) of finer materials (sand, silt, clay, muck, detritus). Both fronts and toes slope gradually for some distance. Deep pockets are generally found on the sides of teardrop-shaped islands and on the main channel side of crescent-shaped ones, extending from just below the head to the tip of the toe. With the exception of areas directly below dams, the heads of islands most closely resemble a natural run/riffle habitat in the Ohio River. It is these zones that are most populated with freshwater mussels (now experiencing a major comeback in the Ohio system after years of pollution) and fish species (e.g., darters) that require water currents. Depending on the island, the sides and toe may contain emergent and submerged logs and stumps and beds of aquatic plants that provide excellent fish cover. Pondweeds colonize silt/sand/gravel substrates, whereas eurasian watermilfoil colonizes pure silt. Island geometry is affected by passage of tows, which induces erosive waves and periodic reverse flows during low water.

Backchannels of islands (i.e., the smaller of the channels at the sides of an island, which is often shallow and not navigable except in small boats) constitute important fish habitat. These backchannel aquatic habitats have a greater degree of protection from natural and man-induced disturbances such as erosive high currents, wind, and navigation. Diking has further protected backchannels from river currents. These channels are often heavily colonized by emergent and submergent beds of aquatic plants, which provide abundant fish cover. For islands aligned in the midstream, there is little true backchannel and little difference from the main river.

The diversity of water depths, current patterns, substrates, and riparian cover makes aquatic habitats near islands suitable for large numbers and high diversity of fish and other aquatic life. Although there are some differences along the length of the upper Ohio River, the overall composition and diversity of aquatic organisms is believed similar for island habitats (Tolin and Schettig, 1983a,b). The shallow water areas against an island, particularly the backchannels, were found by Tolin and Schettig (1983a,b) to be important nursery areas for a variety of game and forage fish. Freshwater drum, channel catfish, bluegill, spotted bass, redhorses, river shiner, sand shiner, mimic shiner, bluntnose minnow, and young-of-the-year suckers and game fish were found at many sites. The major forage fish, emerald shiner and gizzard shad, were found throughout the system. The shallow areas were major feeding sites for larger predators such as spotted bass, white bass, largemouth bass, mooneye, goldeye, longnose gar, and sauger.

The good diversity and abundance of game fish around islands provide a viable sport fishery, and islands are favored fishing sites (Tolin and Schettig, 1983a,b). Excellent catches of spotted and largemouth bass are obtained around river islands in summer and fall months, while angler success is greater in the embayments in spring and early summer.

The suitability of Ohio River shallow-water habitats for producing freshwater mussels is improving markedly, most likely because of pollution reduction (Taylor, 1980; Tolin and Schettig, 1983a,b). The areas around river islands (except the toes) seem especially important for mussel recolonization. Most of the species that are adapted to the slower moving impoundments are being found increasingly around islands in the steady currents, well-oxygenated and nutrient-rich water, variable depths, and in substrates of clean silt, sand, and gravel. Eighteen islands in the upper Ohio River were sampled intensively by Tolin and Schettig (1983a,b) and living mussels were found around 14 of them. Backwater areas harbor thin-shelled species such as paper pond shell (Anodonta imbecillus), floater (A. grandis grandis), and fragile paper shell (Leptodea fragilis).

3.1.4.4 Dam Tailwater

Dam tailwater is a highly characteristic habitat of the existing river, being the principal place where high flow velocities are found in both deep- and shallow-water zones. Although some intermittent high velocities are created by lock discharges, the most consistent flows come from gates or fixed crests of nongated dams.

Fixed-crest dams provide a plume of high-velocity water across the full width of the dam. The velocity often remains high downstream of an apron or plunge pool until the deeper river is reached. Gated dams usually concentrate lower flows in a few of the gates, below which there is a plume of highly turbulent water. Rapidly flowing backeddies generally form below the nonoperating gates. Some gated dams also have fixed weirs that may consistently discharge a plume of high-velocity water. Velocities below gated dams, like those at fixed-crest dams, slow once the deeper river is reached below the locks. Bottom substrates in dam tailwaters are generally hard rock and cobble. Immediately below the spillway there is usually a deep scourhole; farther downstream (a few hundred feet) there are typically shallow gravel bars, some with islands, where the scoured gravel is deposited.

The high-velocity zones of tailwaters and the zones of velocity transition along shoreline structures or bottom topography provide excellent habitat for certain fish species, including the gamefish walleye and sauger. Although the obstruction of a dam may concentrate some fish during their upstream movements (e.g., spawning sauger and walleye in spring), the rapids habitat seems to be a highly productive zone at all times of year. Species of fish and invertebrates that require swift-water riffle or run habitats are located there but not in the slower moving river reaches. Most fish do not pass upstream through dams, although walleye are an exception (Holland et al., 1984).

Under the provisions of the U.S. Fish and Wildlife (USFWS) Mitigation Policy (Federal Register, Vol. 46, No. 15, January 23, 1981), dam tailwater areas are classified by the USFWS as Resource Category 2 because of their high value to fish and the habitat types' relative scarcity in the ecoregion (USFWS, 1985a). The mitigation goal for this resource category is no net loss of in-kind habitat value.

3.1.4.5 Riverine Aquatic Bed and Riverine Emergent

Riverine aquatic beds (RAB) and riverine emergents (REM) are riverine zones that provide shallow water areas which support floating or rooted aquatic vegetation RAB and seasonally exposed vegetated flats REM. They are often considered as part of terrestrial "wetlands" as well as aquatic habitats (Section 3.1.5). Along islands in the upper Ohio system, the RAB habitat type is reasonably abundant as submerged aquatic beds at island margins ranging in depths from 1 to 4 feet. For example, 13 of 22 islands between Hannibal and Gallipolis dams had RAB in the early 1980s (Tolin and Schettig, 1983a,b). The RAB habitats are extremely important for fish. They are nursery areas for many juvenile game fish (e.g., spotted and largemouth bass, freshwater drum, channel catfish, and several sunfish species). The food and cover provide for an abundance of plankton-feeding and grazing minnows and shiners, which attract fish-eating gamefish.

The REM-type habitat alternates annually between unvegetated mudflats and rooted, herbaceous hydrophytes standing in water. The importance of this habitat for fish also varies through the year. During flooded, vegetated periods, REM areas are valuable nursery habitat for juvenile fish and provide food and cover for numerous species of shiners and small minnows (Tolin and Schettig, 1983a,b).

3.1.4.6 Palustrine Open Water Wetland

Palustrine open water wetland (POW) aquatic habitats, located as pockets or embayments within islands or drier wetlands, which are cut off from the river and intermittently flooded, are characterized by shallow water (less than 5 feet), mud or silt substrate, and emergent and fallen logs and stumps (Section 3.1.5). Floating and rooted aquatic plants are often abundant. For example, approximately 3 acres of POW exists in the interior wetland of Blennerhassett Island (RM 185-189.9, Belleville pool). Fish occurring in POW consist of occasional carp and largemouth bass, and assorted small minnows (Tolin and Schettig, 1983a,b).

3.1.5 Terrestrial Ecological Resources

The study area is located in the Appalachian Plateau, a region of narrow valleys and rolling hills, with elevations ranging from about 600 to 5000 feet. The region is heavily urbanized with both industrial and residential development along the rivers. The few areas of undeveloped forest land generally are not adjacent to the rivers. These mixed mesophytic forests are within the oak-chestnut region of the eastern deciduous forest. The extensive, forested bottomlands are now narrow strips ranging in width from a few feet to several hundred feet of successional stage trees. The Pennsylvania Fish and Wildlife Database lists over 200 species of birds, about 50 species of mammals, and about 50 species of reptiles and amphibians that may occur in the study area (Pennsylvania Game Commission, 1985). The Division of Wildlife Resources, Department of Natural Resource offices in Ohio and West Virginia report similar numbers and species diversity (ODNR, 1982; WVDNR, 1985). Tolin and Schettig (1983a,b) report recordings of 123 species of birds, 7 mammal species, and 49 species of fish utilizing the islands of the upper Ohio River. The study area is also in the pathway used by migratory bird species. Bellrose estimated that 100,000-350,000 dabbling ducks and 250,000-500,000 diving ducks used this corridor during fall migration (Herdendorf et al., 1986).

3.1.6 Threatened and Endangered Species

3.1.6.1 Federal Listing

The following federally listed endangered species are considered to range throughout Pennsylvania and West Virginia:

bald eagle (*Haliaeetus leucocephalus*)
American peregrine falcon (*Falco peregrinus anatum*)
Arctic peregrine falcon (*Falco peregrinus tundrius*)

The peregrine falcons are listed as migratory, with the Arctic peregrine falcon listed as having no nesting sites in these states. Re-establishment efforts for the American peregrine falcon to its former breeding range are under way. There are no known nesting sites of the bald eagle within the study area; however, transient bald eagles do use the area as a feeding and resting place (USFWS, Region 5, 1987b).

The study area is within the historic range of the Indiana bat (Myotis sodalis), a federally listed endangered species in Pennsylvania and West Virginia. In West Virginia; however, there are no known hibernacula or critical habitat areas listed in the study area. Distribution of the Indiana bat is strongly correlated with major rivers which may serve as navigation routes for the species (USFWS, Region 5, 1987; Plewa and Putnam, 1986).

The Eastern cougar (Felis concolor cougar), probably extinct, is federally listed as endangered in Pennsylvania and West Virginia (USFWS, Region 5, 1987).

The federally listed threatened flat-spired three-toothed land snail (Tridopsis platysayoides) occurs in the Cooper's Rock State Forest, Monongalia County, West Virginia. This state forest is located approximately 10 miles east-southeast of the proposed Point Marion L&D project site. There are no known occurrences of the snail in the immediate vicinity of the proposed project (USFWS, Region 5, 1987).

The pink mucket pearly mussel [Lampsilis orbiculata (-L. abrupta)] is a federally listed endangered species known to occur in the Muskingum River, Washington County, Ohio and in the upper Greenup L&D pool in the Ohio River (USFWS, Region 3, 1987). Dr. David Stansbery, a freshwater mussel expert, has conducted extensive studies of the pink mucket pearly mussel on the central section of the Mississippi River system, which includes the Muskingum and Ohio Rivers. He reports that the species most likely occurs in the Muskingum River in the first one to three miles downstream of L&D Nos. 2, 3, 4, and 5. In recent years, the greatest number of fresh or relatively fresh shells of the pink mucket pearly mussel has been found in the Muskingum L&D No. 3 site at Lowell, Ohio. The occasional collection of fresh dead shells at this site in recent years indicates the continued presence of this species (Mitex Inc., 1987; letter to B. Fowler from K. E. Kroonemeyer dated August 7, 1986). On August 13, 1987, this mussel was found in the upper Greenup pool between RMs 292.0 and 292.4 on the Ohio River. The USFWS has identified suitable habitat in the Ohio River between the confluences of the Muskingum River and the Little Kanawha River (RMs 172.0 to 184.0); Gallipolis L&D to the confluence of the Guyandotte River (RMs 280.0 to 305.0); and Belleville L&D to the toe of Buffington Island (RMs 204.0 to 218.0) (letter from C. Kulp to J. Keany, September 28, 1987; letter from M. Plenert to K. Plumb, November 17, 1987; Letter from B. Blanchard to K. Plumb, March 7, 1986). Historically, the species has also occurred in the Monongahela River (Plewa and Putnam, 1985).

There were no listed federally endangered or threatened fish species encountered in recent studies of the upper Ohio River system (Tolin and Schettig, 1983; Jernejcic, 1982). The blue sucker (Cycleptus elongatus), known to occur in the immediate study area, is classified as Category 2 by the USFWS and is being studied for possible future listing (51 FR 19941). No federally listed endangered or threatened plant species occur in the study area.

Other species that have been classified by the USFWS as Category 2 for possible future listing as endangered or threatened are Bewick's wren (Thryomanes bewickii), eastern woodrat (Neotoma floridana magister), northern long-eared bat (Myotis septentrionalia), small-footed myotia (Myotis leibii), New England cottontail (Sylvilagus transitionalis), and salamander shell (Simpsonaias anabiqua).

3.1.6.2 State Listing

A number of terrestrial species of special concern have been listed by the states that comprise the study area (Table 3.1.6-1). The osprey (Pandion haliaetus), listed as endangered in Pennsylvania and endangered in West Virginia, is being re-introduced in West Virginia. The Tygart Dam is one of the experimental re-introduction sites, with artificial nests presently located on the dam.

A detailed description of fish and freshwater mussel species is given in Section 3.1.4 (Table 3.1.4-1). The states of Ohio and West Virginia recognize, as endangered (Ohio) and on a special species list (WV), the following fish species collected recently in the Ohio River (Tolin and Schettig, 1983):

goldeye (Hiodon alosoides) (WV)
mooneye (Hiodon tergisus) (WV, OH)
silver chub (Hybopsis storeriana) (WV, OH)
black buffalo (Ictiobus niger) (WV)
river redhorse (Moxostoma carinatum) (OH)

Table 3.1.6-1. Species of special concern likely to be found in the study area. 1/

Common name	Taxonomic name	State	Status 2/
American bittern	*Botaurus lentiginosus*	PA	T
Least bittern	*Ixobrychus exilis*	PA	T
Eastern bluebird	*Sialia sialis*	PA	SC, V
Bobwhite	*Colinus virginianus*	PA	SC, V
Northern harrier	*Circus cyaneus*	PA	SC, V
Cooper's hawk	*Accipiter cooperii*	PA	SC, V
Red-shouldered hawk	*Buteo lineatus*	PA	SC, V
Great blue heron	*Ardea herodias*	PA	SC, V
Purple martin	*Progne subis*	PA	SC, V
Barn owl	*Tyto alba*	PA	SC, V
Short-eared owl	*Asio flammeus*	PA	E
King rail	*Railus elegans*	PA	E
Upland sandpiper	*Bartramia longicauda*	PA	T
Grasshopper sparrow	*Ammodramus savannarum*	PA	SC, V
Henslow's sparrow	*Ammodramus henslowii*	PA	T
Vesper sparrow	*Pooecetes gramminеus*	PA	SC, V
Black tern	*Chlidonias niger*	PA	T
Red-headed woodpecker	*Melanerpes erythrocephalus*	PA	SC, V
Berwick's wren	*Thryomanes bewickii*	PA	E
Marsh wren	*Telmato dytes pulustris*	PA	SC, V
Sedge wren	*Cistotharus platensis*	PA	T
Osprey	*Pandion haliaetus*	PA,WV	E
Peregrine falcon	*Falco peregrinus*	WV	E
Bobcat		PA	SC, V
Indiana myotis		PA	E
Keen's myotis		PA	SC, V
Smallfooted myotis	*Myotis leibii*	PA	T
Eastern woodrat		PA	T
Northern goshawk	*Accipiter gentilis*	PA	U
Sharp-shined hawk	*Accipiter striatus*	PA	U
Long-eared owl	*Asio otus*	PA	U
Whippoorwill	*Caprimulgus vociferus*	PA	U
Yellow-bellied sapsucker	*Sphyrapicus varius*	PA	U
Least flycatcher	*Empidonax minimus*	PA	U
Bobolink	*Dolichonyx aryzivorus*	PA	U
Common tern	*Sterna hirundo*	PA	U
Loggerhead shrike	*Lanius ludovicianus*	PA	U
Least shrew	*Cyptotis parva*	PA	U
Silver-haired bat	*Lasionycteris noctivagans*	PA	U
Rafinesque's big-eared bat	*Plecotus rafinesquerii*	WV	SC
Golden mouse	*Orchrotomus nutalli*	WV	SC
New England cottontail	*Sylvilagus transitionalis*	PA	U
Eastern fox squirrel	*Sciurus niger*	PA	U
Coyote	*Canis latrans*	PA	U
Least weasel	*Mustela nivalis*	PA	U
Salamander shell	*Simpsonaias ambigua*	OH	E
Ohio long-solid	*Fusconaia* maculata *maculata*	OH	E
Knobbed bullhead	*Plethobasus cyphyus*	OH	E
Big river pigtoe	*Pleurobema cordatum*	OH	E
Ohio fan shell	*Cyprogenia stegaria*	OH	E
Knobbed rock shell	*Quadrula metanerva*	OH	E

Table 3.1.6.1 (Concluded).

Common name	Taxonomic name	State	Status 2/
Butterfly shell	Ellipsaria lineolata	OH	E
Fragile heelsplitter	Potamilus ohiensis	OH	E
Ohio mucket	Lampslis abrupta	OH	E
Ridged pocketbook	Lampsilis ovata	OH	E
Warty-back	Quadrula nodulata	OH	E
Sharp-shinned hawk	Accipiter striatus	OH	E
Merlin	Falco columbaris	WV	E
Ostrich fern	Metteuccia pensylvanica	WV	E
Staminate burreed	Sparganium androcladum	WV,OH	E,T
Stiff arrowhead	Sagittaria rigida	WV	E
Sedge	Carex bromides	WV	E
Reflexed umbrella sedge	Cyperus refractus	WV,OH	E
Rush	Juncus filiformis	WV	E
Snowy campion	Silene nivea	WV,OH	E,T
Hairy spurge	Euphorbia vermiculata	WV	E
Long-leaved ammania	Ammania coccinea	WV	E
Toothcup	Rotala ramosior	WV	E
Primrose willow	Jussiaea leptocarpa	WV	E
Round-leaved dogwood	Cornus rugosa	WV	E
Wild oats	Uniola latifolia	OH	PT
Turk's-cap lily	Lilium superbum	OH	PT
Mountain bindweed	Polyonum cilinode	OH	E
Lyre-leaf rock-cress	Arabis lyrata	OH	PT
Two-leaved water milfoil	Myriophyllum heterophyllum	OH	T

1/ Sources: Tolin and Schettig, 1983a,b; Plewa and Putnam, 1985, 1986.

2/ E - Endangered, T - Threatened, SC - Species of Concern,
V - Vulnerable, PT - Potentially Threatened,
EX - Extirpated, U - Undetermined

Ohio-listed endangered or threatened fish species (OHDNR 1982) collected in the Muskingum River at L&D No. 3 during seasonal sampling in 1985 and 1986 were the mooneye (Hiodon tergisus), ghost shiner (Notropis buchanani), mountain madtom (Noturus eleutherus Jordan), slenderhead darter [Percina phoxocephala (Nelson)], and river darter [Percina shumardi (Girard)] (WAPORA, Inc., 1986).

Ohio recognizes as rare and endangered the following species of freshwater mollusks recently collected alive in the Ohio River (Tolin and Schettig, 1983a,b); West Virginia does not list mollusks:

Knobbed bullhead (Plethobasus cyphyus)
Ohio pig-toe (Pleurobema cordatum)
Ohio heelsplitter (Potamilus ohioensis)
Knobbed rock shell (Quadrula metanevra)
Warty-back (Quadrula nodulata)

Tolin and Schettig (1983a,b) also collected specimens of (Elliptio crassidens crassidens), (Actinonaias ligamentina carinata), and (Truncilla donaciformis). These species had been presumed to be extirpated from the Ohio River. A specimen of (Obliquaria reflexa) was the first of this species collected in the Ohio River since 1920.

3.1.7 Socioeconomic Resources

The region that would be affected by the proposed projects includes southwestern Pennsylvania, southeastern Ohio, and northern and western portions of West Virginia. Pittsburgh is by far the largest city in the region, and this urban area dominates the social and economic statistics for this region. Almost two-thirds of the region's population resides in the four-county Pittsburgh Primary Statistical Metropolitan Area (Bureau of the Census, 1983), and the Pittsburgh major trading area includes the entire region except for three counties in the southwestern corner (Rand McNally & Co., 1986). The socioeconomic character, however, is not uniform across the region, and, in order to describe these differences, this discussion considers four subregions. The primary criterion for defining the subregions was geographic contiguity, and secondary criteria were situated within recognized metropolitan regions and topographic characteristics.

Subregion I is located in the southwestern part of the study area and includes Gallia, Meigs, and Washington counties in Ohio; and Jackson, Mason, Pleasants, and Wood counties in West Virginia. The major cities in this subregion are Marietta, Ohio, and Parkersburg, West Virginia. With a 1986 population density of 92 persons per square mile, this is the most rural of the subregions.

Subregion II, located in the northwestern corner of the study area, includes Belmont and Jefferson counties in Ohio; and Brooke, Hancock, and Ohio counties in West Virginia. The major cities in this subregion are Steubenville, Ohio, and Wheeling, West Virginia. This is the second most densely settled of the subregions, with a 1986 population density of 237 persons per square mile.

Subregion III consists of the Pennsylvania portion of the region and includes Allegheny, Armstrong, Beaver, Fayette, Greene, Washington, and Westmoreland counties. Because of the presence of Pittsburgh, this is the most intensely urbanized subregion with a population density of 480 persons per square mile in 1986.

Subregion IV forms the southeastern portion of the study area and includes the counties of Barbour, Harrison, Marion, Monongalia, and Taylor in West Virginia. Principal cities in this subregion are Morgantown, Fairmont, and Clarksburg. With a 1986 population density of 155 persons per square mile, this is the second most rural of the subregions.

3.1.7.1 Population Characteristics and Trends

As reflected by the population data in Table 3.1.7-1, the region as a whole has been experiencing an accelerating decline in population since 1970. The rate of decrease, which

Table 3.1.7-1. Population trends by subregion.

	1970 1/	1980 2/	1982 3/	1984 4/	1986 5/
Subregion I	241,499	272,728	273,500	272,484	270,200
Subregion II	310,021	307,057	304,500	299,870	291,000
Subregion III	2,667,709	2,541,555	2,518,400	2,495,393	2,435,500
Subregion IV	226,006	251,746	254,500	253,254	249,800
Total, Region	3,445,235	3,373,086	3,350,900	3,321,001	3,246,500

1/ U.S. Department of Commerce, Bureau of the Census, 1973. 1970 Census of Population, General Social and Economic Characteristics.

2/ U.S. Department of Commerce, Bureau of the Census, 1983. 1980 Census of Population, General Social and Economic Characteristics.

3/ U.S. Department of Commerce, Bureau of the Census, 1985. Current Population Reports, Local Population Estimates.

4/ U.S. Department of Commerce, Bureau of the Census, 1986. Current Population Reports, Local Population Estimates.

5/ U.S. Department of Commerce, Bureau of the Census, 1987. Current Population Reports, Local Population Estimates.

averaged 0.6 percent per year between 1980 and 1986, reached a peak of 1.12 percent between 1984 and 1986. The decline in population has been more severe in urban areas than in rural areas. Subregions II and III, which are the most intensely urban subregions, have been losing population since before 1980, and the annual rate of loss for these subregions reached 1.5 and 1.2 percent, respectively, between 1984 and 1986. Subregions I and IV, which are comparatively rural, continued to grow through 1982 and have since experienced more moderate losses.

Table 3.1.7-2 indicates that the populations of the more urban subregions are older and have attended school longer than those of the more rural subregions. The median age of residents in counties in the heavily urban subregion III ranges from 30.8 to 33.6. The median school years completed (for persons 25 or more years old) for these counties ranges from 12.1 to 12.5. At the other extreme, in the comparatively rural subregion IV, the median age of residents ranges from 26.0 to 32.8, and the median school years completed ranges from 11.8 to 12.5.

The more rural subregions also tend to have lower per capita incomes and a higher percentage of persons with incomes below poverty level (Table 3.1.7-2). The region as a whole had a per capita income in 1983 of $9031. Incomes in the urban subregions II and III were markedly higher than those in the comparatively rural subregions I and IV. In 1979, 9.9 percent of the region's population had incomes below poverty level, with the subregions ranging from 9.2 percent for subregion III to 16.0 percent for subregion IV.

Table 3.1.7-2. Selected population characteristics.

	Subregion				
	I	II	III	IV	Region
Persons per square mile, 1986 1/	91.9	237.2	480.3	155.3	299.4
Median age (range of counties), 1980 2/	29.3-31.2	30.9-33.1	30.8-33.6	26.0-32.8	
Median school years completed (range for counties), 1980 2/	12.1-12.4	12.3-12.4	12.1-12.5	11.8-12.5	
Per capita income, 1983 3	$7,659	$8,130	$9,440	$7,539	$9,031
Percent of persons below poverty, 1979 2/	12.2	9.8	9.2	16.0	9.9

1/ U.S. Department of Commerce, Bureau of the Census, 1987. Current Population Reports, Local Population Estimates.

2/ U.S. Department of Commerce, Bureau of the Census, 1983. 1980 Census of Population, General Social and Economic Characteristics.

3/ U.S. Department of Commerce, Bureau of the Census, 1985. Current Population Reports, Local Population Estimates.

3.1.7.2 Employment Characteristics and Trends

Table 3.1.7-3 records the level of employment by industrial category for each subregion and the region as a whole. The main employment categories for the region are services, which employed 29 percent of the labor force, and manufacturing, which employed 25 percent. Retail

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Table 3.1.7-3. Employment by industrial category for employed persons, 16 years and over. 1/

Industry	Number of employees				
	Subregion I	Subregion II	Subregion III	Subregion IV	Total region
Agriculture, forestry, fishing	1,940	1,110	7,249	1,019	11,318
Mining	2,870	7,271	21,622	10,088	41,851
Construction	8,658	5,969	54,933	5,739	75,299
Manufacturing	26,646	34,715	263,535	13,547	338,443
Transportation, commerce, and public utilities	8,648	8,557	80,173	7,278	104,656
Wholesale trade	3,023	3,354	42,432	3,191	52,000
Retail trade	16,565	20,345	175,137	15,584	227,631
Finance, insurance, and real estate	3,573	4,325	53,744	3,224	64,866
Services	26,831	29,762	297,591	29,392	383,576
Public administration	4,467	3,353	34,688	4,168	46,676
Total	103,221	118,761	1,031,104	93,230	1,346,316

1/ U.S. Department of Commerce, 1983. 1980 Census of Population, Characteristics of the Population, General Social and Economic Characteristics.

trade also accounted for a significant portion (17 percent) of the total employment. Subregion III, with 77 percent of the region's labor force, accounted for more than one-half of the region's employment in every industrial category. This subregion was especially dominant in the categories of finance, insurance and real estate, and wholesale trade.

Table 3.1.7-3 indicates differences in the economic emphases of the subregions. Subregions I, II, and III follow the same general pattern as the study area as a whole, with manufacturing and services accounting for roughly the same high percentage of employees and retail trade accounting for a significantly lower percentage. Subregion I has a disproportionately high level of employment in the categories of agriculture, forestry, and fisheries and construction. In subregion II, unusually large proportions of the labor force are employed in mining and manufacturing. In subregion IV, the level of manufacturing employment is extremely low, and retail trade is the second largest employment category. The level of mining activity in this subregion, on the other hand, is unusually high.

Table 3.1.7-4 shows trends in overall employment and unemployment based on county of residence. Between 1977 and 1986, the size of the region's civilian labor force decreased by 1.5 percent, the number of employed persons decreased by 3.6 percent, and the number of unemployed persons increased by 28.1 percent.

Table 3.1.7-4 indicates that the level of employment in the region seemed to be growing at a moderate rate between 1976 and 1979. In 1980, however, the number of employed persons began to decline while the labor force continued to grow. As a result, the number of unemployed persons increased drastically. The decline continued for several years, reaching its trough in 1983 when 14.7 percent of the region's labor force was unemployed. The number of employed persons began to increase in 1984, but the size of the civilian labor force continued to decline through 1986.

Although the economic decline has occurred in every subregion, it has not been uniform in degree. Subregion II has been affected most severely, with reductions of 13 percent in the size of the labor force and 17 percent in the number of employed persons over the 10-year period. The number of unemployed persons in this subregion was 38 percent greater in 1986 than in 1977. In other subregions, unemployment has been severe at times during the period. Two counties in subregion I and one county in subregion III recorded annual unemployment rates above 20 percent for one year during the period. On the other hand, one county in subregion IV never recorded an annual unemployment rate above 7.5 percent during the 10-year period.

There are some indications that the region's economy may be stabilizing. The number of unemployed persons and the unemployment rate have decreased steadily since 1983, and the number of employed persons was increasing in every subregion by the end of 1986. These recent improvements depend partly on the fact that the size of the labor force has continued to decline, and they do not mean that the region is returning to its previous level of economic activity. The region's employment levels seem to be stabilizing at a level somewhat below that of a decade ago.

3.1.8 Archaeological and Historical Resources

Current information regarding the prehistory of the study area is limited to a recognition of broad cultural epochs (Corps, 1985). Collections of fluted projectile points helped to establish that primitive cultures inhabited the area as early as 12,000 B.C. The region is known for the presence of numerous mounds and earthworks which date to the Woodland time periods. The latest prehistoric cultural remnants in the region include indian artifacts and middens, which represent the sites of former villages or towns. These cultures were agrarian societies that used the rich Ohio floodplains for growing their crops. Indian artifacts and middens are observed on the islands as well as the floodplains in the study area; sites are known to exist on Muskingum, Blennerhassett, and Buffington Islands (Tolin and Schettig, 1983a,b).

Table 3.1.8-1 lists the number of sites listed on or eligible for listing on the National Register of Historic Places in counties in the study area.

Table 3.1.7-4. Trends in employment and unemployment, 1977-1986. 1/

	Number of persons (in thousands) by year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Change, 1977-1986
Subregion I											
Civilian Labor Force	111.9	116.7	118.5	119.7	118.8	117.6	117.2	112.0	111.5	111.3	-0.6
Persons Employed	105.4	110.8	112.0	109.1	107.1	102.0	100.2	99.0	99.1	99.4	-5.9
Persons Unemployed	6.5	6.0	6.6	10.7	11.7	15.7	17.1	13.1	12.4	11.9	5.3
Subregion II											
Civilian Labor Force	129.1	128.9	129.7	132.3	129.2	124.9	121.5	117.0	113.4	111.8	-17.3
Persons Employed	121.8	121.7	122.7	120.2	116.3	108.5	103.8	102.9	100.3	101.7	-20.1
Persons Unemployed	7.3	7.1	6.9	12.1	12.9	16.5	17.8	14.2	13.0	10.1	2.8
Subregion III											
Civilian Labor Force	1,067.9	1,093.9	1,113.7	1,123.0	1,126.0	1,130.1	1,120.2	1,081.1	1,067.2	1,062.2	-5.7
Persons Employed	994.5	1,023.5	1,044.5	1,036.6	1,036.3	984.0	952.6	954.7	961.7	973.1	-21.4
Persons Unemployed	73.3	70.3	69.1	86.4	89.7	145.9	167.5	126.4	105.7	89.1	15.8
Subregion IV											
Civilian Labor Force	94.3	96.4	100.4	100.5	101.6	99.3	97.8	98.0	96.0	96.4	2.0
Persons Employed	88.9	91.9	95.0	92.6	93.0	90.4	86.4	88.1	86.7	88.9	-0.1
Persons Unemployed	5.4	4.5	5.5	7.9	8.7	9.0	11.4	9.9	9.3	7.5	2.1
Total Study Area											
Civilian Labor Force	1,403.2	1,435.9	1,462.3	1,475.5	1,475.6	1,472.0	1,456.7	1,408.0	1,388.0	1,381.6	-21.6
Persons Employed	1,310.6	1,347.9	1,374.2	1,358.4	1,352.6	1,284.8	1,243.0	1,244.6	1,247.8	1,263.1	-47.5
Persons Unemployed	92.5	87.9	88.1	117.1	123.0	187.1	213.8	163.5	140.4	118.6	26.0

1/ Sources: Ohio Bureau of Employment Services, 1987; Pennsylvania Department of Labor and Industry, 1987; and West Virginia Department of Employment Security, 1986-1987.

Table 3.1.8-1. Number of sites listed or eligible for listing on the National Register of Historic Places in study area counties.

Counties	National Register of Historic Places properties by county	Potentially eligible
Ohio 1/		
Belmont	15	9
Gallia	7	0
Jefferson	15	5
Meigs	9	4
Monroe	8	0
Washington	28	0
West Virginia 2/		
Barbour	6	1
Brooke	19	0
Hancock	2	0
Jackson	6	2
Marshall	2	1
Mason	7	4
Monongalia	26	4
Ohio	18	1
Pleasants	1	0
Taylor	5	1
Wood	43	8
Pennsylvania 3/		
Allegheny	164	172
Armstrong	6	6
Beaver	15	14
Fayette	21	13
Greene	21	6
Washington	56	58
Westmoreland	26	40

1/ Listings as of December 15, 1987. (Source: Katherine Stroup, Ohio Historical Society, personal communication, February 10, 1988.)

2/ Listings as of December 1987. (Source: Rodney Collins, West Virginia Department of Culture and History, personal communication, February 11, 1988.)

3/ Listings as of January 15, 1988. (Source: Bill Sisson, Pennsylvania Historical and Museum Commission, personal communication, February 10 & 11, 1988.)

3.1.9 Aesthetic Resources

3.1.9.1 Landscape

The aesthetic resource values in the study area vary widely in quality. Surrounding hillsides serve as a backdrop to extensive cultural modifications along some study area reaches. Steel mills, factories, towns, river terminals, and barges are predominant features, particularly on the main stem of the Ohio River and along the lower reaches of the Allegheny and Monongahela rivers. Resource-based industries, including oil and gas, limestone, sandstone, sand and gravel, and coal, are prominent in the region. Although some reaches are subject to heavy industrial and urban development, relatively remote sections of undeveloped floodplain, forest, and agricultural lands are located within the upper reaches of the Monongahela and Allegheny rivers and along the Tygart Valley and Muskingum rivers.

Topography and Vegetation

Relatively flat floodplains have formed adjacent to the river corridor. These floodplain terraces have widths of up to 6000 feet, from which rise the steep, wooded slopes and rolling hills that are characteristic of the region. Rising several hundred feet above the river, the wooded slopes create a sense of enclosure and unity in the landscape.

Cultural Modifications

Diverse land uses (including industrial, commercial, agricultural, recreational, and residential areas) and an infrastructure of roadways, bridges, and railroads are found along river corridors. The floodwalls, levees, and industrial complexes that occur along the more intensively developed areas in the study region tend to limit not only physical access to the river but also visual access (Corps, 1984b). Other areas in the study region are comparatively pastoral, with more prevalent natural features.

3.1.9.2 Waterscape

The improvements in water quality have enhanced the aesthetic quality of the area. As a result, waterfront development is now encouraged in the Pittsburgh area and a popular sport fishery has returned to the basin. The upper reach of the Allegheny River from East Brady to the Kiskiminetas River has a proposed classification of "scenic" under the Pennsylvania Scenic Rivers System (Section 3.3.4).

The rivers in the study region are part of an integrated water system of locks and dams created for navigation. The rivers are, therefore, characterized by stairstep pools which vary in average water acreage from 400 acres on the Monongahela River's Morgantown Pool to 12,600 acres on the Ohio River's Gallipolis Pool (Corps, 1984a). The large river widths, averaging roughly 680 feet on the Monongahela, 920 feet on the Allegheny, and 1200 feet on the Ohio main stem, coupled with the slow-moving water in the navigation pools contribute to a placid river setting and a broad visual corridor. Islands and embayments create visual interest in the river corridor by altering the stream width and introducing visual diversity in texture and form to the waterscape.

The islands in the Ohio River have been used for a variety of purposes, including farming, logging, commercial dredging, mooring, construction, and oil drilling (Tolin and Schettig, 1983a,b). In spite of the diverse history of land uses, most of the islands are generally undisturbed in appearance, particularly with respect to the shoreline and floodplain development. The undeveloped character of the islands, in addition to the large island-to-water interface, contributes to the aesthetic value of the islands. The numerous tributary embayments in the study area are also valued for their undisturbed aesthetic character and for the unique terrestrial and aquatic habitats and the recreational opportunities they provide to the region.

The tailwaters of the locks and dams are popular recreation sites for boat and shoreline fishing because of the prized sport fishery resource found in these high-current areas (Sections 3.1.4 and 3.2.3). Some tailwater locations in the study area (e.g., on the Muskingum River and at Pike Island and Racine on the Ohio River) have developed recreation areas that provide open space and riverfront access, adding to the aesthetic enjoyment of the riverscape (Figure 3.1.9-1). The L&D structures themselves contribute to the visual interest of the area. The fixed-crest dams in the study area create a long smooth profile on the water surface with a spillway that is an aesthetic attraction in the landscape. The massive size of the gated-dam structures on the Ohio main stem is in sharp contrast to the smooth form of the fixed-crest L&D structures found on the Muskingum, Allegheny, and Monongahela rivers in the study area (Figures 3.1.9-2 and 3.1.9-3).

The operation of the lock structures and the movement of barges and recreational boat traffic on the waterscape are part of the region's long history of river transport and, thereby, contribute to the aesthetic character of the region.

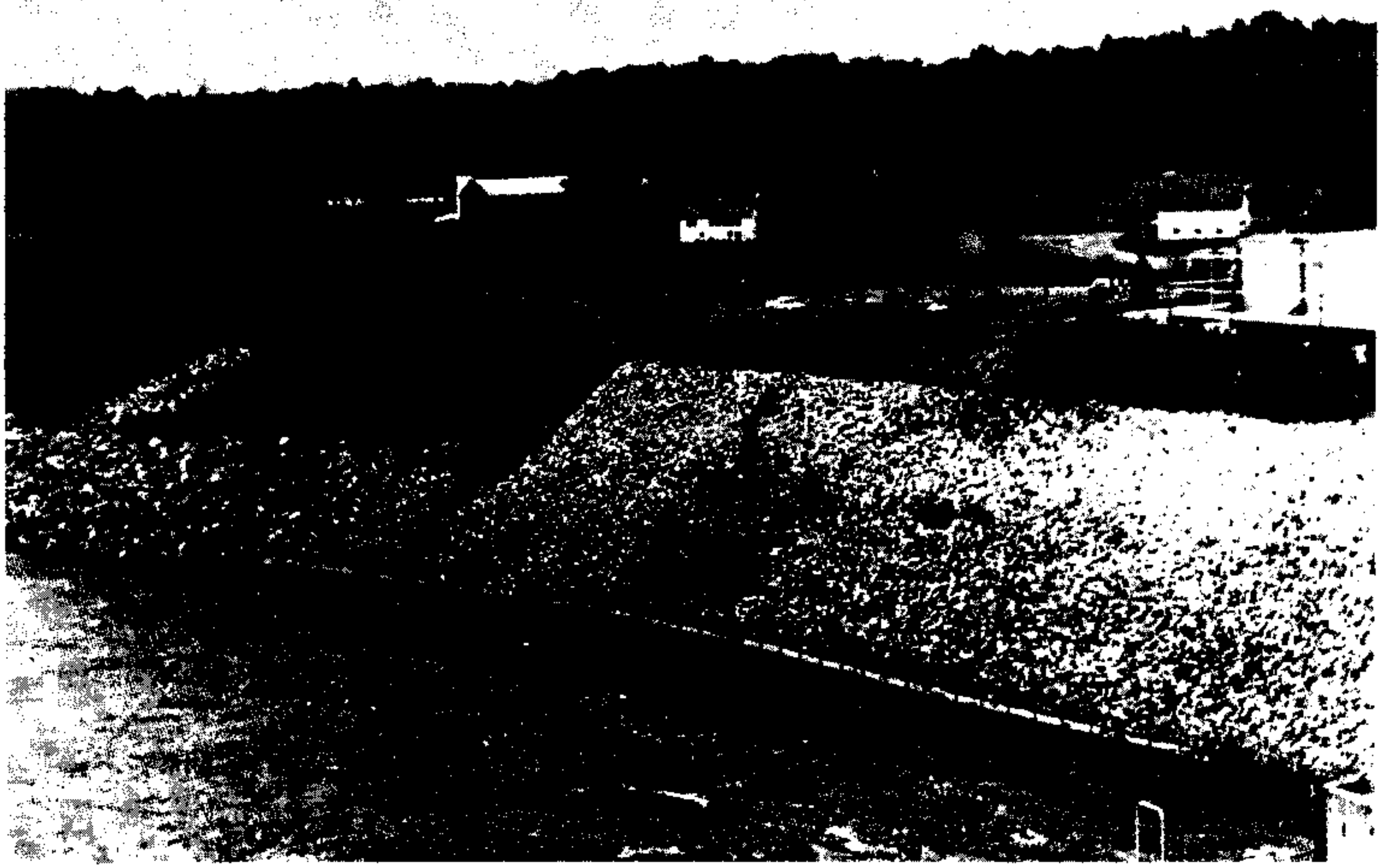

Figure 3.1.9-1. Recreational fishing area at the Racine Hydroelectric Project (June, 1987).

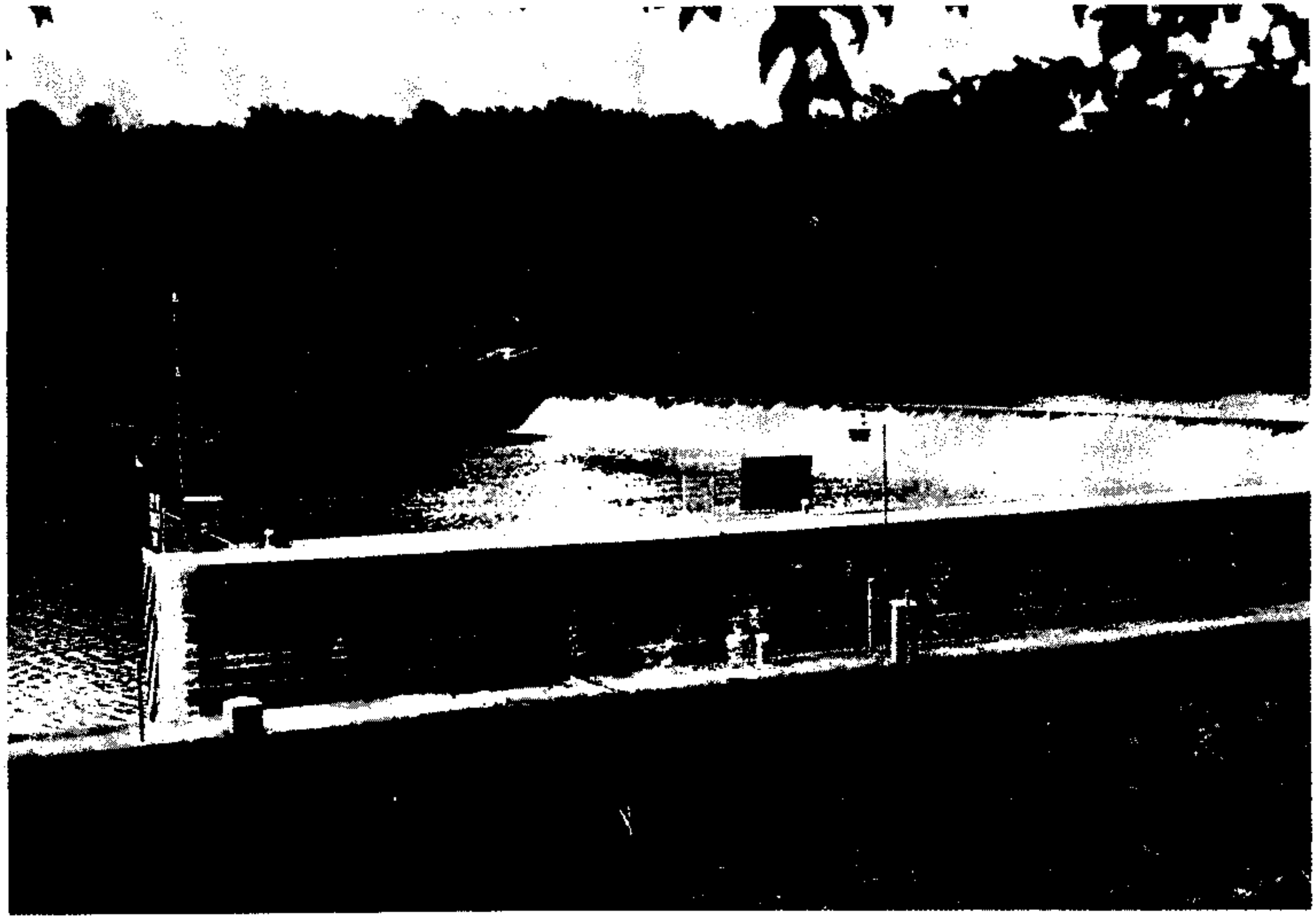

Figure 3.1.9-2. Fixed-crest dam at Monongahela Lock and Dam No. 7 (June, 1987).

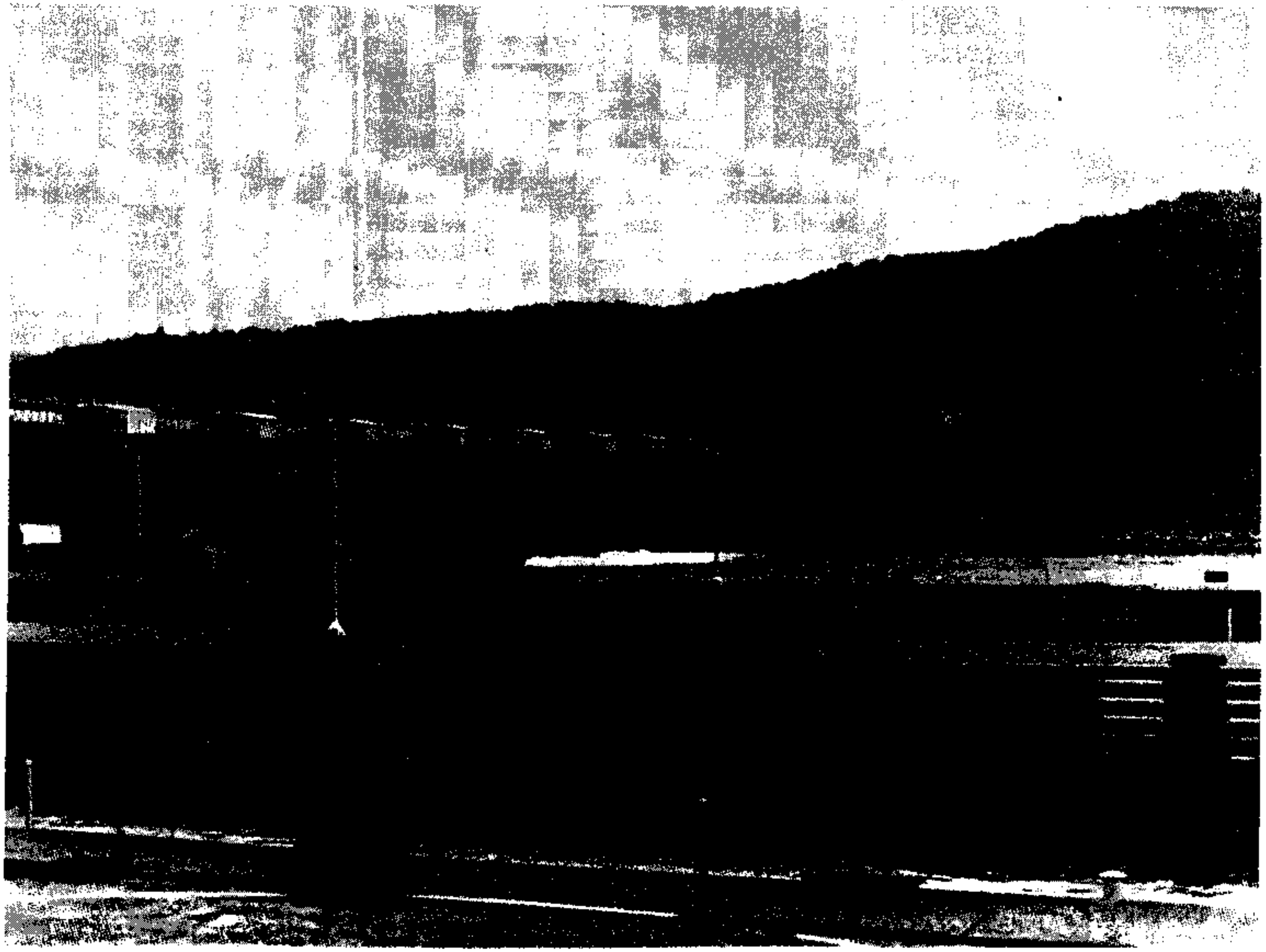

Figure 3.1.9-3. Gated dam at New Cumberland Lock and Dam (June, 1987).

3.2 TARGET RESOURCES

3.2.1 Introduction

This section describes general features of those environmental resources having the greatest potential for cumulative effects from proposed projects (referred to in this document as target resources).

3.2.2 Water Quality

Water quality is a concern in new hydroelectric development at navigation dams because of the reduced mixing of air and water during hydropower operation and the resuspension of contaminated sediments that may occur during construction of the proposed facilities. The mixing of air and water affects both aeration (the dissolving of oxygen into the water) and the removal of some contaminants from the water.

In natural rivers, DO in the water comes from aeration at the water surface. This surface aeration is higher when turbulence is higher and depths are shallower. In the rivers under study here, turbulence has been decreased and depth increased by the navigation dams, so the amount of surface aeration is relatively low. Consequently, the aeration of water as it spills over the dams can be an important source of DO. When hydropower facilities are added to a dam, much of the river flow is routed through a turbine and is no longer spilled over the crest or through the gates of the dam (Section 1.4). The result can be a net loss of oxygen input to the river because hydropower turbines provide little aeration (AEP, 1969; 1987).

Each of the navigation dams in the study area aerates differently; some are efficient aerators, providing DO concentrations consistently near saturation, and others provide very little aeration. The importance of a dam for aeration depends not only on how well it aerates but also on whether or not it is located where DO concentrations are typically low. For example, a dam that provides only fair aeration but is located where DO concentrations are depressed by major wastewater discharges may still be critical for maintaining adequate DO concentrations.

The effects of changing aeration at different dams in the system are clearly cumulative and interactive. Differences in DO caused by changes in aeration at one dam affect not only the pool immediately downstream of that dam but also the aeration rate at the next downstream dam (Section 4.1.1) and, consequently, the DO concentrations in the following downstream pools. Changes in aeration at a series of dams can accumulate into changes in DO concentration greater than the change caused by each individual dam. Because the processes controlling DO concentrations are complex and because the proposed action would change aeration at many of the dams in the system, the effects of each proposed project on DO cannot be evaluated independently. A cumulative, system-wide modeling analysis of the impacts of the proposed hydroelectric projects on DO concentrations is required.

The reduced spillage that occurs with hydropower development may have effects on other water quality constituents whose concentrations are controlled by the rate at which the constituents are transferred to or from the air. The aquatic concentrations of some toxic constituents are reduced as molecules of the constituents leave the water and enter the air (a process called volatilization). This volatilization can occur in the turbulent mixing of air and water at dams, probably at a rate significantly higher than in the navigation pools. Reduced spillage at dams may reduce volatilization of organic contaminants such as chloroform. Ammonia can similarly be removed from water via mixing with air.

Reductions in the rate at which toxic constituents would be removed from the water at several dams in a river could have a cumulative effect on the instream concentrations of such constituents. Therefore, the effects of the proposed projects on volatilization of toxic constituents will be included as a potential impact to the water quality target resource.

Water quality could also be affected by resuspension of contaminated sediments. The proposed projects would require excavation during construction, and projects at fixed-crest dams would increase river velocities, potentially increasing the need for channel dredging (Section 4.1.5). The potential for resuspension of contaminated sediments at all the proposed project sites is therefore a potential cumulative impact to water quality.

There are many other water quality constituents whose concentrations or effects are not influenced by the mixing that takes place at dams or by sediment resuspension. These constituents are not expected to be significantly affected by the projects; for example, hydropower plants are not expected to alter river temperatures. Therefore, the water quality target resource is limited to the concentrations of DO and volatile compounds and contaminated sediments, for which clearly defined mechanisms for impacts of the hydroelectric projects exist.

3.2.3 Fisheries

3.2.3.1 General

Water quality must be suitable to sustain the reproduction and growth of important fish and invertebrate species. The water quality feature most subject to change with hydroelectric generation is DO, as discussed in Section 3.2.2. Water quality standards for minimum allowable DO concentrations have been established by the states to protect aquatic life (5 mg/L). However, the most sensitive juvenile stages often require higher levels (USEPA, 1985) that are established by a complex interaction among fish size, temperature, and other water quality features that can be modeled (Cuenco et al., 1985a,b,c). Freshwater mussels are highly tolerant of low DO concentrations for exposures of a few days but are thought to require 6.0 mg/L or above for long-term growth (Appendix I).

Habitat protection is one of the most important resource concerns for fisheries. Without appropriate habitat, the key species in the upper Ohio River system (see below) would not be expected to thrive. These habitats have been discussed above; the ones most likely to be affected by hydroelectric development include (1) the relatively rare swift-water, rocky substrate dam tailwaters and (2) the shallow-water, vegetated backwater channels of islands and tributary mouths, especially in pools above fixed-crest dams.

Fish are directly at risk from hydroelectric generating facilities by being drawn into the flows passing through the turbines (entrainment) and killed or injured by rapidly fluctuating hydrostatic pressures, shear forces, and the rotating turbine blades. This damage is most likely to occur to fishes that move with currents through the dam passageways either in early life stages or as adults.

Key fish species are those important to the recreational fishery, although sustaining the food chain of primary producers, invertebrates, and forage fishes is recognized. In general, protection of habitats and water quality and minimization of additional sources of mortality (e.g., turbine entrainment) will provide conditions necessary for maintaining the whole riverine ecosystem. A brief synopsis of the most important gamefishes (see Figure 3.1.4-2) is given in Sections 3.2.3.2 through 3.2.3.14.

3.2.3.2 Bluegill and Other Sunfishes

These species prefer warm, shallow, standing-water habitats with an abundance of aquatic vegetation. Because spawning is in the same habitat, these fishes are not prone to extensive migrations or interpool movements.

3.2.3.3 Carp

Important because of its abundance, this species is being promoted nationally as a gamefish, although it is not currently highly valued in the upper Ohio River system. The species has an affinity for quiet, backwater areas and does not travel between pools in the upper Mississippi River, an area similar to the upper Ohio River system where many of the same species have been studied (Holland et al., 1984). It is abundant around the navigation locks in much of the upper Ohio River system and is typically one of the last species to die out under highly polluted conditions.

3.2.3.4 Channel Catfish

This species is found throughout the main channels and margins, pools and tailwaters of the upper Ohio River system, often comprising the largest weight in survey catches other than carp. The species is a valuable game fish. These bottom-dwelling fish are highly mobile within pools but movements are random and related to feeding rather than seasonal spawning migrations. They move both upstream and downstream between pools in the Mississippi River (Holland et al., 1984)

Spawning is in shallow water with submerged cover; larvae occasionally are found drifting in the main river flow.

3.2.3.5 Freshwater Drum

This species, although not a prized gamefish, has been expanding its abundance in the upper Ohio River system in conjunction with improved water quality. It is a pelagic species that seems to be found in nearly all habitats at some time. It is not highly migratory and does not seem to move voluntarily through dams in the upper Mississippi River (Holland et al., 1984), but it is a large component of turbine-passed fish in studies at the Racine facility on the Ohio River (WAPORA, Inc., 1987b). Pelagic spawning produces eggs and larvae that are prominent components of planktonic drift.

3.2.3.6 Gizzard Shad

This is a principal forage or food chain fish in the upper Ohio River system that is highly abundant in the pelagic (open-water) environment of pools. Schools of shad move throughout the quiet zones of the system and are passed through dams regularly where they feed the walleye, sauger, channel catfish, and other species that use this habitat. They are highly vulnerable to damage in turbines. Spawning also occurs on the open-water channels, and eggs and larvae are often the dominant components of planktonic drift. The species has a high reproductive rate.

3.2.3.7 Largemouth Bass

This is an important pool species in the upper Ohio River system that lives in quiet waters with mud and sand substrates in association with emergent and submerged vegetation. There is limited movement, usually less than 2 miles, and no migration between pools (Holland et al., 1984).

3.2.3.8 Northern Pike

Northern pike are primarily sedentary in shallow-water, vegetated habitats in all life stages and they do not exhibit extensive spawning migrations. Studies on the Mississippi River showed that this species moves less than 5 miles annually, and no individuals were recaptured outside the pools in which they were released (Holland et al., 1984). They are a highly valued game fish but are not particularly abundant in the study area.

3.2.3.9 Sauger

As much as any species, the return of this pollution-sensitive fish to the upper Ohio River system as an important angler catch symbolizes the recovery from poor water quality. Sauger are bottom-dwellers, inhabiting rocky bottoms of main channels. They are particularly abundant, and caught, in dam tailwaters. Sporadic interpool movements occur [about 20 percent of tagged sauger in one study (Holland et al., 1984)], although most remain in the home pool showing movements between main channel border and wing dams to tailwaters and tributaries. Sauger spawn in gravel and rubble of dam tailwaters. Broadcast eggs settle in crevices and occasionally enter the drift, and newly hatched larvae are dispersed via drift.

3.2.3.10 Smallmouth Bass

Smallmouth bass prefer quiet waters of rivers and lakes with sandy or rocky substrates, such as quieter zones of the dam tailwaters where they are important to angler catches. Only localized movements have been reported, with no movement between dams on the upper Mississippi River (Holland et al., 1984). Spawning is in shallow water where the nest and young are guarded.

3.2.3.11 Spotted Bass

Spotted bass closely resembles and is often confused with largemouth bass by anglers. It occupies very similar habitats and is expanding in the upper Ohio River drainage as water quality improves.

3.2.3.12 Striped Bass and Hybrids of Striped Bass and White Bass

Striped bass, a migratory (anadromous) fish native to east coast estuaries, and its hybrid with locally native white bass have been stocked into the upper Ohio River drainage by management agencies. These are pelagic species that attain a large size and which move great distances. They are not migratory and have not been shown to be naturally reproducing. Their large size and tendency to pass downstream through dams from upstream stocking locations makes them potentially vulnerable to turbine-related mortality.

3.2.3.13 Walleye

This is an abundant and highly mobile species in the upper Ohio River system. It is a prized sports fish that inhabits and is caught in dam tailwaters, especially in spring. Interpool movements are well documented in the upper Mississippi River, where some fish traversed as many as five pools (Holland et al., 1984). Spawning movements in spring toward tributaries cause aggregations at dams, where some spawning takes place. Local movements at other times of year reflect the walleye's preference for moderate velocities, some cover, and turbid water and take fish to backwaters, sloughs, and side channels (Holzer and Von Ruden, 1983; Bahr, 1977). Larvae are occasionally abundant in planktonic drift.

3.2.3.14 White Bass

White bass school in the open channels of pools and in tailwaters. Prespawning adults will aggregate in tailwaters in spring, although spawning is in tributaries. Eggs adhere to rocks and gravel, and larvae are not abundant in drift. Adult movements between pools have been documented but are not patterned or pronounced and most movements are within pools (Holland et al., 1984).

3.2.4 <u>Recreation</u>

Recent improvements in the water quality of the Ohio River Basin have significantly increased the opportunities for water-based recreation in the region. Fish management and water quality improvement efforts have brought about the return of a popular sport fishery resource. In spite of the popularity of recreational fishing, there is currently a deficiency of facilities for boat and shoreline fishing. Better access is needed and desired at the tailwaters of the L&D where fishing pressure (per unit area) as well as the number of fish caught and kept is greatest in the basin. In addition, there is a lack of access at tributary embayments which also receive much higher fishing pressure and success rates (per unit area) than the navigation pools. The supply of access facilities is particularly lacking in the vicinity of larger population centers. In addition, many facilities have inadequate parking and serious maintenance problems, such as excessive siltation, or are privately owned.

Potential changes in recreational access and navigation due to the alteration of river flow patterns and reservoir pool elevations from proposed hydroelectric development could affect both recreational fishing and boating in the basin. Operation of hydroelectric facilities would shift the flow patterns at the tailwaters of the L&D to a turbine tailrace and would replace with a powerhouse a section of shoreline often used by anglers. Commenting agencies are concerned with the need to maintain and optimize shoreline fishing access to tailrace areas where turbulent water creates a preferred fish habitat. Flow modifications associated with hydroelectric operations could impact boating access (ramp, dock, hoist, or mooring space) and navigation close to shorelines or around islands if reservoir pool elevations and flow dynamics are altered (Section 3.2.6).

Potential adverse cumulative impacts to recreational fishing from the development of hydroelectric facilities also include potential changes in the existing quality of recreational fishing resulting from impacts to the fishery resources. Any significant cumulative decrease in DO levels from the operation of multiple hydropower projects could result in significant adverse impacts to the fishery resources and recreational fishing in the basin. Turbine-induced mortality and injury and changes in fish habitat from the alteration of reservoir pool elevations could also produce adverse cumulative effects to the fishery resources and recreational fishing in the basin.

Commenting agencies have expressed concern regarding adverse impacts to recreational fishing during construction. Concurrent construction of multiple projects may have basin-wide effects on recreational fishing. Even with adequate temporary fishing facilities at each project site, concurrent construction may have cumulative adverse effects on recreational fishing because access and facilities in the construction area would be unappealing. The potential loss of fishing opportunities during periods when the powerhouse is inoperative could also have an effect on recreational fishing success in the basin.

3.2.5 Wetlands

In recent years, the knowledge of wetlands and riparian zones and their function has greatly increased with efforts to preserve these areas as natural resources. The most comprehensive and widely accepted definition of wetlands was adopted in 1979 by the U.S. Department of Interior, Fish and Wildlife Service (Cowardin et al., 1979):

> "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water ... Wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominately hydrophytes, (2) the substrate is predominately undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."

The Corps applies the following definition of wetlands for implementation of dredge and fill permits as required by Section 404 of the 1977 Clean Water Act Amendments (33 CFR Part 323.2(c) 1984):

> "The term 'wetlands' means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

The USFWS definition is generally used for ecological studies and inventories, while the Corps definition is applied for wetland management and regulation. It is in the context of these definitions that wetlands are described in this assessment.

Wetlands and riparian zones are classical "edge effects", because both diversity and density of species tends to be higher at the land-water interface than in adjacent upland habitats. Many small species are restricted or endemic to the wetlands/riparian habitat. Larger mammals, such as deer, require access to the water edges for survival, even though they spend most of their time in upland habitats. The riparian edge provides a corridor for mammals and birds to move safely from one place to another (Odum 1978). The riparian vegetation provides shade over river or stream banks, thereby moderating the temperature of the water. Cover is provided for fish, and organic detritus from the canopy provides an important source of nutrients. This vegetation also provides bank stability, and helps protect the water body from sediment due to upland soil erosion.

Wetlands are among the most productive ecosystems. Terrestrial and aquatic habitats associated with wetlands are recognized as being extremely valuable to fish and wildlife resources, outdoor recreation activities, and as scenic/natural heritage areas (Mitsch and Gosselink, 1986). The majority of the plant species listed in the federal list of threatened and endangered species occur in wetland environments, and many animal species on the federal list depend on wetlands for survival. Wetlands are of particular importance to migatory bird species, serving as feeding and resting sites during stopovers.

The sites proposed for hydropower plant development are located in southwestern Pennsylvania, southeastern Ohio, and northern West Virginia (Appalachian Highlands Province). Recently published statistics (Tiner, 1987) on trends of wetlands in the Northeast United States show that approximately 2 percent of land area in Pennsylvania is classified as wetlands, with forested wetlands and shrub wetlands (the classifications of the majority of the wetlands in the study area) comprising less than 0.02 percent of the state's area. Less than I percent of the state of West Virginia is classified as wetlands, with about 41 percent of the wetlands area classified as forested wetlands, and equal amounts of shrub and emergent wetlands present. Gains in forested and shrubs wetlands have been recorded, with much of the emergent wetlands being reclassified as shrub, and shrub wetlands reclassified to forested wetlands as the wetlands go through successional stages. In the highly industrialized and urbanized study area, this resource is limited, and protection and preservation become very important issues in maintaining environmental quality.

Within the study area, wetlands occurring in the pools above fixed-crest dams are most likely to be adversely affected by the construction and operation of the proposed hydropower projects. Pool elevations at gated structures will not be changed. The fixed-crest dams in this study are Allegheny River (all dams are fixed-crest), L&D Nos. 2, 3, and 7 on the Monongahela River, Muskingum L&D No. 3 on the Muskingum River, and Dashields on the Ohio River (Figure 1.1-1). Fixed-crest dams having significant wetland areas in the proposed project vicinity are the Allegheny L&D Nos. 2, 3, 4, 7 (Section 3.3.5) and the Muskingum L&D No. 3 (Section 3.6.5). In addition, the Montgomery L&D on the Ohio River has the Montgomery Embayment area nearby (Section 3.5.5). Descriptions of wetlands in the study area are given in Section 3.3.5 (Allegheny River), Section 3.4.5 (Monongahela River), Section 3.5.5 (Ohio River) and Section 3.6.5 (Muskingum River).

3.2.6 River Navigation and Hydraulics

All of the rivers in the study area are operated to maintain commercial navigation by barges, except the Muskingum where navigation by recreational boats is maintained. Any impacts of the proposed projects on river navigation would be important economically. One potential mechanism for project impacts on barge navigation is alteration of flow patterns near lock entrances and exits; hydropower projects could cause eddies and currents that make steering barges into and out of locks more difficult (Section 4.1.5).

Hydropower projects at fixed-crest dams reduce the pool elevation above the dams (Section 4.1.5) when operating. Lowering of pool elevations could have numerous effects, including insufficient depths at recreational boat ramps, increased water velocities, and impacts to wetlands (Section 3.2.5). These effects are not expected at gated dams because the gates allow maintenance of existing pool elevations with hydropower in operation.

Some of the proposed hydropower projects could reduce the ability of the dams to pass water during flood flows. Such projects are those that would replace part of an existing crest, gate, or spillway with a powerhouse, increasing the flood water levels above the dam (Section 4.1.5). Increased water levels during high flows could also increase the amount of time when the rivers are closed to navigation during floods.

The Corps coordinates flow releases from the various storage reservoirs that control the overall river flows in the upper Ohio River system, but they do not coordinate control of flow releases at the navigation dams. Flows cannot be controlled at fixed-crest dams, but at each gated dam the flow rate is controlled manually by the Corps lockmaster on site (the Pittsburgh District, which operates projects in the study area on the Allegheny and Monongahela and as far downstream as Hannibal on the Ohio, does provide daily flow guidance to its lockmasters, however). Flows are released to maintain the normal pool elevation as well as possible, but manual flow control is difficult and can magnify changes in river flow rates. Sudden changes in river flow can start from pulsed releases from hydroelectric plants on tributaries of the Allegheny and Monongahela rivers, which can be propagated downstream through the Ohio River.

The unsteady flows in the upper Ohio River system are of concern because sudden decreases in flow can cause wastewaters discharged to the Ohio to stagnate and potentially enter drinking water intakes. Major pulses of flow can affect sediment transport and sandbar formation at the mouth of the Ohio River. The proposed hydropower projects would assume some control over river flows at the navigation dams, and so could have system-wide effects on flow control. These effects could be either positive or negative.

Installation of hydropower at several dams on each river could have cumulative effects on river navigation and river hydraulics. If hydropower creates hydraulic conditions that delay barge lockage at even one dam, creating a bottleneck, the overall barge traffic capacity of the system could be decreased. Impacts of lower pool elevations caused by hydropower at the fixed-crest dams on the Allegheny could occur throughout that river. Increases in flood elevations caused by powerhouses could, at least in short pools, extend to the next upstream dam and cause increased flooding in more than one pool. Changes in flow regulation caused by hydropower would affect flows in all downstream pools. These potential effects on barge navigation, pool elevations, flood elevations, and flow regulation will be targeted in the cumulative impact analyses.

3.3 ALLEGHENY RIVER

3.3.1 Basin Description

The Allegheny River has a watershed area of 11,778 square miles. The lower 72 miles of river is navigable by barges, with depths maintained by eight fixed-crest navigation dams (Allegheny River Locks and Dams 2 through 9; Dam 1 was removed following the installation of Emsworth Dam on the Ohio River). Major tributaries to the navigation channel include Mahoning Creek (with a watershed area of 425 square miles), Redbank Creek (with a watershed area of 605 square miles) and the Kiskiminetas River (with a watershed area of 1890 square miles). River flows are largely controlled by ten major reservoirs on the Allegheny and its tributaries, all but one operated by the Corps for flood control, flow augmentation, and other purposes (Corps, 1975). Annual median flows are approximately 8,000 cubic feet per second (cfs) at L&D 9, 9,000 cfs at L&D 5 and 6, and 10,000 cfs below L&D 4. Monthly mean flows are in Table 3.3.1-1. Annual flow duration curves for the Allegheny are shown in Figure 3.3.1-1.

Hydropower licenses have been issued at L&D Nos. 5 (FERC No. 3671), 6 (FERC No. 3494), and 8 and 9 (FERC No. 3021). The powerhouses are under construction at dams 5 and 6. Final requirements for spill flows (flows to pass over the dam and be aerated) at these four licensed projects have not been determined yet, though at dams 5 and 6 there are interim spill requirements of 1170 and 1000 cfs respectively. At L&D Nos. 8 and 9, there are no requirements in the FERC licenses for an interim spill flow. Conditions of the license require the licensee to conduct studies to determine the spill flow needed to protect DO concentrations and fishery resources. Additional spill flow is likely to be required by the Corps in their operating agreement with the hydropower developer.

3.3.2 Water Quality

Water quality in the Allegheny River has improved during the past several decades. The improvement has resulted from improved treatment of wastewater discharges, reductions in acid mine drainage impacts resulting from mitigation measures such as release of dilution water from reservoirs and improved mining techniques, and the demise of some of the large industries along the river. There are still a number of water quality impacts such as municipal and industrial discharges, continuing acid mine drainage, and nonpoint sources. Several power plants contribute thermal discharges (heated water) to the Allegheny.

DO concentrations were monitored daily by ORSANCO at Allegheny RM 13.3 from 1962 until 1986. Data from the ORSANCO monitor can be used to show the historic range of DO concentrations at this location. Figure 3.3.2-1 shows the frequency distribution of water temperatures and DO concentrations during summer and fall months, when DO concentrations are lowest, at the ORSANCO monitor.

Other sources of information on Allegheny River water quality include other data collected by ORSANCO, data from the stations operated by the USGS in its National Stream Quality Accounting Network, and data collected by the state of Pennsylvania (ORSANCO, 1986b). The Pittsburgh District of the Corps has sampled summer water quality in the Allegheny annually since 1973; DO measurements above and below each dam from 7 of these surveys are shown in Figure 3.3.2-2. In addition, DO concentrations and temperatures have been monitored starting in the summer of 1987 by the hydropower applicant at L&D 3. Toxic compounds in the Allegheny are discussed in Section 3.1.3.

DO concentrations in the Allegheny are controlled to some extent by aeration at the navigation dams. With the exception of dam 7, all of the Allegheny River dams provide good aeration (Section 4.1.1). Dam 7 provides little aeration, probably because of the apron on the downstream side, which keeps water from plunging as far below the surface after cresting the dam as it does at other similar dams.

3.3.3 Fisheries

The Allegheny River upstream of the Kiskiminetas River inflow, at RM 30 (immediately downstream of Allegheny L&D No. 5), is a high quality warm-water river containing a diverse and typical assemblage of fish species and other aquatic life (WAPORA, Inc., 1987b). The Kiskiminetas River has carried a heavy load of acid mine drainage that degrades the Allegheny below the confluence, although there have been recent improvements. A notable indicator of good quality water in the Allegheny River upstream of dams has been an abundance of the

Table 3.3.1-1. Monthly mean flows in the Ohio River Basin. 1/

	Station					
	Monongahela at		Allegheny at		Ohio at	Muskingum at
Month	Point Marion	Dam 2	Dam 7	Dam 4	Dashields	McConnelsville
Oct	2,000	5,300	8,000	9,100	14,800	2,400
Nov	3,100	9,500	13,600	15,000	25,000	4,500
Dec	5,800	15,900	18,800	23,900	39,700	7,700
Jan	7,700	16,700	20,800	24,000	43,800	10,100
Feb	8,500	20,900	21,000	27,700	49,000	12,000
March	8,500	24,100	33,600	40,600	67,300	15,500
April	6,000	19,100	27,800	36,100	56,700	13,700
May	4,200	13,700	18,500	23,100	37,400	9,200
June	3,500	9,700	11,300	14,900	24,600	6,400
July	2,000	6,300	6,700	8,700	15,300	4,300
Aug	2,100	6,000	4,900	6,500	13,000	3,400
Sept	1,600	4,600	5,000	6,000	10,700	2,600
Annual	4,600	12,600	15,600	19,600	33,000	7,700

1/ Source: USGS unpublished data.

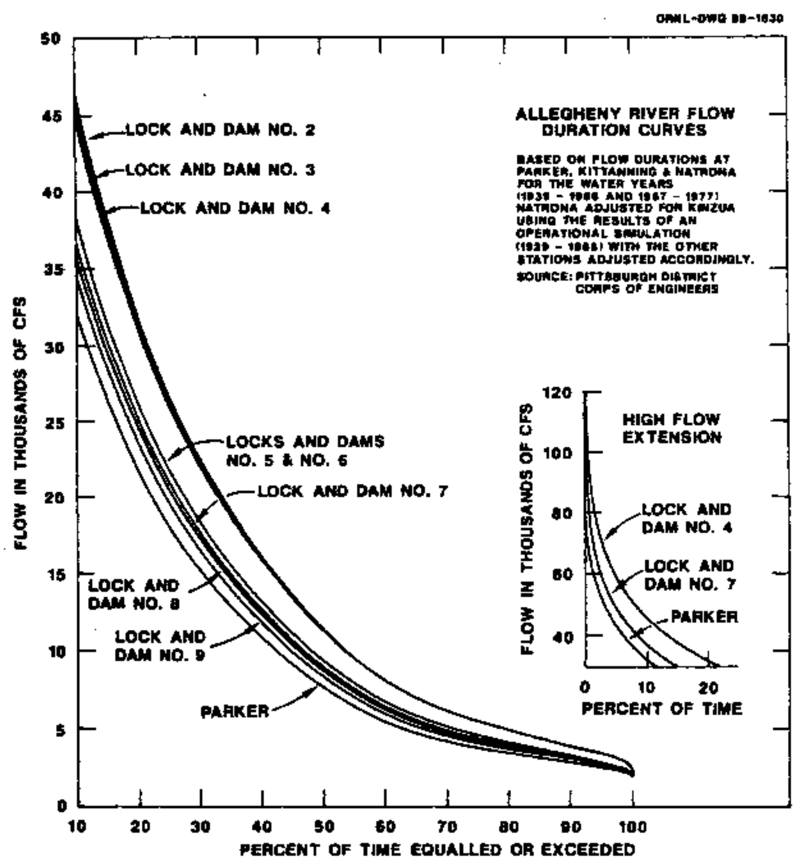

Figure 3.3.1-1. Allegheny River annual flow duration curves.

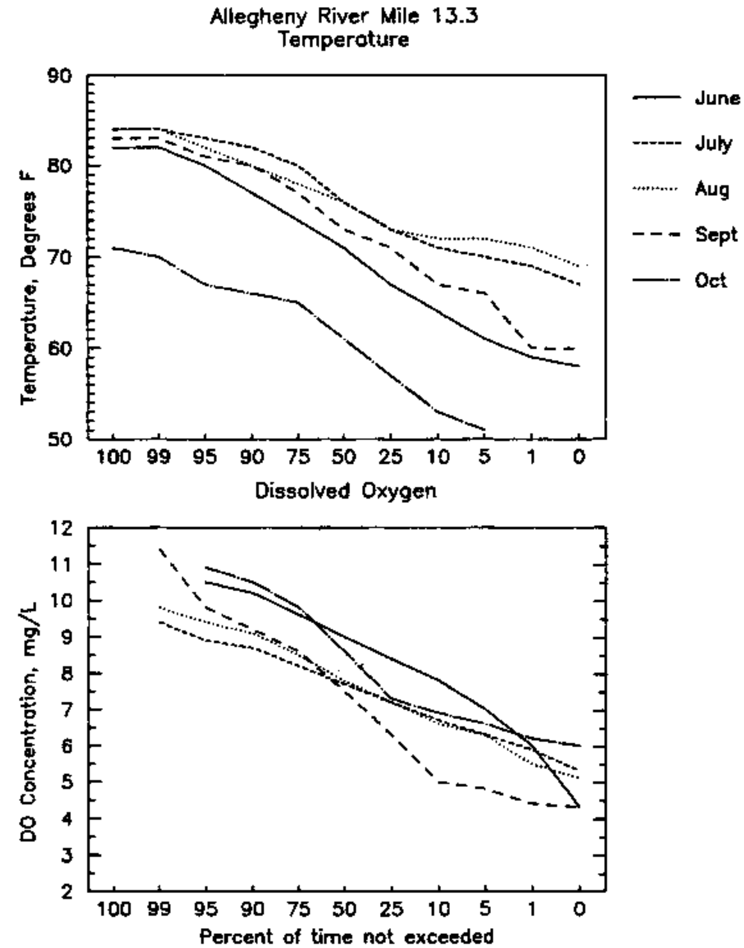

Figure 3.3.2-1. Summer temperature and DO frequency distributions (from ORSANCO monitor at Allegheny RM 13.3, 1980-1986).

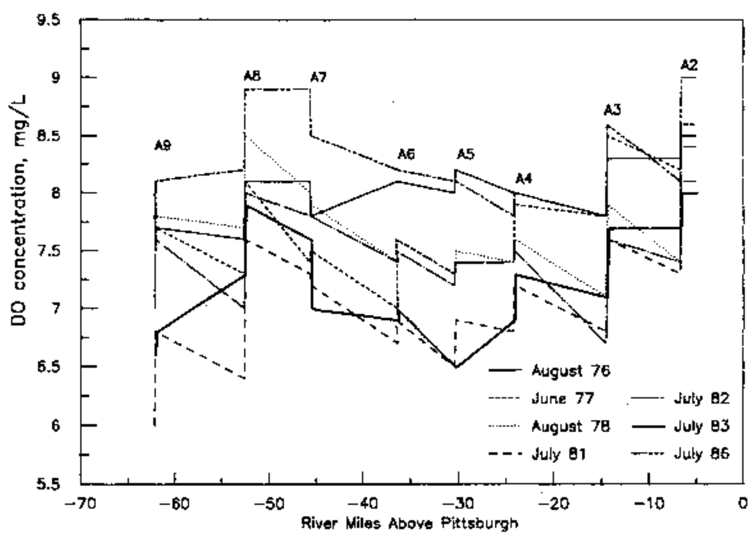

Figure 3.3.2-2. DO measurements above and below each dam (from Corps summer water quality surveys of the Allegheny River).

redhorse species, bottom-feeding members of the sucker family often missing in polluted reaches of streams (studies by applicants). Both the pool-oriented species of centrarchids (spiny-rayed fishes, such as largemouth bass and sunfishes) and the tailwater-oriented walleye and sauger are abundant, although in the relatively small and faster flowing Allegheny, these species are more uniformly distributed between pool and tailwater habitats than they appear to be in the larger mainstem Ohio (Section 3.5.3). The smaller river also provides more shallow water habitat and islands for fish spawning and rearing. Islands and their associated shallow-water habitats are common. There are prominent gravel bars, some with islands, downstream of the plunge pools below dams. Downstream of the Kiskiminetas River and in the more urban and industrial zone near Pittsburgh, the fish populations are dominated by carp and channel catfish although other game species also occur. Notable features of the river in the study area follow:

Allegheny L&D No. 7 - Immediately downstream of this dam is a small island and a 14-acre gravel bar that lies on the proposed powerhouse side of the river.

L&D No. 4 - Jacks Island lies immediately above the dam, and its shallow backwater channel is on the proposed powerhouse side of the river.

L&D No. 3 - Islands lie both immediately upstream and downstream of this dam. A proposed powerhouse will discharge into a large, shallow riffle on the backchannel side of a 2-mile-long chain of downstream islands (Fourteen Mile and Twelve Mile islands).

L&D No. 2 - There are shallows and islands in the middle of this dam's pool near RM 10. Extensive shallow water and an island (Six Mile Island) lie in the dam tailwater on the right side of the river (i.e., the side on which the proposed powerhouse would be located).

3.3.4 Recreation

3.3.4.1 Recreation use and activities

Recreational activity along the Allegheny River has been increasing substantially in recent years, as improvements in water quality enhance the attractiveness of the recreation resource. Recreational use statistics at Corps water resource projects on the Allegheny River, for example, indicate a substantial increase in the number of recreation days of use between 1984 and 1986 (Table 3.3.4-1). Recreational boating contributes more than any other activity to the number of recreational days of use recorded on the river (Table 3.3.4-2). Fishing is the second most frequent activity in which visitors participate and is popular along the dam abutments (although formal access is not provided), the gravel areas along the shoreline, backwater areas behind the dam abutments at high flows, and at the islands and tributaries of the river. Although there is a substantial portion of water acreage available on the Allegheny, Table 3.3.4-3 shows that there is relatively little total land acreage along the river set aside for recreation.

Table 3.3.4-1. Recreation days of use at U.S. Army Corps of Engineers water resource projects on the Allegheny River. 1/, 2/

Allegheny River	1984	1985	1986
L&D No. 9	12,600	15,600	25,400
L&D No. 8	13,200	16,300	25,900
L&D No. 7	13,800	16,500	24,800
L&D No. 6	15,800	17,200	25,300
L&D No. 5	24,400	35,800	47,300
L&D No. 4	38,700	54,600	79,300
L&D No. 3	39,800	55,800	85,300
L&D No. 2	94,600	119,000	160,500

1/ Source: Corps, 1987. Natural Resources Management System, Pittsburgh District.

2/ One recreation day of use is equal to one person participating in one or more activities within a project for any length of time during a 24-hour period.

Table 3.3.4-2. Percentage of recreation days of use by activity at U.S. Army Corps of Engineers water resource projects on the Allegheny River. 1/, 2/

Project area	Picnicking	Camping	Swimming	Water Skiing	Boating	Sight seeing	Fishing
L&D No. 9	2	0	15	10	60	1	25
L&D No. 8	2	0	15	10	65	1	25
L&D No. 7	2	0	15	10	55	3	20
L&D No. 6	8	0	15	10	60	3	20
L&D No. 5	3	0	15	10	65	2	20
L&D No. 4	2	0	15	10	65	2	20
L&D No. 3	0	0	15	10	70	4	15
L&D No. 2	1	0	15	10	70	7	15

1/ Source: Corps, 1987. Natural Resources Management System, Pittsburgh District.

2/ Percentages often exceed 100 percent because visitors generally participate in more than one activity.

Table 3.3.4-3. Land and water acreage and facility count at U.S. Army Corps of Engineers water resource projects on the Allegheny River. 1/

Project area	Average water acreage	Recreation total land acreage	Pool shoreline miles	Picnic sites	Camp sites	Launch lanes	Park lots
L&D No. 9	1,089	41	20	0	0	0	1
L&D No. 8	1,087	84	19	0	0	0	1
L&D No. 7	950	3	14	0	0	0	1
L&D No. 6	1,295	49	19	6	0	0	1
L&D No. 5	871	6	12	0	0	0	1
L&D No. 4	870	15	12	0	0	0	1
L&D No. 3	1,273	22	19	0	0	0	1
L&D No. 2	1,240	6	16	0	0	0	1

1/ Sources: Corps, 1984. 1982 Recreation Statistics Volume II (EP 1130-2-401). Corps Computer Data System, Washington D.C.

The demand for recreational boating and fishing opportunities in the region is particularly evident in Allegheny County, which has the highest boat registration and fishing license sales in Pennsylvania. Table 3.3.4-4 lists boat registration and fishing license sales statistics for the three counties along the Allegheny River with proposed hydroelectric development: Allegheny, Armstrong, and Westmoreland. Although much of the angling done by Allegheny Countians may take place outside the county, the trend and potential for expansion is limited by only the quality and accessibility of the water resource (personal communication, F. W. Johnson, Pennsylvania Fish Commission, October 1, 1987).

An indicator of the extent of recreational boating on the Allegheny River is the number of recreational boat lockages at each of the river's locks. Table 3.3.4-5 indicates that the heaviest concentration of recreational boaters is at L&D No. 2. Furthermore, close to 70 percent of the total number of recreational boat lockages occur at locks in Allegheny County (L&D Nos. 2-4). A comparable concentration of users is reflected in the number of recreational user days for all activities at Corps projects displayed in Table 3.3.4-1.

Table 3.3.4-4. Fishing license sales and boat registrations issued during 1986 in counties along the Allegheny River with proposed hydroelectric projects. 1/

County	1986 Population	Fishing license		Boat registration	
		number	percent	number	percent
Allegheny	1,373,600	92,243	6.7	26,147	1.9
Armstrong	78,500	11,548	14.7	2,396	3.0
Westmoreland	381,100	38,179	10.0	8,294	2.2

1/ Source: Pennsylvania Fish Commission; U.S. Department of Commerce, 1987.

Table 3.3.4-5. Recreational lockage during 1986 on the Allegheny River. 1/

Project area	Recreational lockages	Recreational vessels
L&D No. 9	550	982
L&D No. 8	613	1,080
L&D No. 7	646	1,081
L&D No. 6	840	1,158
L&D No. 5	1,191	2,093
L&D No. 4	2,114	3,761
L&D No. 3	1,896	4,041
L&D No. 2	3,372	8,667
Total	11,222	22,863

1/ Source: Corps. Performance Monitoring System, Pittsburgh District.

Table 3.3.4-6 summarizes by dam pool the recreational dock and launching facilities along the river. Over 60 marinas, boat clubs, and privately owned docks line the river from Pittsburgh to East Brady, 70 miles upstream. Although there are many recreational docks along the Allegheny River, most anglers use public access points to launch their boats because many of the private marinas and clubs have parking restrictions for non-dock users. The availability of public access points for boat launching along the Allegheny River is limited, however, to the Pennsylvania Fish Commission (PFC) launch ramps at Harmarville (RM 13), Springdale (RM 16), Tarentum (RM 22), Applewood (RM 44), Templeton (RM 55), East Brady (RM 70), the public launching ramp at Freeport (RM 29), and the municipal ramp at Kittanning (RM 45).

The PFC estimated 290,000 angler days occur each year on the Allegheny River from Pittsburgh to East Brady. Table 3.3.4-7 lists the 1980 use estimates and projected use estimates for the Allegheny and its tributaries. The number of angler days in 1980 may have increased by 10 percent since the time of the inventory due to improvements in water quality (personal communication, F. W. Johnson, PFC, October 1,1987). The number of potential fishing days per year (assuming that limiting factors such as acid mine drainage, pollution, excessive siltation, and uncontrolled power boating could be overcome) is substantially larger than 1980 estimates for the lower 28.6 miles of the river.

The PFC classified the lower 28.6-mile reach of the Allegheny River in Allegheny County as a medium-quality, warm-water fishery, signifying a moderate population of legal-sized game fish and a good population of pan fish. In Armstrong County the river is classified as a high-quality, warm-water fishery, indicating a large population of legal-sized game fish and a good

Table 3.3.4-6. Recreational facilities by pool along the Allegheny River. 1/

Pool	Launch ramps	Recreation docks	Berths
Pool No. 9	2	0	0
Pool No. 8	3	0	0
Pool No. 7	2	1	60
Pool No. 6	2	2	47
Pool No. 5	0	0	0
Pool No. 4	1	41	69
Pool No. 3	4	4	45
Pool No. 2	7	9	1,112
Emsworth	2	7	272

1/ Source: Corps, 1987. Allegheny River Navigation Charts. Pittsburgh District. Corps, 1987 (revised). Ohio River and Tributaries - Small Boat Harbors, Ramps, Landings, etc. Ohio River Division.

Table 3.3.4-7. Estimates of the number of current and future fishing days per year along the Allegheny River and its side creeks. 1/

Name of water body	Location	1980	Future use
Allegheny River	RM 0 - 28.6	190,000	325,000
Pine Creek	Emsworth Pool	24,000	24,000
Deer Creek	Dam 2 Pool	25,000	25,000
Plum Creek	Dam 2 Pool	0	15,000
Pucketa Creek	Dam 3 Pool	10,000	10,000
Bull Creek	Dam 3 Pool	20,000	20,000
Allegheny River	RM 29 - 69	100,000	150,000
Buffalo Creek	Dam 4 Pool	25,000	28,000
Kiskiminetas River	Dam 4 Pool		30,000
Crooked Creek	Dam 6 Pool	10,000	15,000
Glade Run	Dam 6 Pool	7,000	10,000
Cowanshannock Creek	Dam 7 Pool	900	20,000
Limestone Run	Dam 7 Pool	500	2,000
Mahonning Creek	Dam 8 Pool	6,000	20,000

1/ Source: Pennsylvania Fish Commission, 1980 Fishing and Boating Inventory Computer Run.

2/ Use figures may have increased by up to 10 percent because of improvements in water quality since 1980, when these data were collected.

population of pan fish. The difference in quality between the lower and upper reaches is partially attributed to the Kiskiminetas River, which flows into the Allegheny at RM 30. In the past, the Kiskiminetas River has carried significant acid mine drainage into the lower Allegheny. As the water quality of the river continues to increase, the availability of fishing access areas becomes a more limiting factor to use along the Allegheny and its side creeks. As emphasized in Pennsylvania's State Recreation Plan (Pennsylvania Department of Environmental Resources, 1981), there is a need to acquire and develop more fishing and boating access facilities on rivers, such as the Allegheny, that are close to population centers.

3.3.4.2 Wild and Scenic River Status

The reach of the Allegheny River from RM 0 to RM 69.5 was studied by the Bureau of Outdoor Recreation and was determined in 1974 to be ineligible for inclusion into the National Wild and Scenic Rivers System. The reach is designated a priority 1-C stream under the Pennsylvania Scenic Rivers System, which signifies the need for further study of the river's statewide importance. The proposed classification of the 30-mile reach from the Kiskiminetas River to Pittsburgh is "modified recreational," which means the river should remain conducive to recreational as well as utility uses. The reach from the East Brady to the Kiskiminetas River is proposed as "scenic" (personal communication, Don Dreese, Division of Scenic Rivers, Pennsylvania Department of Environmental Resources, January 26, 1988).

3.3.5 Wetlands

Wetlands on the Allegheny River are extremely important and most likely to be impacted by changes in pool elevations and velocities associated with hydropower operation because all the dams in the 37.3 mile-long study area are fixed-crest. The Corps, Pittsburgh District, conducted a limited vegetation survey, including wetland and riparian areas, of the navigable portion of the Allegheny River as a part of water quality studies during 1982-87. Detailed surveys were made at 14 sites (Table 3.3.5-1) and the shoreline survey was based on observations made from a boat. The estimated results of these surveys were mapped on navigation charts. Riparian vegetation is present in long, narrow stretches and is dominated by floodplain forest species (e.g., black willow - Salix nigra Marsh.). Aquatic vascular plants [e.g., water willow, Justica americanus (L.) Vahl], Japanese knotweed (Polygonum cuspidatum Sieb. & Zucc.), and reed canary grass (Phalaris arundinacea L.) vegetate only a small portion of the riparian zone, mostly on river islands and their backchannels. There are eleven islands within the boundaries of the Allegheny River portion of the study area, with five located in immediate project site vicinities. These islands and riparian zones are especially important because the dams on the Allegheny River are located in heavily industrialized and urbanized areas close to one another.

Some of the results describing wetland and riparian areas, locations and types are summarized in Table 3.3.5-2. A total of approximately 80 miles of shoreline riparian vegetation is estimated for the stretch of the Allegheny River in the study area.

Table 3.3.5.1. Vegetation survey sites on the Allegheny River during 1982-83, 1985-87. 1/

Site	River mile	Location	Pool	Year visited
1	1.0	Left bank	Emsworth	1986
2	3.18	Left bank	Emsworth	1987
3	5.99	Left bank	Emsworth	1987
4	14.3	Left bank, 14 Mile Island	Allegheny 2	1983
5	23.9	Left bank	Allegheny 3	1983
6	24.3	Back channel, Jack's Island	Allegheny 4	1983
7	38.3	Right bank	Allegheny 6	1983
8	39.5	Ross Island	Allegheny 6	1983
9	40.9	Right bank	Allegheny 6	1982
10	42.5	Cogley's Island	Allegheny 6	1985
11	62.0	Right bank	Allegheny 8	1983
12	67.6	Left bank	Allegheny 9	1985
13	68.5	Right bank	Allegheny 9	1983
14	72.0	Left bank	Allegheny 9	1982

1/ Source: Corps, unpublished vegetation survey.

Table 3.3.5-2. Wetland area estimates for Allegheny River islands. 1/

		Wetland area (acres)			
	RM	Total Area	Emergent/ shrubs	Forest	Bottomland forest
Allegheny 6 Pool					
Nicholson Island	36.8	28	0.75	0	27
Ross Island	39.5	9	0.5	3	5
Cogley's Islands (complex)	42.5	20	6	13	1
Isle of White	45.5	2.1	1.4	0	0
Allegheny 5 Pool					
Murphy's Island	32.4	16.5	0.2	2	14
Allegheny 4 Pool					
Jack's Island	24.3	30	3.6	2.5	17
Allegheny 3 Pool					
Fourteen Mile Island (upstream)	14.6	10	0.01	1	9.5
Unnamed Island	21.0	3.5	1.5	2	0
Allegheny 2 Pool					
Sycamore Island	9.8	18	1	0	14
Nine Mile Island	10.0	3.3	0	1	2.2
Twelve Mile Island	12.8	48	0	15	2
Fourteen Mile Island (complex)	13.8	25	1.6	8	16
Unnamed island	14.4	3.78	3.78	0	0
Emsworth Pool					
Herrs Island	2.1	60	0	0	14
Sixmile Island	6.2	4.3	8		7

1/ Source: Corps. Pittsburgh District, vegetation survey.

3.3.5.1 Allegheny L&D No. 7 Pool

There are no islands in this pool. The shoreline upstream of the dam for approximately 1 to 2 miles is a wide littoral zone dominated by immature trees, shrubs, and reed canary grass. Although there is an increase in diversity and abundance of herbaceous hydrophytes, when compared to the downstream part, about 10 percent of the pool's littoral zone is dominated by reed canary grass. Narrow bands of riparian vegetation are dominated by black willow and other floodplain forest species. The upstream shoreline is classified as floodplain forest intermixed with aquatic vascular plants dominated by water willow. The left bank downstream shoreline is classified as a highly disturbed area with little vegetation, while the right bank downstream shoreline is dominated by black willow and reed canary grass.

3.3.5.2 Allegheny L&D No. 6 Pool

The project in this pool has already been licensed by FERC. Although it is outside the scope of the proposed actions, the pool contains major wetland areas which should be considered in an analysis of cumulative impacts from hydropower development. The following description is, therefore, included as a basis for understanding the wetland resource that is present in the study area.

The Isle of White, a small island dominated by small floodplain forest species (black willow and the aquatic vascular plant water willow on the interior and reed canary grass on the perimeter) is located immediately downstream of Allegheny L&D No. 7 and hence is subject to impacts from proposed projects at that L&D. Small areas of emergent plant communities exist along the perimeter, and water willow is dominant in the shoals (approximately 14 acres) around the island. This island is used by fishermen because the shallows are attractive to fish and has been designated a "recreational refuge" by Armstrong County government.

Nicholson Island, located about one mile upstream of L&D No. 6, is dominated by black willow, silver maple, and sycamore. Reed canary grass and other aquatic vascular plants dominate the upstream and downstream tips of the island. Wetlands dominated by arrowhead occur along the left bank of the backchannel and make up about 60 percent of the island's emergent wetlands. The downstream portion of Ross Island, located 3.5 miles upstream of Allegheny L&D No. 6, is dominated by reed canary grass and aquatic vascular plants. The upstream tip has been heavily disturbed and is now a few small islets. All of these islands are predominantly floodplain forest, and the edges support diverse emergent wetlands. Cogley's Islands, seventeen small islands, and many small islets located between RM 42.4 and 42.6, about 2.7 miles downstream of Allegheny L&D No. 7, are dominated by water willow and aquatic vascular plants. This island complex, dominated by water willow, supports the most extensive wetlands in the navigable portion of the river. At least 30 percent of the Allegheny River Wetlands occur on Cogley's Islands. About 40 percent of the emergent wetlands and 60 percent of the forested wetland in Pool 6 occur here. This set of islands is the only place in the Allegheny River where northern pike (Esox lucius Linnaeus) reproduces (personal communication Pennsylvania Fish Commission, Jack Miller, June 12, 1987). When water levels are low, most of these islands are exposed.

3.3.5.3 Allegheny L&D No. 5 Pool

This L&D is not a part of the proposed action, but wetlands present are part of the total resource in the study area.

Murphy's Island, located approximately two miles upstream of Allegheny L&D No. 5, is mostly dominated by floodplain forest, 12 percent of which is black willow. Reed canary grass-dominated emergent wetlands comprise about 6 percent of the shoreline. This wetland, together with over 1000 feet of emergent wetland along the left bank of the backchannel makes up about 30 percent of the emergent wetlands in this pool.

3.3.5.4 Allegheny L&D No. 4 Pool

Jack's Island is located upstream of Allegheny L&D No. 4 and shows evidence of extensive disturbance. The downstream portion is dominated by black willow and silver maple. The upstream portion is dominated by Japanese knotweed. Bur reed and arrowhead dominate the emergent wetlands on the upstream tip of the island, adjacent islets, and the left bank of the backchannel. About 60 percent of the wetlands in Pool 4 occur here. A wide littoral zone, with aquatic plants and black willow as the dominant species, is located along the left bank of the river about 1000 feet below the dam and extends along the shoreline for about 2000 feet. This area supports about 30 percent of the wetlands in pool 3.

3.3.5.5 Allegheny L&D No. 3 Pool

Fourteen Mile Island is actually two islands, one located upstream of Allegheny L&D No. 3 and the other downstream of the dam. Construction of the dam in the 1930s cut the large island into two parts. These islands were surveyed by the applicant and the Corps (Table 3.3.5-3, Site 4). Both sections of Fourteen Mile Island are dominated by black willow, red maple (Acer rubrum L.), silver maple (Acer saccharinum L.), sycamore (Platanus occidentalis L.), black locust (Robinia pseudo-acacia L.), tree-of-heaven [Ailanthus altissima (Mill.) Swingle] and other floodplain forest species. About 6 percent of the downstream island is water willow dominated emergent wetland, half of which is at the upstream end of the island and the remainder on scattered unnamed islands between Fourteen Mile and Twelve Mile Islands. Small areas of Japanese knotweed are located at the tips of the upstream island. An approximately 4-acre thicket of black willow dominates the upstream tip. The downstream island is dominated by water willow at the tips and black willow elsewhere. Small areas of aquatic vascular plants occur at the tips of the island (Table 3.3.5-3). The island perimeter is an important shallows area for fish feeding and spawning. An unnamed island located just below L&D 3 is an emergent

Table 3.3.5-3. Species composition of Allegheny Pool 2. 1/

Vegetation of typical wooded areas	
Equisetum sp.	Horsetail
Rorippa sylvestris (L.) Bess	Creeping Yellow Cress
Rubus sp.	Rasberry
Ranunculus sp.	Buttercup
Polygonum cuspidatum Sieb. & Zucc.	Japanese Knotweed
Rhus radicans L.	Poison Ivy
Parthenocissus quinquefolia (L.) Planch.	Virginia Creeper
Lysimachia vulgaris	Garden Loosestrife
Eupatorium rugosum Houtt.	White Snakeroot
Eupatorium fistulosum Barratt.	Common Joe-pye Weed
Artemisia vulgaris L.	Common Mugwort
Tussilago farfara L.	Coltsfoot
Arctinum minus (Hill.) Bernh.	Common Burdock
Verbesina alternifolia (L.) Britton ex. Kearney	Wing-stem
Physocarpus opulifolius (L.) Maxim.	Ninebark
Cornus amomum Mill.	Silky Dogwood
Rhus typhina L.	Staghorn Sumac
Salix nigra Marsh.	Black Willow
Morus rubra L.	Red Mulberry
Platanus occidentalis L.	Sycamore
Ailanthus altissima (Mill.) Swingle	Tree-of-heaven
Acer saccharinum L.	Silver Maple
Acer negundo L.	Boxelder
Prunus serotina Ehrh.	Wild Cherry
Tilia americana L.	American Linden
Onoclea sensibilis L.	Sensitive Fern
Elymus virginicus L.	Virginia Wild Rye
Boehmeria cylindrica (L.) SW.	False Nettle
Phytolacca americana L.	Polkweed
Alliaria officinalis Andruz.	Garlic Mustard
Rubus odoratus L.	Flowering Raspberry
Acalypha ramboidea Raf.	Three-seeded Mercury
Impations capensis Mecrb.	Spotted Touch-me-not
Vitis riparia Michx	Riverbank Grape
Cascuta sp.	Dodder
Verbena articifolia L.	White Vervain
Verbena hastata L.	Blue Vervain
Solidago sp.	Goldenrod
Hydrangea arborescens L.	Wild Hydrangea
Sambucus canadensis L.	Common Elder
Ulmus rubra Muhl.	Slippery Elm
Fraxinus americana L.	White Ash
Vegetation of typical areas dominated by aquatic vascular plants	
Myriophyllum sp.	Water Milfoil
Potamogeton sp.	Pondweed
Sagittaria sp.	Arrowhead
Typha latifolia L.	Broad-leaved Cattail
Sparganium sp.	Burreed
Spartina pectinata Link.	Prairie Cordgrass
Phalaris arundinacea L.	Reed Canary Grass
Eleocharis sp.	Spike Rush
Scirpus sp.	Sedge
Rumex altissimus Wood	Tall Dock
Lysimachia vulgaris L.	Garden Loosestrife
Lythrum salicaria L.	Spiked Loosestrife
Justicia americana L.	Water Willow
Eupatorium perfoliatum L.	Boneset

Table 3.3.5-3. (concluded)

Vegetation of typical areas dominated by aquatic vascular plants (concluded)

Verbena hastata L.	Blue Vervain
Asclepias incarnata L.	Swamp Milkweed
Physocarpus opulifolius (L.) Maxim.	Ninebark
Cephlanthus occidentalis L.	Buttonbush
Plantanus occidentalis L.	Sycamore
Salix nigra Marsh.	Black Willow
Salix interior Rowlee	Sandbar Willow
Acer saccharinum L.	Silver Maple

Site 4
Mile 14.3 left bank of Fourteen Mile Island
Wooded area - aquatic along shoreline

Onoclea sensibilis L.	Sensitive Fern
Phalaris arundinacea L.	Reed Canary Grass
Scirpus americanus Pers.	American Bulrush
Eleocharis acicularis (L.) R. & S.	Needle Rush
Eleocharis obtusa (Willd.) Schultes.	Spikerush
Lysimachia terrestris (L.) B.S.P.	Swamp Candle
Lysimachia ciliata L.	Fringed Loosestrife
Lysimachia vulgaris L.	Garden Loosestrife
Hypericum sp.	St. John's-wort
Hypericum mutilum L.	Small-flowered St. John's-wort
Justicia americana L. Vahl	Water Willow
Polygonum cuspidatum Sieb. & Zucc.	Japanese Knotweed
Eupatorium perfoliatum L.	Boneset
Cornus amomum Mill.	Silky Dogwood
Salix interior Rowlee	Sandbar Willow
Salix nigra Marsh.	Black Willow
Platanus occidentalis L.	Sycamore
Acer saccharinum L.	Silver Maple
Elymus virginicus L.	Virginia Wild Rye
Boehmeria Cylindrica (L.) Sw.	False Nettle
Phytolacca americana L.	Polkweed
Alliaria officinalis Andruz.	Garlic Mustard
Rubus odoratus L.	Flowering Rasberry
Acalypha ramboidea Raf.	Three-seeded mercury
Impatiens capensis Meerb.	Spotted Touch-me-not
Vitis riparia Michx	River bank Grape
Cuscuta sp.	Dodder
Verbena urticifolia L.	White Vervain
Verbena hastata L.	Blue Vervain
Solidago sp.	Goldenrod
Hydrangea arborescens L.	Wild Hydrangea
Sambucus canadensis L.	Common Elder
Ulmus rubra Muhl.	Slippery Elm
Fraxinus americana L.	White Ash

1/ Source: Personal Communication. R. Reilly, Corps Pittsburgh District, 1988.

and shrub wetland dominated by water willow. The wetlands on and surrounding Fourteen Mile Island account for about 99 percent of the wetlands in Pool 2, providing important habitat for feeding and spawning fish. Immature floodplain forests dominate the shoreline in the project vicinity. Wetlands located in Pool 3 between RM 21 and 22 on an unnamed island, associated islets, and the left bank of the backchannel are also important. About 50 percent of the emergent wetlands and 70 percent of the forested wetlands in Pool 3 occur here.

3.3.5.6 Allegheny L&D No. 2 Pool

Sycamore Island and Ninemile Island are located adjacent to one another about three miles upstream of Allegheny L&D No. 2. Bottomland hardwoods dominate Sycamore Island with about 30 percent of the shoreline lined in black willow. About 1 acre of emergent wetland occurs at the tip. Nine Mile Island is dominated by black willow. Their vegetation is similar to Six Mile Island (Section 3.3.5.7). Twelve Mile Island is located in this pool about 1.5 miles downstream of Allegheny L&D No. 3. About 40 percent of the island is black willow and the remainder has been developed. Aquatic vascular plants and black willow dominate the edges. Riparian vegetation consists of a small area of Japanese knotweed upstream of the proposed project site. Only about 1000 square feet of the upstream tip is emergent wetlands. Both shorelines upstream of L&D 2 are dominated by Japanese knotweed.

3.3.5.7 Emsworth Pool

Six Mile Island, located directly downstream of the proposed Allegheny L&D No. 2 project, has the largest contiguous vegetated habitat in the immediate vicinity of the Allegheny L&D No. 2. The upstream portion of the island is dominated by willow (<u>Salix</u> sp.), mostly black willow with the aquatic vascular plant water willow, submerged aquatic vascular plants, and a wide littoral zone dominated by aquatic plants with few shrubs and annuals. The submerged hydrophyte beds, the only ones observed in the Emsworth Pool, occur at the upstream bed and along the left bank of the river. The right bank near L&D No. 2 has been disturbed and the left bank is floodplain forest. Approximately 4000 square feet of emergent wetlands at the mouth of Pine Creek account for 50 percent of the wetlands in the pool.

3.3.6 River Navigation and Hydraulics

The Allegheny is navigable by barges to RM 72 above Pittsburgh. All eight of the navigation dams on the river are fixed-crest. Therefore, installation of hydropower at any of the dams would result in a drop in pool elevation during low and moderate flows (Section 4.1.5).

The installation of navigation dams and other constrictions to flow, such as bridges and docks, have increased the frequency and magnitude of floods over what they were naturally. For Corps navigation projects, real estate easements were purchased and/or other provisions made prior to construction to compensate for project-induced flood effects, where necessary. However, flooding has been reduced by the flood control dams the Corps has built in the Allegheny watershed (Corps, 1975). Expected flood elevations, adjusted to account for Kinzua Dam and other storage projects, are shown in Figure 3.3.6-1. Flow duration curves for the navigation channel also indicate the frequency of high flows (Figure 3.3.1-1).

3.4 MONONGAHELA RIVER

3.4.1 Basin Description

The Monongahela River has a watershed area of 7386 square miles. The river is formed by the confluence of the West Fork and Tygart Valley rivers, 129 RMs upstream from Pittsburgh. Major tributaries to the Monongahela are the Cheat River (with a watershed area of 1422 square miles), and the Youghiogheny River (with a watershed area of 1764 square miles) (Corps, 1976). The entire Monongahela River is navigable by barges, with depths maintained by nine navigation dams. The lower 3 miles of the Tygart Valley River are also navigable. Flows are presently controlled by Deep Creek, Lake Lynn, Tygart Valley River, and Youghiogheny River reservoirs; additional control will be provided by the completion of Stonewall Jackson Dam on the West Fork River. Deep Creek and Lake Lynn reservoirs are privately owned hydroelectric projects, while the other reservoirs are operated by the Corps for flood control, flow augmentation, and other purposes. Annual median flows are 1200 cfs at Tygart Dam, 2000 cfs at Opekiska dam, 4400 cfs at L&D 7, and 7200 cfs at L&D 2. Monthly mean flows are given in Table 3.3.1-1. Annual flow duration curves for the Monongahela are shown in Figure 3.4.1-1. There are no existing licensed hydropower projects at navigation dams on the Monongahela.

3.4.2 Water Quality

Many of the major industries that once discharged to the heavily industrialized Monongahela and its tributaries such as the Youghiogheny have closed or curtailed their waste-producing

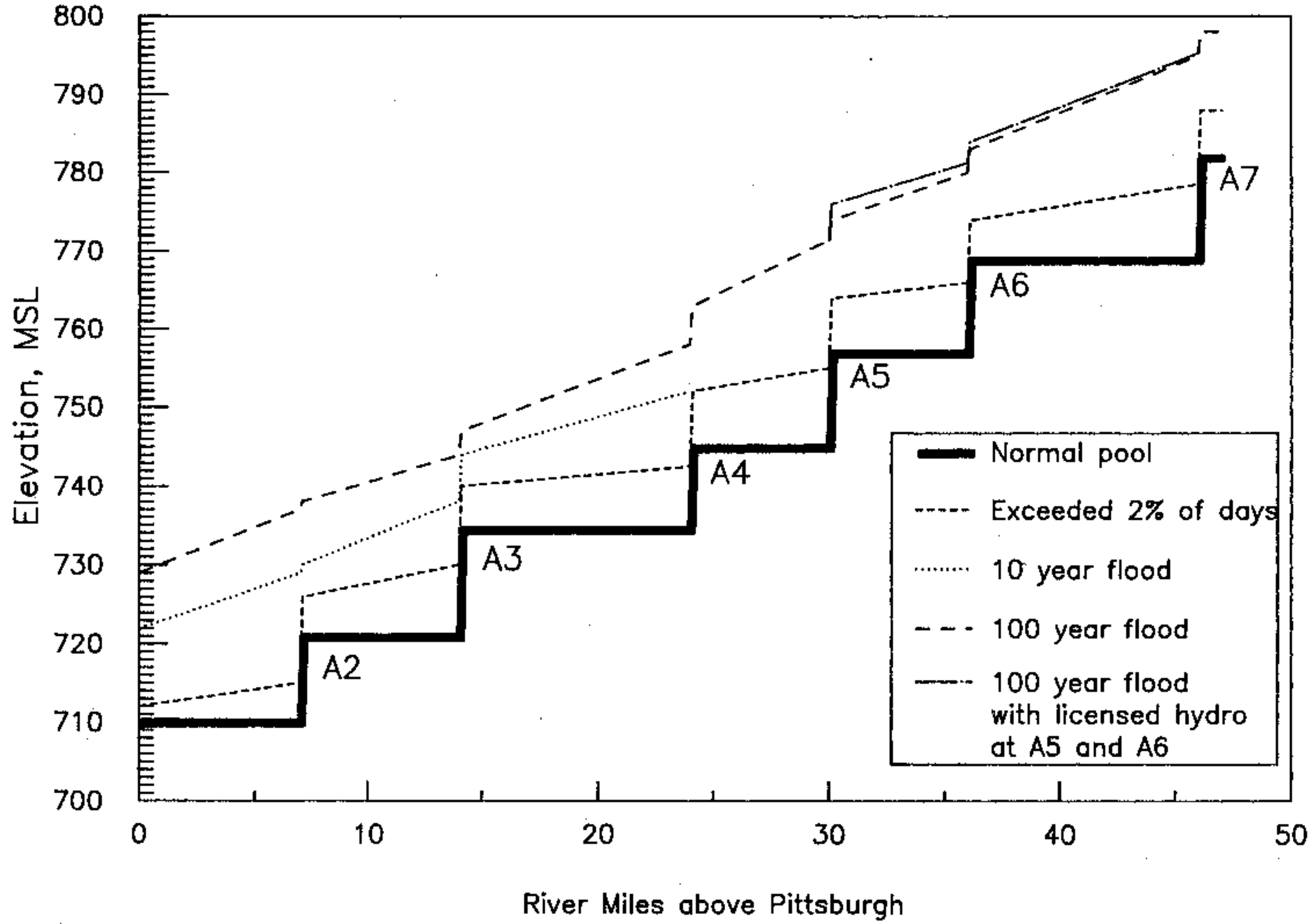

Figure 3.3.6-1. Expected flood elevations for the Allegheny River. Source: Corps, Pittsburgh District.

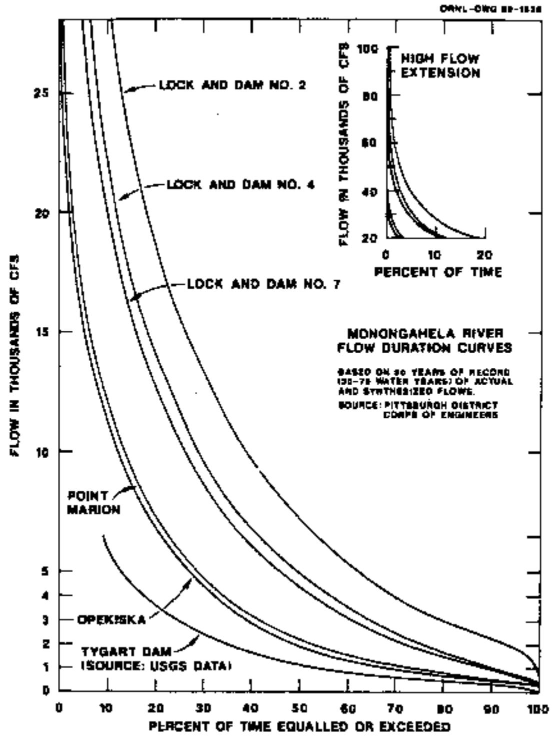

Figure 3.4.1-1. **Monongahela River annual flow duration curves.**

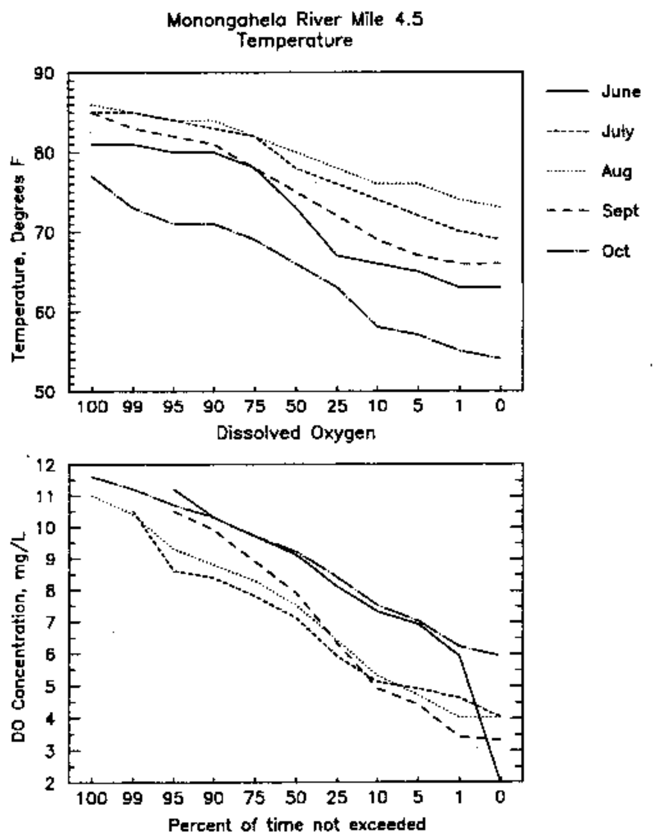

Figure 3.4.2-1. **Summer temperature and DO frequency distributions (from ORSANCO monitor at Monongahela RM 4.5, 1980-1986).**

processes. Improved treatment has been installed at many of the municipal wastewater plants (e.g., see WVDNR, 1982a). However, there are still a number of municipal and industrial dischargers to the Monongahela, including power plants discharging heated water. Mine wastewaters continue to pollute the Monongahela and its major tributaries, and pH and metals concentrations are still water quality problems (WVDNR, undated).

DO concentrations were monitored daily by ORSANCO at Monongahela RM 4.5, from 1975 until 1986. Data from the ORSANCO monitor can be used to show historic ranges of DO concentrations at this location. Figure 3.4.2-1 shows the frequency distribution of water temperatures and DO concentrations during summer and fall months at the ORSANCO monitor.

Other sources of information on Monongahela River water quality include other data collected by ORSANCO, data from the stations operated by the USGS in its National Stream Quality Accounting Network, and data collected by the state of Pennsylvania (ORSANCO, 1986b). The Pittsburgh District of the Corps has sampled summer water quality in the Monongahela annually since 1973 (Corps, 1976); DO measurements above and below each dam from 7 of these surveys are shown in Figure 3.4.2-2. Toxic compounds in the Monongahela are discussed in Section 3.1.3.

Data collected by the Corps show that Tygart reservoir does stratify thermally in summer, though the cool bottom layer with low DO concentrations is small and relatively unstable (Corps, 1976). The outlet from the lake is in the cool, low DO-layer, but the discharge from Tygart Reservoir is generally saturated with DO because of the aeration provided by the dam outlet. Outflow from the dam is sprayed into the air, falls into a stilling basin, and then falls over a weir before entering the Tygart Valley River. The Opekiska pool (from the head of navigation to Opekiska dam) tends to thermally stratify in summer as a result of the colder water from the Tygart Valley River flowing under the warmer water of the West Fork River; the stratification is intensified by the thermal discharge from a power plant (Corps, 1976). Stratification, the formation of a warm, oxygenated surface layer and a cold layer that becomes deoxygenated, causes severe DO deficits in the Opekiska pool. Because the gated Opekiska dam discharges from the lower, deoxygenated strata of Opekiska pool, without providing significant aeration, the deficits in the Opekiska pool are passed downstream to the Hildebrand pool. Hildebrand and the next five dams downstream of it provide good aeration. Therefore, frequently in summer there are severe DO deficits from the head of navigation at RM 131 to Hildebrand dam at RM 108. Low DO concentrations tend to occur also as a result of wastewater discharges and stratification near Pittsburgh.

3.4.3 Fisheries

3.4.3.1 General

Until 1970, the Monongahela River Basin was considered the watershed most intensely polluted by acid mine drainage in the United States (USEPA, 1979). Except for occasional tributaries, the river system was almost devoid of fish populations except for acid-tolerant bullheads [species of the catfish family (Jernejcic, 1982)]. Reports of increasing angler success in 1971 led to confirmatory surveys that showed game fish populations were recovering, especially in the main stem Monongahela and Tygart Lake (Jernejcic, 1982). The West Virginia Department of Natural Resources (WVDNR) has stocked numerous game and forage species in both lake and river since 1972 to rehabilitate the fish communities. The river now supports good populations of game and forage fish and is an important and intensively used fishery (USFWS, 1984b; ORSANCO lock surveys unpublished data). Largemouth bass, smallmouth bass, rock bass, walleye, sauger (recently invading the river), channel catfish, yellow bullhead, brown bullhead, bluegill, green sunfish, and pumpkinseed are popular game fishes, while suckers, minnows, shiners, and gizzard shad compose the forage base.

The Monongahela River is a typical channelized river without any islands. Dam tailwaters have the largest concentrations of such species as walleye and channel catfish, while the pools contain a more lake-like warmwater fish assemblage. The fish populations are somewhat depressed in the urban and industrial lower reaches. Features that are important for fish habitat beyond the general case are described for each dam in Sections 3.4.3.2 through 3.4.3.8.

3.4.3.2 Tygart Lake and River

Tygart Lake is a 1740-acre storage reservoir behind Tygart Dam at RM 23.1. The reservoir and tailwater are significantly different fish habitats from the remainder of the upper Ohio

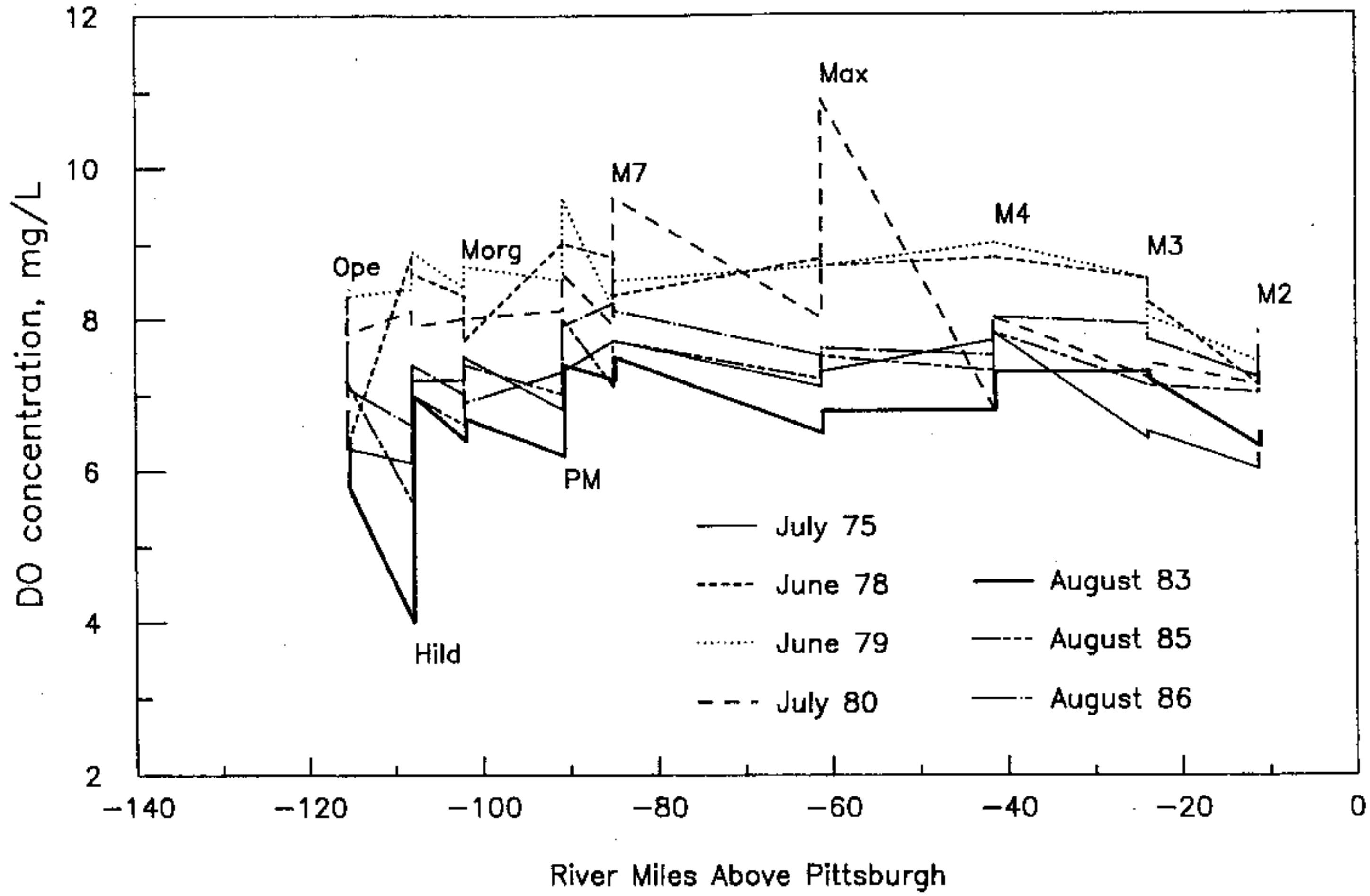

Figure 3.4.2-2. DO measurements above and below each dam (from Corps summer water quality surveys of the Monongahela River).

River Basin study area. This Corps project was built for flood control and low-flow augmentation. Flows from the project ensure a discharge of 340 cfs at Opekiska L&D on the Monongahela River. The project also provides downstream water quality control, a water supply for the City of Grafton, recreational developments on the lake and adjacent lands, and fish and wildlife management.

Tygart Lake is a mesotrophic (moderately productive) standing body of water with major seasonal drawdown in fall and winter amounting to up to 84 feet below the initial summer pool elevation of 1094 feet. Gravel and rubble banks and bottom used for fish spawning are abundant. The tailwater consists of a small stilling basin with discharge over a weir into the rapidly flowing, shallow lower reach of the river. This reach consists of a typical riffle-pool sequence of boulder and bedrock and occasional silt and sand down to the head of the Opekiska pool. The river is subsequently joined by the West Fork River above Fairmont.

Walleye, stocked in the lake from 1973 to 1976 and now a reproducing population, dominate the sport fisheries in both pool and tailwater (Jernejcic, 1982). Young walleye pass through the dam discharge outlets during winter pool drawdown (December-April), and this annual replenishment provides a major spring tailwater fishery (there is little walleye reproduction in the tailwater). Walleye from Tygart Dam populate much of the Monongahela River downstream. Smallmouth and largemouth bass (sufficient for organized bass tournaments) and sunfish are the other principal game fish species in the lake, while put-and-take stocked brown and rainbow trout are the only other important game species in the tailwater. Black and white crappie, yellow perch, brown and yellow bullhead, channel catfish, rock bass, and muskellunge represent minor game-fish components in the lake and tailwater. Nongame species include a varied assemblage of minnows, suckers, and darters (Jernejcic, 1982). The lake has had low numbers of forage fish, presumably kept low by walleye and bass predation (Jernejcic, 1982), but recently it has had an excellent population of emerald shiners (M. Koryak, Corps Pittsburgh District, personal communication to S. F. Railsback, March 21, 1988). The tailwater river has abundant macroinvertebrate fish food organisms, principally mayflies and caddisflies (Corps, 1982; appended to Jernejcic, 1982).

3.4.3.3 Opekiska Pool

The submerged mouths of seven small creeks provide the main diversity from a fairly uniform Monongahela River channel. As the uppermost navigation impoundment, the pool grades into unchannelized reaches of the Tygart Valley and West Fork Rivers, where a species assemblage more typical of flowing water prevails. The pool has a generally good fish community.

The Opekiska pool exhibits summer stratification, one of the few places in the upper Ohio River system where this occurs, in part because of the heated discharge from the Monongahela Power Co. Rivesville electricity generating station located 6 miles upstream of the Opekiska dam and the cool inflow of the Tygart River. This stratification reduces the volume of suitable fish habitat in the lower layer because of reduced DO concentration in the lower strata. Both hydrodynamically and biologically, the pool resembles a shallow stratified lake.

3.4.3.4 Hildebrand Pool; Morgantown Pool; Point Marion Pool

These pools form a largely unbroken channel. Samplings of the Hildebrand lock have revealed a moderately diverse assemblage of warmwater species, with channel catfish and bluegill the dominant gamefishes. Walleye and channel catfish dominate in the tailwaters. The stratification induced in the Opekiska pool continues in the Hildbrand pool because Opekiska dam discharges cooler bottom water that flows under the warmer surface water of Hildebrand pool. The Cheat River, which often carries acidic runoff, enters the Monongahela River at RM 89.5 in the Dam No. 7 pool (not proposed for hydroelectric development).

3.4.3.5 Maxwell Pool

A good warmwater fish community exists in this pool, including the game species walleye, largemouth and smallmouth basses, channel catfish, and muskellunge. A coal-fired power station of the West Penn Power Company significantly raises temperatures in the Maxwell pool, but the effect is mixed through the water column and no stratification results. The principal shallow-water habitat is in a few small tributaries, especially Ten Mile Creek near RM 65.5.

3.4.3.6 Monongahela L&D Nos. 2, 3, and 4

A few small tributaries offer the only diversity for L&D Nos. 3 and 4 pools. L&D No. 3 pool is urbanized and industrialized. Two power stations on Pool No. 3 heat water to levels in summer that exceed tolerance of all but the most heat-tolerant species. There is some stratification at the dam. The fish community is composed mostly of the hardier warmwater species and is less productive than upstream. The Monongahela L&D No. 2 pool is notable for the inflow of the Youghiogheny River. It is otherwise an urbanized and industrialized river reach. Its fish population is improving but is less productive than upstream.

3.4.4 Recreation

3.4.4.1 Recreation Use and Activities

With the dramatic improvements in water quality that have been occurring over the past 10 years in the Monongahela River, recreationists are taking advantage of substantial opportunities along the series of pools created by the river's nine L&D structures. In addition, the reduction in pollution by acid mine drainage in the Tygart River drainage basin has brought about the development of an important sport fishery resource in Tygart Lake and downstream in the Tygart River (WVDNR, 1982b). Tygart Lake, and the lands that comprise Tygart Lake State Park and Pleasant Creek Public Hunting and Fishing Area provide an abundant source of recreation opportunities in the region.

The distribution of recreational use along the Monongahela River is displayed in Table 3.4.4-1, which lists recent recreational use statistics at Corps-owned or -leased facilities. The number of recreational days of use are highest at Maxwell, Opekiska, and Tygart Lake, where there are developed recreation facilities. High visitation at these locations is attributed to the Ten Mile Creek Recreational Area adjacent to the Maxwell Pool, Pricketts Bay Recreational Area at the Opekiska Pool, and the dam picnic area, state park, and fishing and hunting area at Tygart Lake.

Table 3.4.4-1. Recreation days of use at U.S. Army Corps of Engineers water resource projects on the Monongahela River. 1/, 2/

	1984	1985	1986
Tygart	750,402	1,038,383	1,122,856
Opekiska L&D	128,900	119,600	122,100
Hildebrand L&D	14,700	16,900	7,900
Morgantown L&D	17,100	14,300	12,800
Point Marion L&D	5,500	6,300	5,800
Monongahela L&D No. 7	6,600	6,900	6,500
Maxwell L&D	89,100	98,800	108,500
Monongahela L&D No. 4	34,600	32,300	49,100
Monongahela L&D No. 3	53,900	59,700	76,300
Monongahela L&D No. 2	18,100	21,500	27,300

1/ Source: Corps. Natural Resource Management System, Pittsburgh District.

2/ One recreation day of use is equal to one person participating in one or more activities within a project for any length of time during a 24-hour period.

The primary recreation activities along the river are power boating and fishing (Table 3.4.4-2), with power boating being the most popular activity. The popularity of recreational

Table 3.4.4-2. Percentage of recreation days of use by activity at U.S. Army Corps of Engineers water resource projects on the Monongahela River. 1/, 2/

	Picnicking	Camping	Swimming	Water skiing	Boating	Sightseeing	Fishing
Tygart Lake	21	6	17	5	16	51	9
Opekiska	25	0	10	10	50	30	15
Hildebrand	0	0	10	10	75	4	15
Morgantown	2	0	10	15	50	15	15
Point Marion	2	0	10	15	60	3	15
Monongahela L&D No. 7	0	0	10	15	65	3	20
Maxwell	15	0	10	10	60	8	12
Monongahela L&D No. 4	2	0	10	15	65	3	15
Monongahela L&D No. 3	2	0	10	15	65	2	10
Monongahela L&D No. 2	0	0	10	15	70	1	10

1/ Source: Corps. Natural Resources Management System, Pittsburgh District.

2/ Percentages often exceed 100 percent since visitors generally participate in more than one activity.

Table 3.4.4-3. U.S. Army Corps of Engineers recreational lockage statistics during 1986 on the Monongahela River. 1/

	Recreational lockages	Recreational vessels
Opekiska L&D	367	466
Hildebrand L&D	224	279
Morgantown L&D	338	417
Point Marion L&D	161	195
Monongahela L&D No. 7	182	233
Maxwell L&D	1,395	2,578
Monongahela L&D No. 4	1,155	1,613
Monongahela L&D No. 3	1,130	1,742
Monongahela L&D No. 2	1,303	2,257
Total	6,255	9,780

1/ Source: Corps. Performance Monitoring System, Pittsburgh District.

boating is evidenced by the number of recreational boat lockages at each of the river's L&Ds (Table 3.4.4-3). Cumulatively, there is a large amount of water acreage on the river available for power boating (Table 3.4.4-4). Aside from the developed areas at Maxwell, Opekiska, and Tygart Lake, however, there is relatively little total land acreage set aside for recreation. Most of the facilities along the river accommodate boaters, as can be seen by the number of private marinas, boat docks, and launch ramps which line the river (Table 3.3.4-5). Approximately 70 launch ramps and docks are on the river. Nevertheless, the majority of the areas which are accessible to the public are not well maintained and do not provide easy access

Table 3.4.4-4. Land and water acreage and facility count at U.S. Army Corps of Engineers water resource projects on the Monongahela River. 1/

Project area	Average water acreage	Recreation total land acreage	Pool shoreline miles	Picnic sites	Camp sites	Launch lanes	Park lots
Tygart Lake 2/	1,700	4,262	31	100	68	4	8
Opekiska 3/	770	382	37	10	0	4	3
Hildebrand	480	60	15	0	0	0	1
Morgantown	400	117	12	0	0	0	1
Point Marion	810	94	22	0	0	0	1
Monongahela L&D No. 7	460	4	12	0	0	0	1
Maxwell 4/	1,741	140	48	45	0	4	3
Monongahela L&D No. 4	1,440	59	39	0	0	0	0
Monongahela L&D No. 3	1,435	16	35	0	0	0	1
Monongahela L&D No. 2	1,357	5	25	0	0	0	1

1/ Source: Corps. 1984. 1982 Recreation Statistics Volume II (EP 1130-2-401). ACOE Computer Data System, Washington D.C.

2/ Facilities listed for Tygart Lake include those at the dam picnic area, the state park, and Pleasant Creek.

3/ Facilities listed for Opekiska include those at Opekiska Lock and Prickett Bay.

4/ Facilities listed for Maxwell include those at Maxwell Lock, Ten Mile Creek, and Rices Landing.

Table 3.4.4-5. Recreational boating facilities by pool along the Monongahela River. 1/

Pool	Private launch ramps	Public launch ramps	Recreation docks	Berths
Opekiska	3	1	1	0
Hildebrand	2	0	0	15
Morgantown	1	1	0	22
Point Marion	1	2	2	44
Pool No. 7	0	1	0	0
Maxwell Pool	11	3	8	80
Pool No. 4	1	5	6	340
Pool No. 3	4	6	6	100
Pool No. 2	1	1	4	59
Emsworth Pool	0	2	1	0

1/ Source: Corps, 1987. Monongahela River Navigation Charts. Pittsburgh District.
ACOE, 1987 (revised). Ohio River and Tributaries - Small Boat Harbors, Ramps, Landings, etc., Ohio River Division.

(USFWS, 1985a). The PFC operates and maintains five access areas on the river, at McKeesport (RM 15.5), Monongahela (RM 33), Speers (RM 43.4), Rices Landing (RM 68.5), and Point Marion (RM 90.3). The WVDNR operates a public ramp at Uffington (RM 105) and at Pricketts Bay (RM 121).

Although fishing is not as popular as power boating, it does occur over more water area in the region when small streams and lakes are considered (Smith and Desvousges, 1986). The demand for both recreational boating and fishing in the region is indicated by the number of fishing licenses sold and the number of boats registered during 1986 in counties in the region (Table 3.4.4-6). Fishing license sales in Allegheny County are the highest in Pennsylvania, with 92,243 sold in 1986. Although much of the angling by residents of Allegheny County may

Table 3.4.4-6. Fishing license sales and boat registrations issued during 1986 in counties along the Monongahela River with proposed hydroelectric projects. 1/

State	County	1986 population	Fishing license		Boat registration	
			number	percent	number	percent
PA	Allegheny	1,373,600	92,243	6.7	26,147	1.9
PA	Fayette	155,800	29,282	18.8	2,693	1.7
PA	Greene	40,800	4,820	11.8	704	1.7
PA	Washington	212,500	19,266	9.1	4,867	2.3
PA	Westmoreland	381,100	38,179	10.0	8,294	2.2
WV	Barbour	16,500	1,364	8.3	312	1.9
WV	Marion	64,100	4,650	7.2	1,687	2.6
WV	Monongalia	77,700	6,038	7.8	1,688	2.2
WV	Taylor	16,300	2,097	12.9	543	3.3

1/ Source: Pennsylvania Fish Commission, Bureau of Boating and Fishing License Sales Division; West Virginia Department of Natural Resources, Hunting and Fishing License Sales Division; West Virginia Department of Motor Vehicles, 1986 Annual Report; U.S. Department of Commerce, 1987.

the county, the trend and potential for expansion is limited by only the quality of the river and the availability of recreational access to the river (personal communication, F.W. Johnson, Pennsylvania Fish Commission, October 1, 1987).

In 1981 the PFC estimated 150,000 angler days occurred along the Monongahela River from Pittsburgh to the West Virginia border near Point Marion L&D (Pennsylvania Fish Commission, 1980 Fishing and Boating Inventory). The number of angler days may have increased by 10 percent since then (personal communication, F. W. Johnson, PFC, October 1, 1987). The lower 25 miles of the river downstream of Monongahela L&D No. 4) receive the heaviest use, approximately 50 percent of the total. In general, shoreline fishing is the most popular at the tailwaters of the dams, stream mouths, and areas with easy access. Boat fishing tends to concentrate at the first few miles downstream of dams, in tailwaters, near launch areas, banks with underwater structures, and stream mouths (USFWS, 1985a). Projected use along the Monongahela River, assuming that limiting factors such as acid mine drainage and siltation could be overcome, is estimated at 420,000 angler days per year (Pennsylvania Fish Commision, n.d., 1980 Fishing and Boating Inventory). The PFC classified the river as a low- to medium-quality, warmwater fishery, signifying limited to moderate populations of one or more species of legal-sized game fish.

3.4.4.2. Wild and Scenic River Status

The 71-mile stretch of the Tygart Valley River from Fairmont to Belington is identified in the National Park Service's Nationwide Rivers Inventory as possessing significant recreational attributes for potential inclusion in the National Wild and Scenic Rivers System (NPS, 1982). This segment of the Tygart Valley River possesses a variety of flow gradients, including up to

Class IV rapids. Passing through a variety of environments, the river offers an extended recreation experience (NPS, 1982).

The Monongahela River from Point Marion to Pittsburgh (91 miles) is identified in the Pennsylvania Scenic Rivers Inventory as a third-priority waterway (primarily local significance), with a proposed classification of "modified recreational" (Pennsylvania Department of Environmental Resources, 1975). A modified recreational designation signifies that the river should remain conducive to recreational as well as utility uses.

3.4.5 Wetlands

Wetlands along the Monongahela River are confined to shoreline edges (riparian vegetation sites), because there are no major islands or embayments on the river. Only 10 acres are classified as embayment or islands in the 128-mile length along the Monongahela River (WVDNR, 1982a). The Corps, Pittsburgh District, conducted extensive vegetation surveys at 13 sites (Table 3.4.5-1) along the Monongahela River during the period 1979-87 (personal communication, R. Reilly, 1988). The results of these surveys were mapped on navigation charts

Table 3.4.5-1. Vegetation survey sites on the Monogahela River during 1979, 1983, and 1987.

Site	River mile	Location	Pool	Year visited
1	1.05	Left bank, Pittsburgh	Emsworth	1987
2	3.53	Left bank, Pittsburgh	Emsworth	1987
3	5.95	Right bank, Hazelwood	Emsworth	1987
4	7.26	Bank, Homestead	Emsworth	1987
5	40.65	Left bank, below L&D 4	L&D No. 2	1987
6	71.2	Left bank, Arensburg	Maxwell	1979
7	79.75	Right bank, Grey's Landing	Maxwell	1983
8	81.5	Right bank	Maxwell	1979
9	85.5	Right bank, upstream L&D 7	L&D No. 4	1983
10	86.8	Left bank, settling pond	L&D No. 4	1983
11	88.9	Right bank, downstream Cheat R.	L&D No. 4	1987
12	108.15	Right bank, upstr. Hildebrand L&D	Hildebrand	1987
13	120.1	Right bank, Catawba	Opekiska	1983

according to vegetation type. Large tracts of emergent hydrophytes are not generally found; however, there are several small areas that dominate about 8 percent of the shoreline. Submerged hydrophytes occur in scattered patches in the shallow waters and along the banks. Bands of deciduous trees, mostly willow (Salix sp.), sycamore (Platanus occidentalis L.), red maple (Acer rubrum L.), and silver maple (Acer saccharinum L.) occur along the banks in narrow strips. Rooted aquatic vegetation is rarely present in the river. When present, it is found in bands of water 15-50 feet offshore at depths of 3-6 feet and widths of 10-50 feet. Burreed (Sparganium sp.) is the most abundant aquatic macrophyte along the shoreline and has an important seasonal influence on the turbidity levels. Submerged burreed grows in relatively deep water in bands parallel to the river banks (Corps, 1976). Approximately 11 percent of the shoreline is lined with aquatic beds, most occurring in the Maxwell Pool.

The tailwaters of Maxwell L&D, Monongahela L&D Nos. 2, 3, and 4, and the Monongahela L&D No. 3 Pool weed beds have been classified as a resource category 2 (habitat is of high value for important fish and wildlife resources with high ecological significance or public interest and is scarce or is becoming scarce; see 46 FR 7657-58 by the USFWS for mitigation policy issues (Plewa and Putnam, 1985).

Silver maple, black willow, and sycamore are the dominant species in wooded areas, with the least diversity occurring near the Emsworth L&D and the greatest diversity occurring near the Opekiska and Hildebrand L&D. Approximately 53 miles are classified as floodplain forest community and approximately 24 miles are classified as oak-hickory forest. Disturbed areas along the banks of the Maxwell L&D, Monongahela L&D No. 2 pool near Elizabeth, Pennsylvania, Monongahela L&D No. 7 pool near Greensboro, Pennsylvania, and Opekiska L&D pools have more aquatic vascular species than the other sites. There are few aquatic vascular plants in the Emsworth L&D pool, with small areas of arrowhead (Sagittaria) present. No water willow [Justicia americana (L.) (Vahl)] is present in the Emsworth pool. Terrestrial and emergent forms of arrowhead and submerged macrophytes are very abundant in the Monongahela L&D No. 2pool near Elizabeth. Riparian vegetation at sites in the Monongahela L&D No. 4 pool near Charleroi, Maxwell L&D pool near Maxwell, and the Monongahela L&D No. 7 pool near Greensboro are similar in composition. The Maxwell and Greensboro sites have larger and thicker bands of emergent burreed (Sparganium sp.) and arrowhead (Sagittaria sp.) along the banks. Sites near the Point Marion and Morgantown L&D's show decreased diversity in water willow, submergents, and aquatic plants. The impacts of industrialization and urbanization are apparent with the decreased diversity in species and number of sites with vegetation present along the river.

3.4.5.1 Tygart Dam

Shorelines are dominated by wooded areas mixed with annual and perennial grasses.

3.4.5.2 Opekiska L&D

The downstream abutement side is a disturbed area interspersed with woods and Japanese knotweed understory. The upstream abutement side has a bed of aquatic vascular plants located about 300 feet from the dam.

3.4.5.3 Hildebrand L&D

The downstream shoreline on both sides of the river are classified as wooded floodplain and hardwood forests, with Japanese knotweed dominating the understory. The upstream shorelines are disturbed areas.

3.4.5.4 Point Marion L&D

The downstream shoreline on the abutement side is mostly wooded, with a wide 2000-foot-long littoral zone dominated by grasses. The upstream abutement side is classified as wooded floodplain.

3.4.5.5 Monongahela L&D No. 7

The abutement side shoreline located downstream is mostly wooded. The littoral zone is dominated by hydrophytes, grasses being the most abundant for a distance of about 3000 feet from the dam. The upstream shorelines are wooded areas.

3.4.5.6 Maxwell L&D

The downstream shoreline on the abutement side is dominated by grasses (predominantly Panicum sp.) intermixed with other hydrophytes and nonaquatic herbaceous species. The upstream shoreline is classified as wooded floodplain. It should be noted that 27 percent of the aquatic beds (the largest in the Corps Pittsburgh District) and 25 percent of the wooded wetlands in the Monongahela River occur here.

3.4.5.7 Monongahela L&D No. 4

Both sides of the downstream shoreline (about 4000 feet) are dominated by submerged aquatic plants (Sagittaria sp. and Sparganium sp.). The shoreline upstream is classified as a disturbed area. About 30 percent of the emergent wetlands and 28 percent of the wooded wetlands on the Monongahela River occur in the pool near Elizabeth, Pennsylvania.

3.4.6 River Navigation and Hydraulics

The 131 miles of navigation channel in the Monongahela and Tygart rivers are maintained by three fixed-crest and six gated dams. The installation of navigation dams and other constrictions to flow, such as bridges and docks, have increased the frequency and magnitude of floods over what they were naturally. For Corps navigation projects, real estate easements were purchased and/or other provisions made prior to construction to compensate for project-induced flood effects, where necessary. However, flooding has been reduced by the storage reservoirs the Corps has built in the Monongahela watershed. Expected flood elevations, adjusted to account for storage at the reservoirs, are shown in Figure 3.4.6-1.

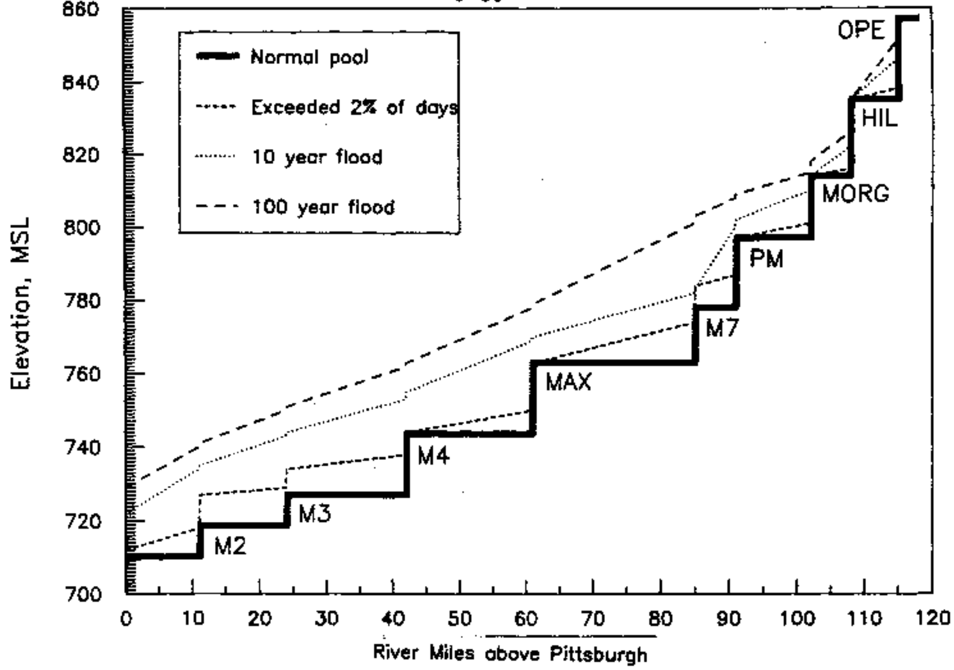

Figure 3.4.6-1. Expected flood elevations for the Monongahela River. Source: Corps, Pittsburgh District.

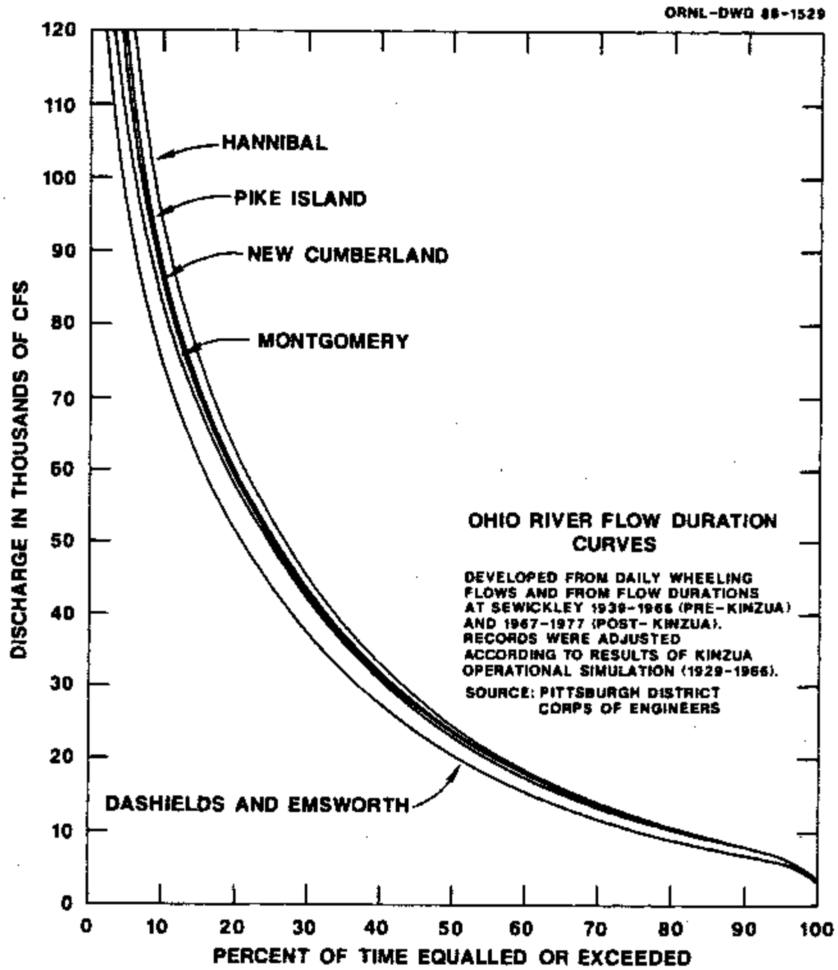

Figure 3.5.1-1. Ohio River annual flow duration curves.

Monongahela L&D 7 (RM 85) is scheduled for replacement in the near future by the Corps. The new dam, called Grays Landing L&D, will be 3 miles downstream from L&D 7. Grays Landing L&D will be another fixed-crest dam, with a crest length of 576 feet. There will be a single lock chamber. The same pool elevation currently maintained by L&D 7 (778 feet) will be maintained by Grays Landing (Corps, 1987b).

3.5 OHIO RIVER

3.5.1 Basin Description

The Ohio River is formed by the confluence of the Allegheny and Monongahela rivers at Pittsburgh, Pennsylvania, and flows 981 miles to its confluence with the Mississippi River at Cairo, Illinois. The entire Ohio River is navigable by barges, with depths maintained by 20 navigation dams. This EIS is concerned with approximately the first 300 RMs downstream of Pittsburgh. Flows in the Ohio are largely controlled by a number of reservoirs throughout the watershed. Major tributaries in the study reach are the Beaver (with a drainage area of 3,130 square miles), Muskingum (with a drainage area of 8,040 square miles), Hocking (with a drainage area of 1,190 square miles), Little Kanawha (with a drainage area of 2,320 square miles), and Kanawha (with a drainage area of 12,200 square miles) rivers (ORSANCO, 1986b). The median flow is approximately 20,000 cfs at Pittsburgh. Monthly mean flows at Pittsburgh are given in Table 3.3.1-1, and annual flow duration curves for the Ohio are provided in Figure 3.5.1-1.

There are two licensed hydropower plants at operating navigation dams in the study reach of the Ohio. These are at Racine dam (FERC No. 2570) and at Hannibal dam (FERC No. 3206).

3.5.2 Water Quality

Water quality in the upper Ohio River is heavily influenced by water quality in the Allegheny and Monongahela rivers and by wastewater discharges in the Pittsburgh vicinity. The largest discharger of BOD in the upper river is the Allegheny County Sanitary Authority's plant at RM 3.1. There are approximately 58 municipal dischargers and over 100 industrial dischargers between Pittsburgh and Gallipolis dam (ORSANCO, 1986b). There are also approximately 70 river terminals that handle petroleum and hazardous chemicals in this reach and about 10 major power plants that discharge once-through cooling water (ORSANCO, 1986b).

There is a large body of information and research on water quality in the upper Ohio River, starting with the classic DO surveys and modeling work of Streeter and Phelps (1925). DO concentrations were monitored daily until 1986 by ORSANCO at Ohio RMs 15.2 (since 1963), 40.2 (since 1961), and at 102.4, 260.0, and 279.2 (since 1975). Data from the ORSANCO monitors can be used to show historic ranges of DO concentrations at these locations. Figures 3.5.2-1 through 3.5.2-5 show the frequency distribution of water temperatures and DO concentrations during summer and fall months at the ORSANCO monitors.

Other sources of information on Ohio River water quality include other data collected by ORSANCO, data from the stations operated by the USGS in its National Stream Quality Accounting Network, and data collected by the states of Pennsylvania, Ohio, and West Virginia (ORSANCO, 1986b). The Pittsburgh District of the Corps has annually sampled summer water quality in the Ohio as far downstream as Hannibal dam since 1973 (Corps, 1976); DO measurements above and below each dam from seven of these surveys are shown in Figure 3.5.2-6. Huntington District of the Corps collects water quality data in the river below Hannibal. Toxic compounds in the Ohio River are discussed in Section 3.1.3.

All of the first five dams on the Ohio downstream of Pittsburgh (Emsworth, Dashields, Montgomery, New Cumberland, and Pike Island) are efficient aerators and, being located downstream of the largest waste discharges, are important for maintaining DO concentrations (Section 4.1.1). The dams at Hannibal and below to Gallipolis are all gated dams that discharge far below the surface of the downstream pool; such deeply submerged discharges provide little aeration, so these dams below Pike Island are less important to the Ohio River DO budget.

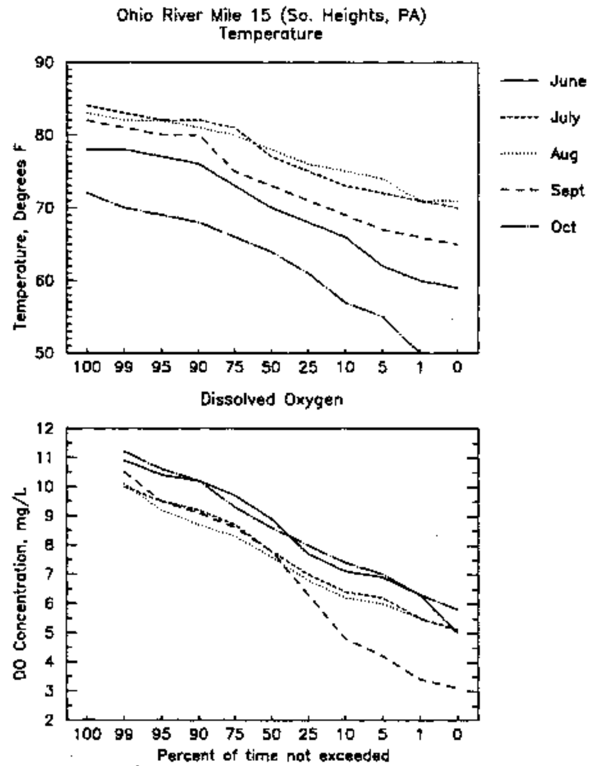

Figure 3.5.2-1. Summer temperature and DO frequency distributions (from ORSANCO monitor at Ohio RM 15.2, 1980-1986).

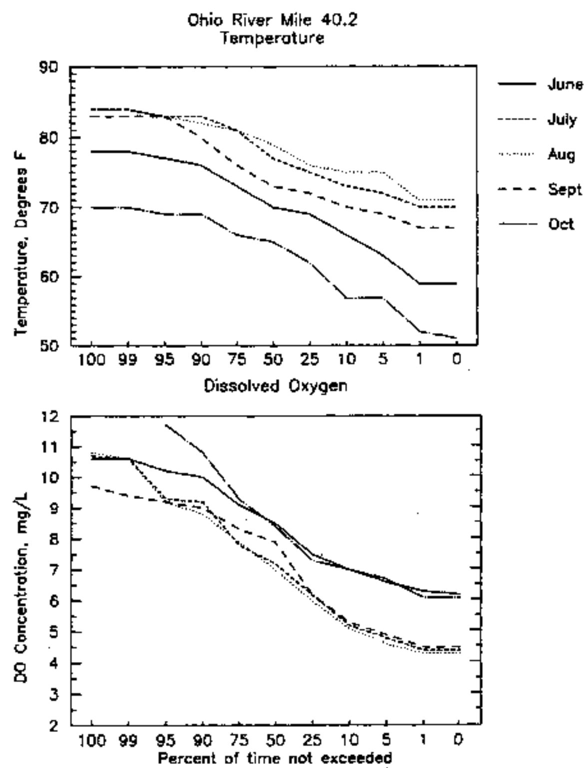

Figure 3.5.2-2. Summer temperature and DO frequency distributions (from ORSANCO monitor at Ohio RM 40.2, 1980-1986).

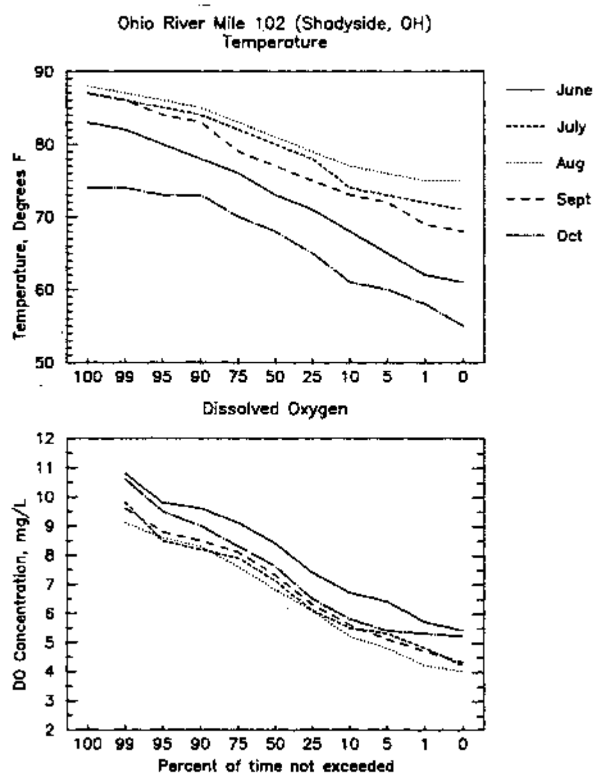

Figure 3.5.2-3. Summer temperature and DO frequency distributions (from ORSANCO monitor at Ohio RM 102, 1980-1986).

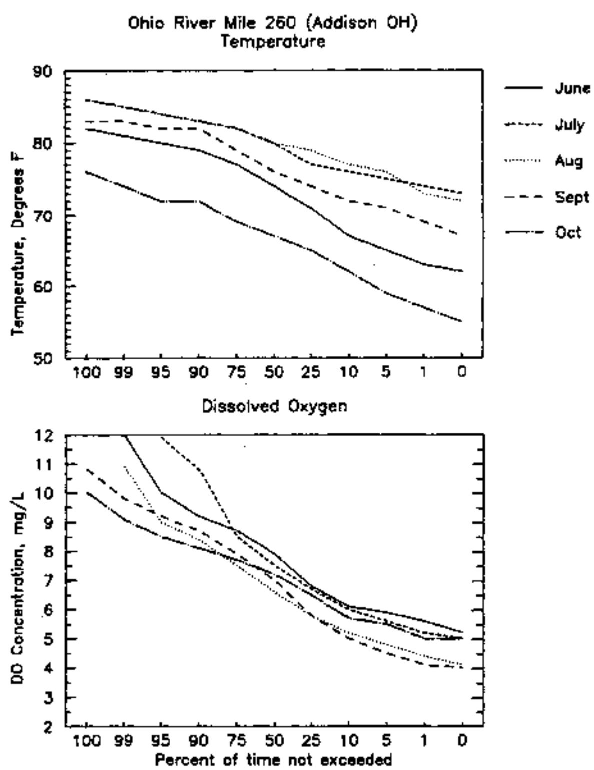

Figure 3.5.2-4. Summer temperature and DO frequency distributions (from ORSANCO monitor at Ohio RM 260, 1980-1986).

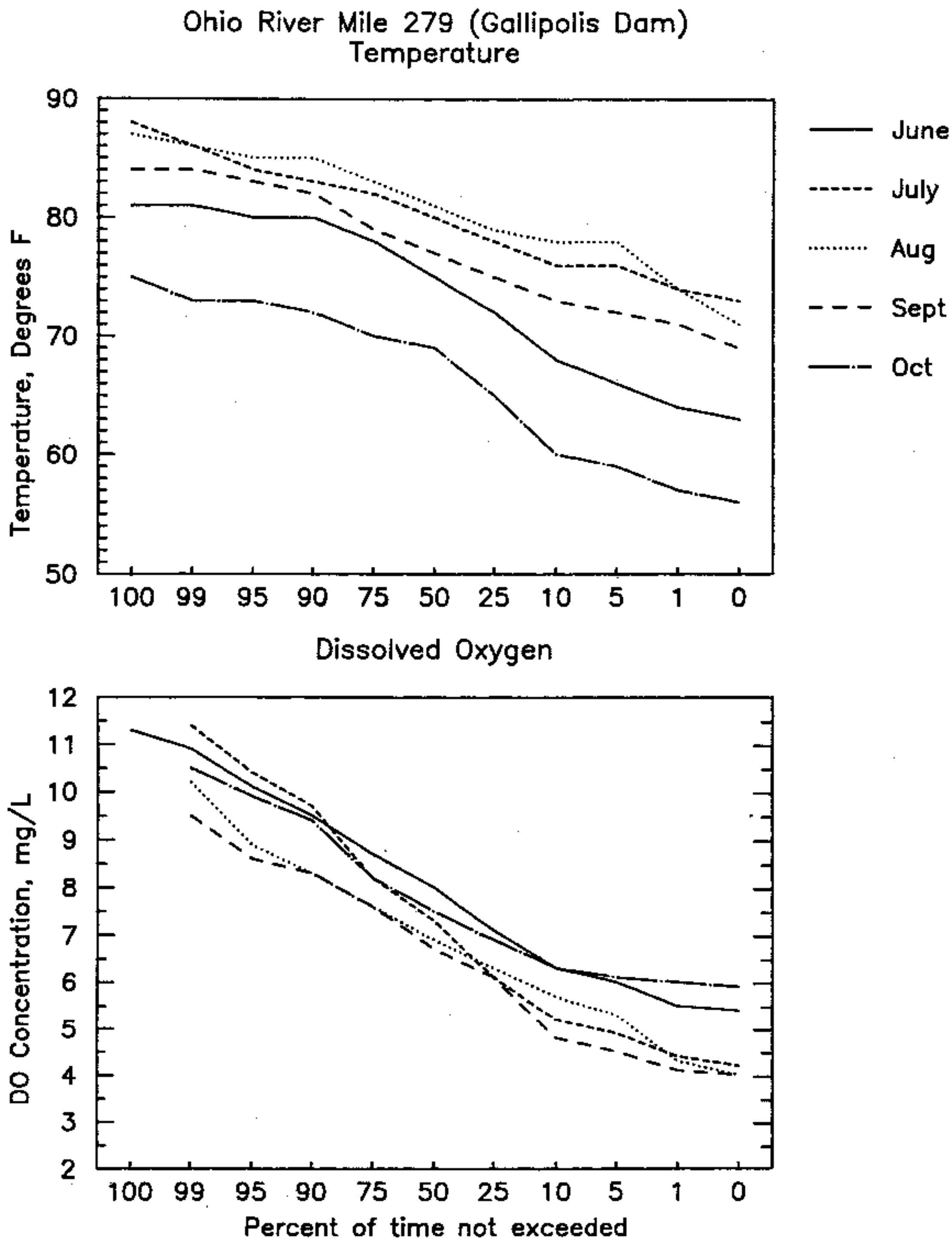

Figure 3.5.2-5. Summer temperature and DO frequency distributions (from ORSANCO monitor at Ohio RM 279, 1980-1986).

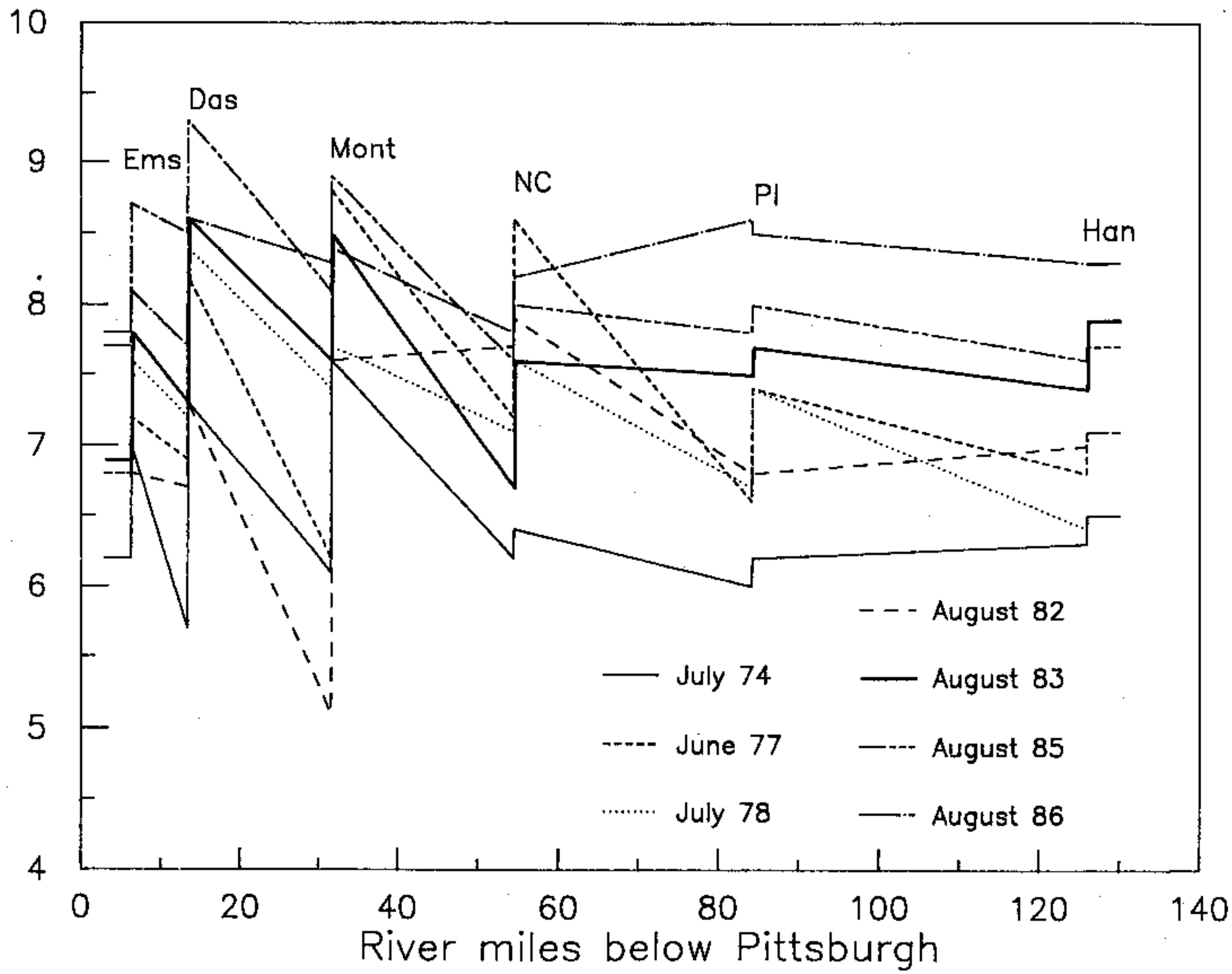

Figure 3.5.2-6. DO measurements above and below each dam (from Corps summer water quality surveys of the Ohio River).

3.5.3. Fisheries

3.5.3.1 General

There is a rapidly increasing fish community in the Ohio River, as shown by intensive sampling in recent years and continuing lock surveys (Pearson and Krumholz, 1984; USFWS, 1986). Lock studies from 1957 to 1970 in the upper 100 miles of the Ohio River showed that rough species, mostly carp and gizzard shad, were the dominant species, whereas there is currently a diverse fish community with new species being recorded at nearly each survey (Pearson and Krumholz 1984). Economic decline, more effective constraints on industrial dischargers, and stocking programs have contributed to major repopulation of former habitats. Angling pressure has increased but is restricted by limited access to the river. Much of the river is channelized, either naturally or dredged; however, there are several notable habitats important for fisheries resources, identified for each pool below. All dam tailwaters are included in the USFWS Resource Category 2 or higher [(i.e., having high value for evaluation species and is scarce or becoming scarce; (USFWS, 1986)]. Walleye and sauger predominate in tailwaters, especially in spring. Introductions by fisheries agencies include tiger muskellunge and walleye by the PFC and muskellunge, tiger muskellunge, striped bass, the hybrid between striped bass and white bass, and northern pike by the WVDNR (FPC and WVDNR, unpublished data supplied by the agencies). Other aquatic life is also improving; freshwater mussels that had been nearly extirpated are currently showing increased numbers (Tolin and Shettig 1983a,b; Zeto et al. 1987, Tolin et al. 1987).

3.5.3.2 Emsworth Pool

The Emsworth Pool, which includes 6.7 miles of the Allegheny River and 11.2 miles of the Monongahela River, is characterized by urbanization and industrialization, particularly numerous barge docks. Nevertheless, the Ohio and Monongahela river portions of this pool support a large population of channel catfish [47 percent of the total catch in a combined USFWS and PFC study in 1985 (USFWS, 1986)]. This species is returning faster than its competitors. Other game fish include, in order of the 1985 catch, smallmouth bass, rock bass, walleye, freshwater drum, and sauger. Rough fish include gizzard shad, carp, quillback, and shorthead redhorse. The bullhead minnow, last recorded in the Pittsburgh area before the 1900s, was collected in the Allegheny portion.

The Emsworth Dam is in two parts, separated by Neville Island (Figure 2.2-14). The Emsworth Pool contains the upper end of urban and industrial Neville Island with its smaller upstream companion, Davis Island, and industrial Brunot Island, which has a navigation channel on each side. Upstream of the Emsworth backchannel dam, which is constructed across the Neville Island backchannel, there are about 250 acres that are nonnavigable.

3.5.3.3 Dashields Pool

Carp, freshwater drum, and channel catfish dominate catches. Smallmouth bass, spotted bass, and walleye are reasonably abundant. Other species that indicate improving water quality in recent years include river redhorse, quillback, white catfish, and striped shiner.

A prominent shallow-water shoal in the main channel downstream of the Emsworth Dam is considered a habitat of special significance (Resource Category 1 as defined in USFWS mitigation policy; Federal Register Vol. 46, No. 15, Jan. 23, 1981) by the USFWS (USFWS, 1986). This shallow water habitat is used by prey species of fish (gizzard shad and various shiners) and shorebirds. Only the downstream end of the large, urban, and industrial Neville Island, to which the Emsworth dam is anchored, occurs in the Emsworth pool. The lower portion of Neville Island is less developed and provides suitable fish habitat. There are navigation channels on both sides of Neville Island (i.e., in the main channel and the backwater channel).

3.5.3.4 Montgomery Pool

Carp and channel catfish were the most common species collected in USFWS and PFC surveys. Other species added to the community in recent years include the smallmouth buffalo [not officially listed, but "endangered" according to the Pennsylvania Biological Survey (Cooper, 1985)], river redhorse, northern hogsucker, goldfish, white catfish, and silverjaw minnow.

The Montgomery Pool has the most ecologically significant area (USFWS Resource Category 1) in the Pennsylvania portion of the Ohio river in the form of an embayment just upstream of the dam (USFWS, 1985a). Its shallow water areas and wetlands provide excellent spawning and feeding areas and cover for many fish species. There are no islands. The Beaver River is a major tributary with shallow-water habitat.

3.5.3.5 New Cumberland Pool

Species assemblages are similar to other pools. Recent additions to the community include silver redhorse, river chub, and stoneroller (USFWS, 1986).

There are four islands in this pool. Aquatic backwater areas range from about 15 to about 70 acres each, totaling about 180 acres. The perimeters of Georgetown and Phyllis islands are important fish habitats, having been classified as Resource Category 1 by the USFWS (USFWS, 1986). At these islands, especially the backchannels, there is both underwater and overhanging cover in abundance. The Little Beaver River enters downstream of Georgetown Island, and it provides shallow-water fish habitat. Other significant tributaries with fish habitat in their mouths include Yellow Creek and Little Yellow Creek.

3.5.3.6 Pike Island Pool

There is an island complex in the Pike Island Pool, consisting of Browns Island and the two-island Griffin Island near RMs 61 to 64. Approximately 250 acres of backwater lie around this complex. Several small tributaries provide shallow fish habitat at their mouths, the most prominent being Indian Short Creek about 2 miles upstream of the dam, which has an extensive "estuary" broken up by rail and highway causeways as it enters the Ohio River.

3.5.3.7 Hannibal Pool

The Hannibal Pool has six islands. The largest island is urban and industrialized and is within the city of Wheeling. Aquatic backwater areas of three of the remainding island are each about 50 acres; one is a tiny channel, and one is in the Pike Island tailwater without a clear backchannel. There is a total of about 365 acres of aquatic backwater.

3.5.3.8 Willow Island Pool

Willow Island Pool has the most islands (11) of any pool in the study area. Aquatic backwater areas range from 10 to 100 acres, totaling about 250 acres. Several creeks have flooded mouths that provide considerable shallow-water fish habitat, including Bells Run, Newell Run, French Run, Danas Run, Middle Island Creek, and Leiths Run.

3.5.3.9 Belleville Pool

Seven islands occur in the Belleville Pool, ranging in aquatic backwater areas from 7 to 285 acres, with a total of about 750. The Little Muskingum, the Little Kanawha, Little Hocking, and Hocking rivers are tributaries to this pool. There are also drowned mouths of several smaller creeks, most prominently Little Sand Creek, that provide shallow-water fish habitat. The pool contains abundant freshwater mussels. The USFWS has indicated that the federally listed endangered species Lampsilis abrupta may be present (letter to J. Kearny from C. J. Kulp, September 28, 1987).

3.5.3.10 Racine Pool

Racine Pool has two islands, each having backwater areas of about 30 acres. The mouths of nine tributaries appear to provide important shallow-water fish habitat. The USFWS suspects that the upper pool in the tailwater of Belleville L&D contains the federally listed endangered freshwater mussel, Lampsilis abrupta (letter to J. Kearny from C. J. Kulp, September 28, 1987).

3.5.3.11 Gallipolis Pool

Backwater areas of about 7 acres each are associated with two islands in the Gallipolis Pool. Six small tributaries and the Kanawha River enter the Ohio in the Gallipolis Pool, with significant shallow-water fish habitat at their mouths.

3.5.3.12 Greenup Pool

Downstream of Gallipolis L&D, the Greenup Pool contains a confirmed location of the federally listed endangered freshwater mussel, Lampsilis abrupta (letter to J. Kearny from C. J. Kulp, September 28, 1987).

3.5.4 Recreation

The Ohio River is an important recreation resource for all of the states in the study area. The pools created by the river's L&D structures range from 1,100 to 12,600 water acres and provide an abundant source of recreational opportunities (Table 3.5.4-1). In addition, there are over 12,000 land-acres owned or leased by the Corps for recreation in the study area. As shown in Table 3.5.4-1, the extent of land acreage set aside for recreation is more pronounced in the lower pools of the study area. The Belleville Pool receives the heaviest recreation use, as indicated by the number of recreational days of use at Corps projects in recent years (Table 3.5.4-2). Overall, the Corps' water resource projects on the Ohio River receive roughly 1.5 million recreational days of use. Although the primary recreation activity along the river is power boating, the river has a broad range of recreation uses, as displayed in Table 3.5.4-3.

Recreation use surveys indicate that both boating and fishing are very popular along the Ohio River (WVDNR, 1983; ODNR, 1986). In spite of the popularity of boating and fishing along the Ohio River, the supply of boating and fishing access facilities is inadequate (Appendix D). Boating access facilities are particularly deficient in areas with a larger population base. Many existing boat access facilities have inadequate parking and serious maintenance problems, such as excessive siltation, or are privately owned. Improved fishing access is needed at the tailwaters of the locks and dams where fishing pressure (per unit area) is the most intense (WVDNR, 1983). In addition, there is a shortage of shoreline and boating access at tributary embayments, which receive a much higher fishing pressure and more successful catch rates (per unit area) than the navigation pools (WVDNR, 1983). A summary of recent recreation use surveys for each pool is given in Sections 3.5.4.1 through 3.5.4.8 (WVDNR, 1983; ODNR, 1986).

3.5.4.1 New Cumberland Pool

The New Cumberland Pool has a higher rate of fish caught and kept per water acre than any other pool surveyed in the WVDNR recreation use survey (Figure 3.5.4-1). The most popular shoreline fishing areas on the Ohio shore include Little Yellow Creek (RM 47), Jethro Run (RM 45), East Liverpool (RM 42 and 44), and Yellow Creek (RM 50). The most favored site for shoreline fishing in West Virginia is at Chester (RM 43). The mouth of Tomlinson Run is the next most popular area for West Virginia shore anglers.

The two largest Ohio communities in this pool are East Liverpool and Wellsville. There is a need to improve existing access facilities in these communities (ODNR, 1986). The WVDNR recommends upgrading the Chester public access and constructing a public access near Wellsville, Ohio (WVDNR, 1983).

3.5.4.2 Pike Island Pool

Unlike other pools characterized by large distances between communities, many communities border this pool. Nevertheless, there is only one usable public launch facility along the Ohio shoreline. Although launch facilities exist on the West Virginia shoreline, there is a shortage of bridge crossings for Ohio residents in the area. ODNR recommends additional launch facilities at the Old Rt. 7 site and in the Steubenville area. In addition, improved access to the tailwater of the New Cumberland Locks and Dam (RM 54) and at Old L&D No. 9 are needed. The WVDNR recommends upgrading the public access at Costonia (RM 62) and at Buffalo Creek (RM 75).

The most popular fishing area in the Pike Island Pool is the New Cumberland Dam tailwaters along the West Virginia shoreline. Other areas along the West Virginia shore of the pool that are popular for shore angling include Kings Creek (RM 60), Skull Run (RM 74), Hardin Run area (RM 56), New Cumberland (RM 57), and Old Lock No. 10 (RM 66). The most important areas for shoreline fishing along the Ohio shore are at Jeremy Run (RM 56) and Steubenville (RMs 66,67).

Fishing boat use is less than other watercraft use, such as pleasure boating. Boat anglers use the area between Browns Island and Island Creek (RM 61) as well as the Jeremy Run area (RM 56) the most frequently.

Table 3.5.4-1. Land and water acreage and facility count at U.S. Army Corps of Engineers water resource projects on the Ohio River. 1/

Project area	Average water acreage	Recreation total land acreage	Pool shoreline miles	Picnic sites	Camp sites	Launch lanes	Park lots
Emsworth	3,420	5	48	0	0	0	1
Dashields	1,100	3	14	0	0	0	1
Montgomery	2,718	0	37	0	0	0	1
New Cumb. 2/	3,420	426	45	24	0	4	4
Pike Island 3/	4,940	761	60	40	0	13	5
Hannibal 4/	5,615	2,126	84	50	0	6	3
Willow Island 5/	6,424	1,653	70	42	0	8	5
Belleville 6/	8,900	3,892	84	69	0	12	7
Racine 7/	5,300	2,101	67	46	0	4	8
Gallipolis 8/	12,600	1,936	145	121	0	8	7

1/ Source: Corps, 1984. 1982 Recreation Statistics Volume II (Engineering Pamphlet 1130-2-401).

2/ Facilities listed for New Cumberland include those at the New Cumberland Lock and Kennedy Park.

3/ Facilities listed for Pike Island include those at Pike Island Lock, Buffalo Creek, Indian Short Creek, Island Creek, and Old Lock 10.

4/ Facilities listed for Hannibal include the Hannibal Day Use area, Powhatan Point, the Wheeling Island.

5/ Facilities listed for Willow Island include the Willow Island Lock and Abutment, St. Marys, and New Martinsville.

6/ Facilities listed for Belleville include the Belleville Lock and Abutment, Coolville, Point Park, Parkersburg, and Williamstown.

7/ Facilities listed for Racine include the Racine Lock and Abutment and Ravenswood.

8/ Facilities listed for Gallipolis include the Gallipolis Lock and Abutment, Point Pleasant, Middleport, and Mason City.

Corps Computer Data System, Washington D.C.

Table 3.5.4-2. Recreational days of use at U.S. Army Corps of Engineers water resource projects on the Ohio River. 1/, 2/

	1984	1985	1986
Emsworth	128,300	166,500	Missing
Dashields	59,000	79,100	95,600
Montgomery	66,100	83,500	42,100
New Cumberland	76,300	102,700	84,200
Pike Island	67,400	70,100	74,500
Hannibal	65,100	77,600	73,500
Willow Island	170,600	174,000	84,900
Belleville	425,400	461,700	589,100
Racine	166,200	164,900	77,500
Gallipolis	353,100	362,400	165,900

1/ Source: Corps. Natural Resource Management System, Pittsburgh District.

2/ One recreation day of use is equal to one person participating in one or more activities within a project for any length of time during a 24-hour period.

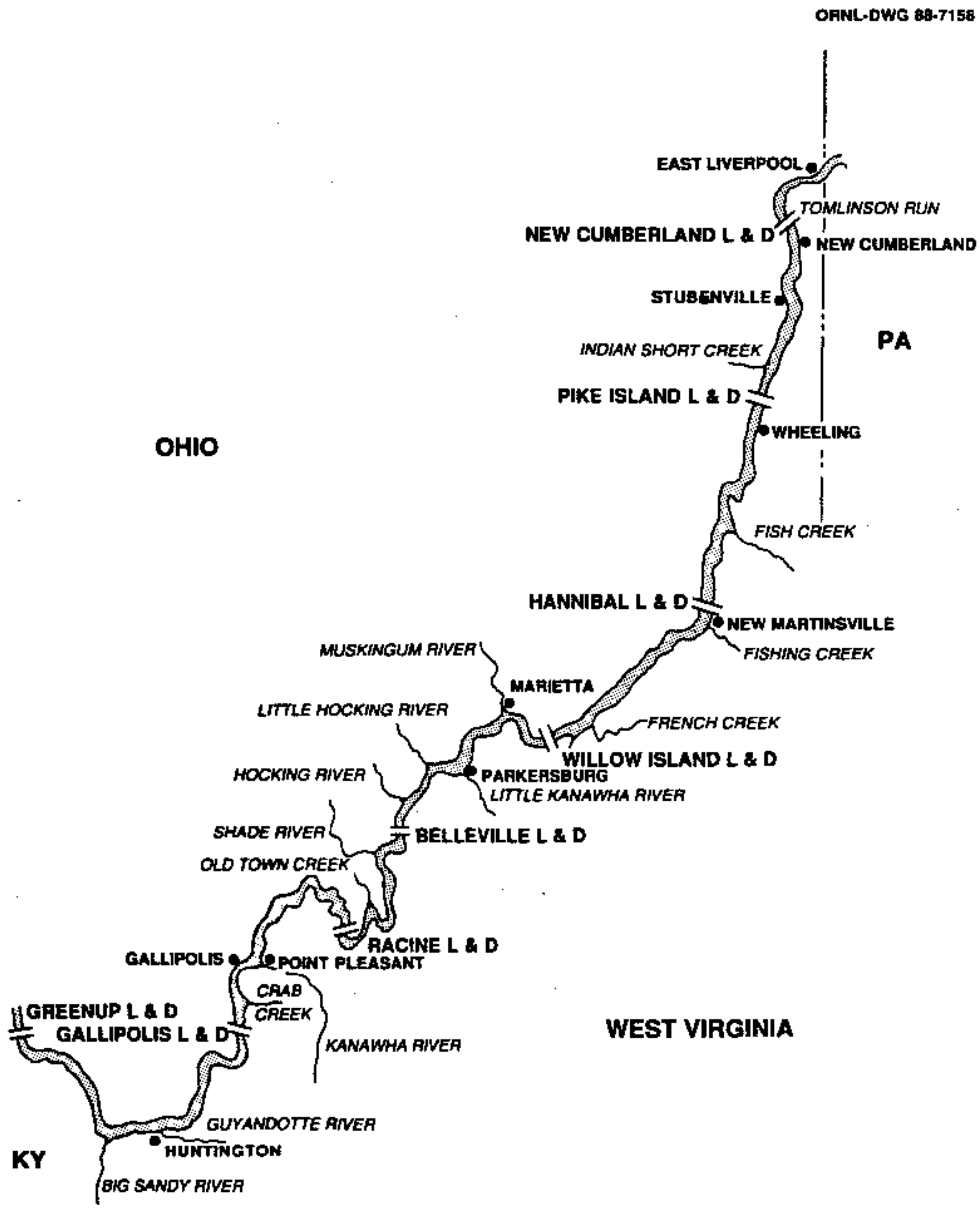

Figure 3.5.4-1 Study area of the West Virginia Department of Natural Resources recreational use survey of the Ohio River (WVDNR 1983)

Table 3.5.4-3. Percentage of recreation days of use by activity at U.S. Army Corps of Engineers water resource projects on the Ohio River. 1/

	Picnick-ing	Camp-ing	Swimming	Water skiing	Boat-ing	Sight seeing	Fishing
Emsworth	0	0	10	10	40	40	10
Dashields	0	0	10	15	65	5	10
Montgomery	2	0	10	10	65	2	15
New Cumber-land	5	0	10	10	50	40	10
Pike Island	10	0	10	10	40	30	15
Hannibal	10	0	10	10	65	15	0
Willow Is-land	20	0	5	15	20	40	20
Belleville	30	0	10	20	30	40	20
Racine	20	0	5	15	20	50	10
Gallipolis	25	0	5	15	20	50	20

1/ Source: Corps. Natural Resources Management System, Pittsburgh District.

2/ Percentages often exceed 100 percent because visitors generally participate in more than one activity.

The boat fishing pressure in the New Cumberland Pool is much lower than the shoreline fishing pressure (Table 3.5.4-4). Boat fishing is the most common at the mouth of Tomlinson Run. Other popular areas for boat fishing include RM 49 near Wellsville, RM 45 near Newell, West Virginia, and RM 51 below Yellow Creek.

Table 3.5.4-4. Total fishing pressure (boat vs shore) per navigation pool surveyed by the West Virginia Department of Natural Resources. 1/

Navigation Pool	Boat user hours	Shore user hours	Total use hours
New Cumberland	11,000	33,000	44,000
Pike Island	13,500	72,000	85,500
Hannibal	26,000	73,500	99,500
Willow Island	17,000	32,000	49,000
Belleville	22,000	75,000	97,000
Racine	15,000	29,000	44,000
Gallipolis	16,000	48,000	64,000
Total	120,500	362,500	483,000

1/ Sources: Ohio Department Natural Resources, 1986; West Virginia Department of Natural Resources, 1983.

3.5.4.3 Hannibal Pool

The Pike Island tailwater area (RM 84) receives the most fishing pressure (number of hours fished) of those surveyed by the WVDNR (WVDNR, 1983). Other areas along the Ohio shore used by anglers are McMahon Creek at Bellaire (RM 95), Patton (RM 85) and Wegee Creek (RM 99). Popular areas for West Virginia shore anglers include Big Grave Creek (RM 103), Wheeling (RM 90), and Warwood (RM 85).

Boat anglers concentrate at Wheeling Island (RM 90), Clarington Station, West Virginia (RM 118), and Proctor, West Virginia (RM 122). The Wheeling Island Boat Launch is operated by the Corps and serves as a popular facility for both West Virginia and Ohio residents. The importance of the facility to Ohio residents is attributed to the fact that there are no Ohio launching facilities for 16 miles along this reach of the river.

Except for the upper third of the pool, there is sufficient recreational access. Improved access in the upper pool area is recommended by the ODNR at Martin's Ferry/Bellaire area, the Clarington Public Launch, Shadyside Public Launch, and the Pike Island Dam Fishing Pier. The WVDNR also recommends upgrading the public access at Shadyside as well as along the West Virginia shore at Moundsville (RM 101) and Fish Creek (RM 114).

3.5.4.4 Willow Island Pool

The tailwater of the Hannibal L&D (RM 126) is the most popular fishing area in the Willow Island Pool, with the highest fishing pressure on the West Virginia side of the river. The tailwater had a higher catch and harvest of largemouth bass and white bass than any other tailwater in creel censuses conducted as part of the WVDNR recreational use survey. Other important areas for shore anglers along the West Virginia shoreline include Paden City (RM 133), Raven Rock (RM 150), and Sistersville (RM 138). Fishing pressure along the Ohio shoreline is greatest at the New Martinsville Highway Bridge (RM 127), Old Lock No. 15 (RM 129), and Leiths Run (RM 150). Popular areas for boat fishing are St. Marys, West Virginia (RM 155), between French Creek and Newell Run (RM 158), and Grandview Island (RM 143).

Relatively small population centers are found along the Willow Island pool. The existing access facilities are thought to be sufficient to serve the recreation needs in the area. Improvements are recommended by the Ohio River Access Study (ODNR, 1986) at Old L&D No. 15, Leith's Run Launch Ramp, and the Danas Run area. The recreational fishing enhancements currently under construction at the licensed Hannibal hydropower project should satisfy the need for access identified in the Ohio River Access Study (ODNR, 1986) at this location.

3.5.4.5 Belleville Pool

The Belleville Pool is the most important pool to recreationists on the Ohio River. The pool has the greatest harvest rates per angler hour; WVDNR creel censuses revealed the highest catches of freshwater drum and flathead catfish in this pool as well as the highest channel catfish harvest of any pool (WVDNR, 1983). In addition, the tailwaters of the Willow Island L&D (RM 162) receive the most angler trips, angler trips per acre, and hours of use per acre of the six tailwaters surveyed (WVDNR, 1983). Thirty car parking spaces are provided at the Willow Island L&D to accommodate anglers who fish in the tailwaters.

Fishing pressure along the Ohio shore also occurs at Davis Run (RM 189) and Old Lock No. 18 (RM 180). Shore fishing in West Virginia is popular in the Parkersburg area (RMs 184-185) and Old Lock No. 19 (RM 192).

Boat anglers frequent the Old Lock No. 19 access and the area between Indian Run and Hocking River (RM 200). The Belleville pool is the most important pool for pleasure boaters. Blennerhassett Island (RMs 186-189) receives much of the pleasure boating pressure.

There are only three public access facilities in this pool on the Ohio shoreline and some of the communities, notably Belpre, have no public access. The Ohio River Access Study (ODNR, 1986) recommends a new access facility at Belpre and Hockingport. The study also recommends improved fishing access at Old L&D No.18, the Willow Island Dam tailwaters, and the Devola Locks and Dam on the Muskingum River.

3.5.4.6 Racine Pool

The WVDNR recreation use survey indicates that the Racine pool receives the least amount of fishing activity of all the pools surveyed. Most of the shoreline fishing pressure along the West Virginia shoreline is at Sandy Creek (RM 221) and near Turkey Run (RM 219). The Shade River (RM 211) and Old Lock No. 21 (RM 215) are important areas for shore angling on the Ohio side.

Boat angling is most popular at the Sandy Creek area (RM 221) and a 5-mile section from RMs 219 to 223 near Ravenswood, West Virginia.

There is a relatively low population along the Racine pool and very little recreational access. Construction of new small-scale fishing and boating access sites is recommended by the Ohio River Access Study (ODNR, 1986) at Old L&D No. 21, Shade River, and Old Town Creek. The WVDNR also recommends constructing public access along RMs 210-214 on the Ohio shore.

3.5.4.7 Gallipolis Pool

Construction of a licensed hydropower project and fishing pier at the Racine tailwaters was under way at the time of the WVDNR recreation use survey. Currently, the fishing pier is considered the most heavily used shoreline fishing area in the Gallipolis Pool (ODNR, 1986). Recreational facilities at the Racine hydropower project include a 1,200-foot shoreline fishing pier with various levels, a 64-space car parking lot, restrooms, and a picnic area. The Ohio River Access Study (ODNR, 1986) identifies the recreational area as an "excellent facility and an excellent example of the potential of dam tailwater areas."

Other locations for shore fishing along the Ohio include Chickamauga Creek (RM 270) and the Middleport area (RM 252). The Crooked Creek diversion channel (RM 264) and the Pomeroy-Mason Highway bridge (RM 251) are popular locations along the West Virginia shore for fishing.

Boat anglers use the Kyger Creek area (RM 261), the Crab Creek-Raccoon Creek area (RM 276), and Eight Mile Island (RM 258).

The Ohio River Access Study (ODNR, 1986) recommends new access facilities at Rousch Landing and the Leading Creek area. Additional parking is recommended for the Pomeroy Public Launch. In addition, secondary (Phase II) development of fishing areas and boating access at Dunham Run Embayment, Raccoon Creek, and Teen's Run Embayment is recommended. The WVDNR recommends constructing public access along the Ohio shore RMs 274-277 (Crab Creek-Racoon Creek area).

3.5.4.8 Emsworth, Dashields, and Montgomery Pools

The three pools in the study area not discussed in the above summary are Emsworth, Dashields and Montgomery. As shown in Table 3.5.4-1, there is a small amount of land acreage for recreation along these pools relative to the remainder of the pools in the study area. On the other hand, recreational boating is extremely high in the Emsworth and Dashields pools relative to other pools. Table 3.5.4-5 lists the number of recreational boat lockages at each of the L&D structures in the study area. The number of recreational boats locked at Emsworth and Dashields locks and dams account for over 40 percent of the total number of boats passing through the locks along the river.

The relatively large population base in Allegheny and Beaver counties account for the large number of registered watercraft and licensed anglers in these areas relative to other counties in the study area (Table 3.5.4-6). Allegheny County has the highest boat registration and fishing license sales in the state of Pennsylvania. As the water quality of the river continues to improve, the potential for increased recreational usage could be significant. The PFC's 1980 fishing and boating inventory of the Ohio River estimated 41,000 angler days per year in the Emsworth, Dashields, and Montgomery pools. This estimate may have increased by 10 percent since the time of the inventory (personal communication, F. W. Johnson, PFC, letter to ORNL, October 1, 1987). The potential for future use (assuming limiting factors, such as siltation, habitat quality, and access limitations, could be overcome) was projected to be 20 percent higher than the 1980 use estimate. Allegheny County has more limiting factors than Beaver County that hinder the development of an increased fishery along this reach of the river. Additional limiting factors in the Ohio River in Allegheny County include acid mine drainage, pollution, unsuitable water temperature, and uncontrolled power boating.

The PFC classified Allegheny County (Emsworth and Dashields Pools) as a low-quality, warm-water fishery with limited to moderate populations of one or more species of legal-sized game fish. Beaver County (Montgomery Pool) was classified as a medium-quality, warmwater fishery with a moderate to substantial population of one or more species of legal-sized game fish (Pennsylvania Fish Commission, n.d., 1980 Fishing and boating inventory).

Table 3.5.4-5. Corps recreational lockage statistics during 1986 on the Ohio River. 1/

	Recreational lockages	Recreational vessels
Emsworth L&D	1,773	3,528
Dashields L&D	1,427	2,257
Montgomery L&D	450	939
New Cumberland L&D	846	1,501
Pike Island L&D	775	1,222
Hannibal L&D	388	582
Willow Island L&D	682	1,484
Belleville L&D	751	1,118
Racine L&D	413	573
Gallipolis L&D	204	325
Total	7,709	13,529

1/ Source: Corps. Performance Monitoring System, Pittsburgh District.

Table 3.5.4-6. Fishing license sales and watercraft registration during 1986 in counties along the Ohio River with proposed hydroelectric projects. 1/

Project	County	State	1986 population	1986 registered watercraft No.	1986 registered watercraft Percent	1986 licensed anglers No.	1986 licensed anglers Percent
Emsworth	Allegheny	PA	1,373,600	26,147	1.9	92,243	6.7
Dashields	Allegheny	PA	1,373,600	26,147	1.9	92,243	6.7
Montgomery	Beaver	PA	193,200	5,286	2.7	17,269	8.9
New Cumber-	Hancock	WV	39,600	896	2.3	2,558	6.5
land	Jefferson	OH	85,700	2,805	3.3	8,912	10.3
Pike Island	Ohio	WV	58,000	923	1.6	2,967	5.1
	Belmont	OH	78,200	3,251	4.2	12,067	15.4
Willow Island	Pleasants	WV	8,100	339	4.2	1,148	14.2
	Washington	OH	64,200	3,114	4.8	11,341	17.7
Belleville	Wood	WV	92,000	3,511	3.8	8,731	9.5
	Meigs	OH	23,900	862	3.6	3,373	14.1
Gallipolis	Mason	WV	25,900	911	3.5	2,796	10.8
	Gallia	OH	29,800	1,040	3.5	3,544	11.9

1/ Sources: Pennsylvania Fish Commission, Bureau of Boating and Fishing License Sales Division; West Virginia Department of Motor Vehicles, 1986; U.S. Department of Commerce, 1987.

3.5.4.9 Wild and Scenic River Status

There are no designated river segments along the Ohio River study area that are existing components of the National Wild and Scenic Rivers System or of the states' scenic rivers programs.

Little Beaver Creek in Columbiana County, Ohio is a National Wild and Scenic River as well as a component of Ohio's Scenic Rivers System (ODNR, 1980-85 SCORP). The Little Beaver River flows into the New Cumberland Pool of the Ohio River at the juncture of the Ohio, West Virginia, and Pennsylvania state lines. Also in the New Cumberland Pool is an 18-mile segment of the Ohio River (from the Ohio-Pennsylvania state line to Wellsville) that was identified in the Nationwide Rivers Inventory as possessing significant scenic, recreational, and historic values to merit consideration for potential inclusion in the National Wild and Scenic Rivers System (NPS, 1982).

The Pennsylvania Scenic Rivers System identifies the Ohio River from Pittsburgh to the Ohio-West Virginia border as a third-priority waterway (primarily local significance), with a proposed classification of "modified recreational." Such a classification signifies that the river should remain conducive to recreational as well as utility uses. Raccoon Creek, from Burgetts Fork to the Ohio River, is also identified as a third-priority waterway with a potential "recreational" designation (Pennsylvania Department of Environmental Resources, 1975).

3.5.5 Wetlands

Wetlands on the Ohio River are of two major types - palustrine and riverine. These wetlands are present in narrow bands around the perimeter of islands, in submerged beds around the islands, in pockets of accreting land, and within interior landform depressions, sloughs, overflow channels, and abandoned riverbed.

There are a total of 28 islands in the Ohio River within the study area. Eighteen of these islands have wetland areas associated with them (Table 3.5.5-1). Tolin and Schettig (1983a,b) mapped and characterized the islands in the Belleville Pool to the Meldahl Pool. Plewa and Putnam (1986) surveyed the five islands in the upper Ohio River upstream of the New Cumberland L&D. There are 43 slackwater embayments over 500 feet in length in the study area that have been created by the Corps' Navigation Modernization Program since 1959. In addition to the wetlands associated with islands and embayments, the riparian vegatation along the shoreline is also an important resource.

3.5.5.1 Greenup L&D Pool

There is one island (Lesage) which contains approximately 18 acres of wetland area.

3.5.5.2 Gallipolis L&D Pool

Two islands are in this pool with no wetlands.

3.5.5.3 Racine L&D Pool

There are two islands in this pool, with a total of about 1.5 acres classified as wetlands.

3.5.5.4 Belleville L&D Pool

There are seven islands in this pool. The largest wetland area (10.5 acres) is on Blennerhassett Island. There are approximately 16 acres of wetland on the islands in this pool. Thirteen small marsh and swamp areas have also been identified in the general project vicinity. In the immediate project vicinity, there is a 10-acre slough adjacent to the Belleville L&D. This slough is a resting, feeding, and breeding area for fish and waterfowl.

3.5.5.5 Willow Island L&D Pool

There are eleven islands in this pool. The largest wetland area (approximately 3 acres) is on Grape Island. Tolin and Schettig (1983) estimated a total of 6 acres of wetland in this pool.

Table 3.5.5-1. Wetland area estimates for islands on the upper Ohio River. 1/

	Wetland Types									
	POW	PEM	PSS	PFO	REM	POW/FO	POW/EM	PSS/FO	PEM/SS	Total
Greenup Pool										
Lesage (unnamed)			0.1	17.9						18.0
Racine Pool										
Letart		0.5			0.1				0.9	1.5
Belleville Pool										
Marietta				1.2				1.5		2.7
Muskingum		0.7		0.3						1.0
Blennerhassett	2.9	5.9		1.7						10.5
Newberry		0.1		0.1						0.2
Mustapha		0.4		1.1						1.5
Willow Island Pool										
Paden				0.7						0.7
Williamson		0.2						1.0		1.2
Witten Towhead		0.2		0.4						0.6
Crab		0.4								0.4
Grape		1.4		0.2		1.5				3.1
Middle		0.1					0.3			0.4
Broadback		0.6								0.6
Eureka					0.05					0.05
New Cumberland										
Georgetown			13.7	13.9						27.6
Phillis		1.0	9.8							10.8
Montgomery										
Mont. Embayment 2/		0.8		10.1						10.9
Submerged rooted aquatic plants (RAB) 3/										50-75

POW - Palustrine open water
PEM - Palustrine emergent
PSS - Palustrine scrub/shrub
PFO - Palustrine forested
REM - Riverine emergent
POW/EM - Palustrine open water/emergent
PEM/SS - Palustrine emergent/scrub-shrub
PSS/FO - Palustrine scrub-shrub/forested
POW/FO - Palustrine open water/forested
RAB - Riverine aquatic bed

1/ Sources: Tolin and Schettig (1983), Plewa and Putnam, 1985, 1986.

2/ Approximately 8 acres of the embayment itself is classified as Palustrine, Unconsolidated Bottom, Mud, and Permanently Flooded.

3/ Aquatic plants such as milfoil and pondweeds, extending from a depth of 1-4 feet are present around Paden, Crab, Wells, Grape, Middle, Broadback, Marietta, Muskingum, Neal, Blennerhassett, Newberry, Mustapha, Letart, Eightmile islands. Neal and Eightmile islands do not have wetlands on the islands.

3.5.5.6 Hannibal L&D Pool

There are five islands in this pool. Wheeling Island is the largest and is highly urbanized. The Upper Sister Island is disappearing, and Boggs is a heavily abused island with abandoned barges, selective clearing, and dredge spoil disposal sites. The Captina Island is classified as floodplain forest with Japanese knotweed (Polygonum cuspidatum Sieb. & Zucc.) on the upstream tip. Fish Creek Island is classified as floodplain forest on the interior with Japanese knotweed on the upper tip. Both islands have exposed shoreline below the ordinary high water mark. There are 25 slackwater embayments, totaling over 15 miles in length, in the Hannibal pool.

3.5.5.7 Pike Island L&D Pool

The heavily urbanized Browns Island is the only island present in this pool. There are no significant wetlands in the project vicinity. There are 11 embayments over 500 feet long and totaling 6.5 miles in length in this pool.

3.5.5.8 New Cumberland L&D Pool

The Georgetown and Phillis islands (resource category 1; habitat that is unique and irreplaceable and important for fish and wildlife resources with high ecological significance or public interest) provide excellent year-around cover for small mammals and songbirds. Migatory species also use this relatively undisturbed area for feeding and resting. Another significant wetland area occurs in this pool. This wetland is a palustrine scrub-shrub wetland located on the north bank above the upstream tip of Georgetown Island. A smaller wetland area is found at the upstream tip of Phillis Island along the south bank. These wetland areas are designated resource category 2. Other islands that had very little wetland area included Babbs, Baker, and Cluster islands. Cluster Island has disappeared and Baker Island and Babbs Island are also disappearing. The tailwaters of the Montgomery L&D have also been classified as riverine lower perennial, resource category 2 as an excellent feeding and spawning habitat. There are 7 embayments over 500 feet in length and totaling 4.4 miles in length in this pool.

3.5.5.9 Montgomery L&D Pool

The Montgomery Embayment above the dam is probably the most ecologically significant area in the upper Ohio River. It is designated as resource category 1 and is listed as a "Special Habitat Area" by the Western Pennsylvania Conservancy. The embayment is one of the largest (17.6 acres) on the Ohio River and serves as a nursery area for forage fish and feeding area for many bird and fish species. Wetlands, featuring emergent and submergent aquatic plant species, floodplain tree species, and shrubs, are found on the eastern and northeastern shores of the embayment and at the inlet just north of the dam abutment. The embayment, probably formed as a result of the dam, contains perhaps the last remaining silver maple-American sycamore stand in the Pennsylvania section of the Ohio River Valley.

3.5.5.10 Dashields L&D Pool

The tailwaters have been classified as riverine lower perennial with resource category 2. This area provides excellent spawning habitat and feeding for several fish species and also attracts waterfowl. The shoal below the Emsworth L&D is periodically exposed and has been classified as a resource category 1 by the USFWS for its waterfowl, especially migatory species, and walleye and sauger spawning and feeding habitat.

3.5.5.11 Emsworth L&D Pool (Ohio River)

This pool includes 6.7 miles of the Allegheny River (Section 3.3.5.7) and 11.2 miles of the Monongahela River (Section 3.4.5). Davis Island is classified as deciduous forest, resource category 3 (habitat of high to medium value for important fish and wildlife resources with high ecological significance or public interest and is abundant) by the USFWS. It is of special value for providing cover, protection, and food in a heavily industrialized area. Neville and Brunot Islands provide the least desirable habitat because they are located in heavily industrialized areas with little attractive habitat for wildlife. The downstream tip of Neville Island is not developed, providing some habitat for wildlife and fish.

3.5.6 River Navigation and Hydraulics

The study area of the Ohio River includes the first ten navigation dams below Pittsburgh. The second of these, Dashields, is the only fixed-crest dam in the Ohio River reach. The installation of navigation dams and other constrictions to flow have increased the frequency and magnitude of floods over what they were naturally. For Corps navigation projects, real estate easements were purchased and/or other provisions made prior to construction to compensate for project-induced flood effects, where necessary. However, flooding has been reduced by the flood control dams on the tributaries throughout the upper Ohio River basin. Expected flood elevations for the first 130 miles of river below Pittsburgh are shown in Figure 3.5.6-1.

3.6 MUSKINGUM RIVER

3.6.1 Basin Description

The Muskingum River enters the Ohio River at RM 172.2. It has a length of about 112 miles and a drainage area of 8,040 square miles, all within the state of Ohio (ORSANCO, 1986b). The Muskingum was canalized (i.e., made into a canal) from its mouth to RM 90, but Corps maintenance for barge traffic was discontinued in the 1950's. The 10 fixed-crest navigation dams and hand-operated locks are now maintained by State of Ohio for recreational use, and the river has maintained its canalized nature (Muskingum River dam 1 was made unnecessary by the installation of Belleville dam on the Ohio, so dam 2 is the most downstream dam on the river). There are a number of small reservoirs in the Muskingum watershed, but no major storage projects (ORSANCO, 1986b). The annual flow duration curve for the USGS gaging stations at McConnelsville (dam 7) is shown in Figure 3.6.1-1, and monthly mean flows for this station are given in Table 3.3.1-1.

3.6.2 Water Quality

There is less water quality information available for the Muskingum than for the other study rivers, in part because there are lower waste loadings to the Muskingum. ORSANCO has a manual monitoring station 5.8 miles upstream from the mouth of the Muskingum. Data from this station indicate that 5-day BOD concentrations generally range between 2 and 4 milligrams per liter (mg/L); ammonia concentrations are usually around 0.1 mg/L; and total suspended solids concentrations are generally <50 mg/L from midsummer through late fall, but range from 50 to 250 mg/L during the winter-spring high-flow season (it should be noted that the number of samples for this station in the STORET database, where these values were obtained, is small; for data collected in 1980 and later, there were usually less than ten samples reported for each of the 12 months).

The aeration studies conducted by the applicant for the proposed hydropower project at dam No. 3 indicate that both dam Nos. 2 and 3 are efficient aerators, though dam No. 3 appears to aerate much better than dam No. 2.

3.6.3 Fisheries

The Muskingum River has habitats similar to other rivers of the upper Ohio drainage. Although smaller, it has more shallow water both near islands and along shorelines. Except for the lock approaches, the downstream reaches below dams are predominantly shallow riffles with numerous shoals and islands. L&D No. 2, with the lock as an integral part of the dam, has a deep-water channel at the left third of the river width and shallow water at the right. L&D No. 3 has the lock in a bypass channel that extends downstream about 1 mile; the entire dam tailwater is a shallow series of islands and shoals. Pool No. 3 has an island near RMs 21-22, where there are about 250 acres of shallow water.

Aquatic life is representative of a warmwater river, and a good recreational fishery exists in pools and especially at the dam tailwaters. An endangered mussel species, the pink mucket pearly mussel (*Lampsilis orbiculata*) is believed to occur in the tailwater of L&D No. 3 (Fish and Wildlife letter dated Nov. 1, 1984), and other fish and mussel species listed as endangered by the Ohio Department of Natural Resources (ODNR) may occur there as well, although no detailed surveys are available (letter dated October 20, 1984).

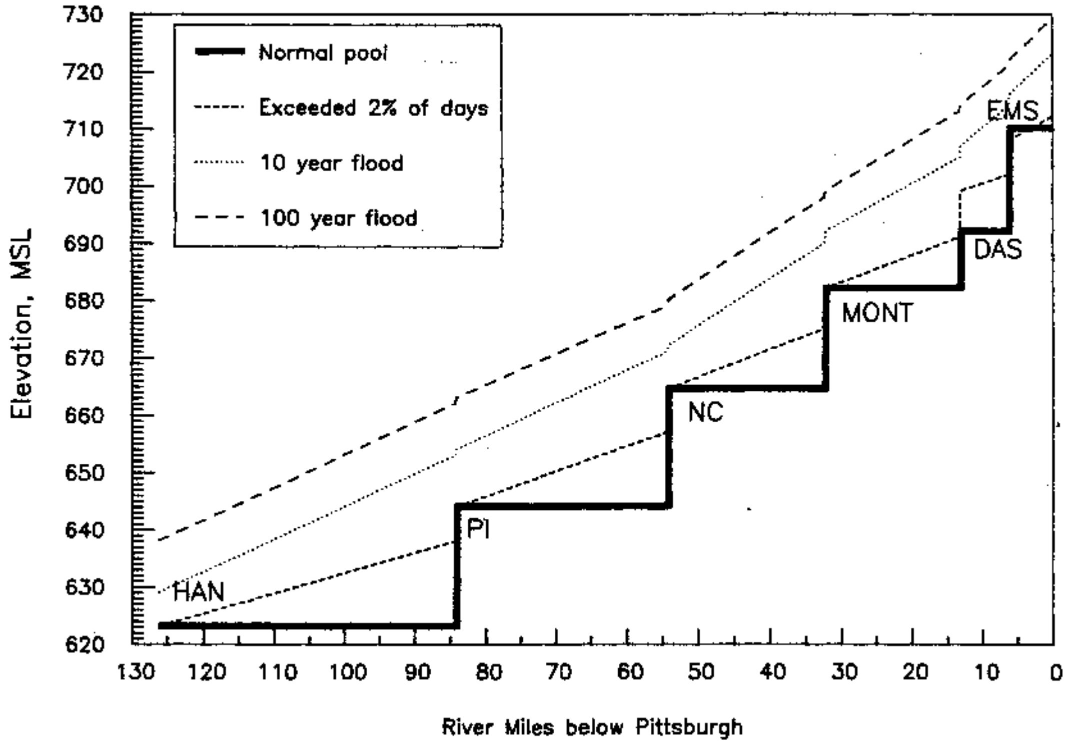

Figure 3.5.6-1. Expected flood elevations for the Ohio River. Source: Corps, Pittsburgh District.

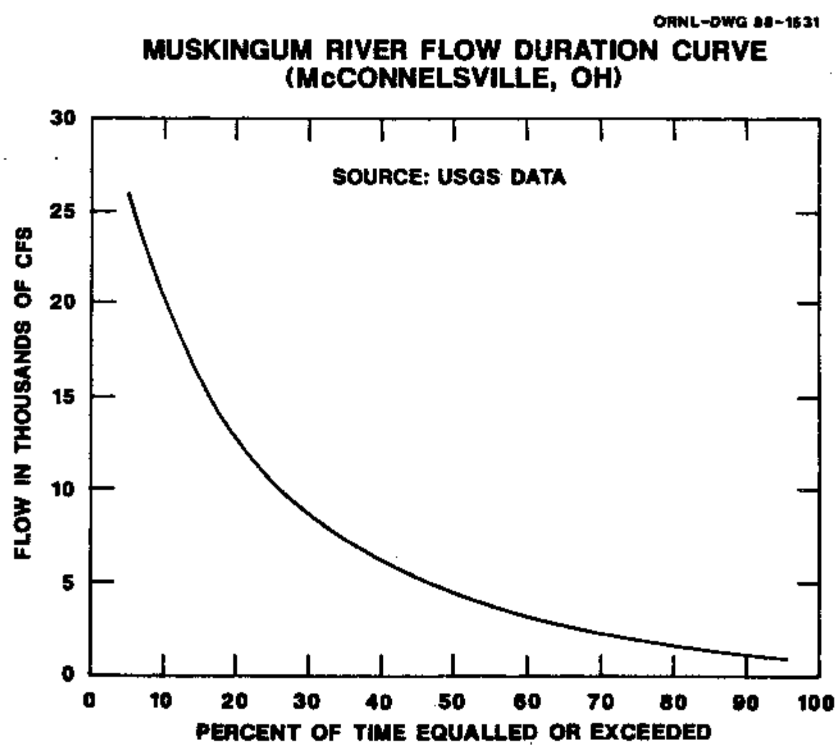

Figure 3.6.1-1. Muskingum River annual flow duration curve.

3.6.4 Recreation

The Muskingum River drains an area equal to one-fifth the area of the entire state of Ohio. Because it is the largest river that is entirely within the state, it is one of Ohio's largest recreational resources. Multipurpose water resource development projects undertaken by the Corps and the ODNR have increased the recreational value of the river. Use of the L&D for commercial navigation ended in the 1950s, and the ODNR, Division of Parks and Recreation, now operates the ten L&D structures on the river solely for recreation purposes. The river's L&D structures extend over 92 miles of waterway, known as the Muskingum River Parkway (Figure 3.6.4-1). Adjacent to each of the L&D sites are ODNR-managed state park facilities which provide open space, river-front access, and public outdoor recreation opportunities. The L&D sites include a total of 113 acres of land, which are part of the state park system. Table 3.6.4-1 lists attendance totals for 1987 at the L&D areas along the Muskingum River Parkway. Pleasure boating accounts for 24 percent of the total attendance given in Table 3.6.4-1 and fishing accounts for 19 percent. Picnickers and other visitors account for the remainder of the use.

Recreation use along the Muskingum River Parkway occurs in four counties: Washington, Morgan, Muskingum, and Coshocton. Table 3.6.4-2 lists the number of boats registered and the number of fishing licenses sold in 1986 in each of these counties. Washington County accounts for the largest number of registered watercraft and fishing licenses.

The river is popular for many types of boats, including motorboats, houseboats, pontoon boats, canoes, and rowboats. Table 3.6.4-3 lists the number of boat lockages at each of the L&D structures along the river. Locks 4, 5, 6, and 11 have public launch ramps, and there are private ramps located near Locks 7 and 10. Some of the tributaries that enter the Muskingum River are navigable for short distances and provide excellent fishing.

The Muskingum Watershed Conservancy District manages ten lakes and surrounding lands in the Muskingum Basin (ODNR, 1985). There are fish stocking programs in lakes in the four subbasins of the Muskingum, including Tuscarawas, Walhonding, Licking, and Wills Creek. Although there are no current quantitative data on the contributions of lake stocking efforts on tributaries of the Muskingum River, ODNR is planning a creel survey on the Muskingum River for 1988 from Zanesville to Marietta (Mitex, 1987b). The river provides angling for a diversity of Ohio game species, including northern pike, muskellunge, walleye, largemouth, smallmouth, spotted and white bass, and flathead and channel cat fish (Upper Mississippi Water Company, 1984). Historically, the impoundments in the basin have produced record-sized muskellunge and catfish (Upper Mississippi Water Company, 1984).

3.6.4.2 Wild and Scenic River Status

There are no designated river segments along the Muskingum River that are existing components or study rivers of the National Wild and Scenic River System or of the Ohio's Scenic Rivers Program (ODNR, 1985).

3.6.5 Wetlands

Wetlands on the Muskingum River in the vicinity of L&D No. 3 are limited to the edges of four islands located immediately downstream of the dam and to the riparian vegetation occurring along the shoreline. The upstream limit of the islands is about 150 feet from the downstream face of the dam. Navigation charts for the Muskingum (Brown and Brown, n.d.) and aerial photographs taken by the Corps on April 29, 1982, depict the islands as being mostly shallow bars, with the center of the largest islands having floodplain forest vegetation and the

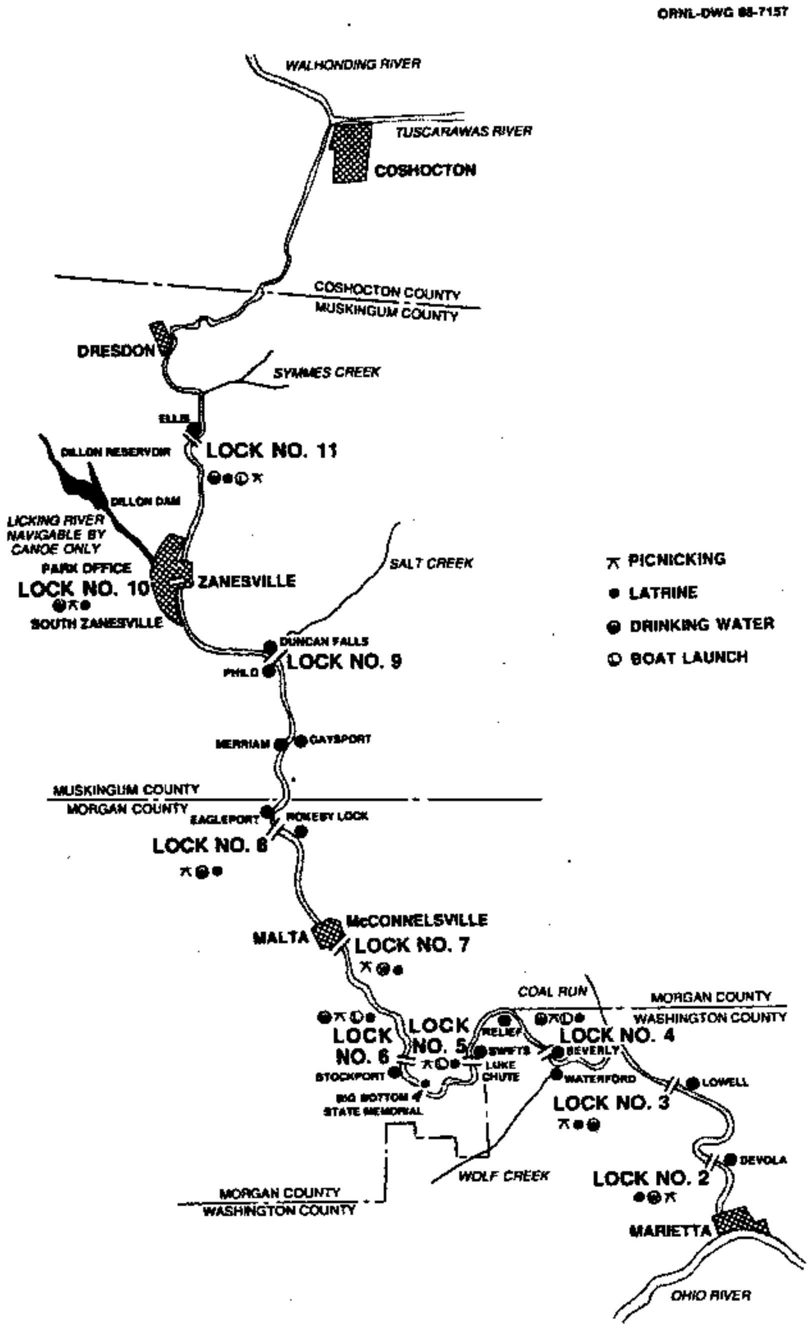

Figure 3.6.4-1. Muskingum River Parkway. Source: Ohio Department of Natural Resources, Ohio State Parks pamphlet (PR-D-44), undated.

Table 3.6.4-1. Recreation use at the lock and dam structures on the Muskingum River. 1/

Lock and dam	River mile	Attendance 2/	Facilities
No. 2 (Devola) 3/	5.8	55,800	Picnic area, restrooms, parking (LB)
No. 3 (Lowell)	14.2	16,994	Picnic area, restrooms, parking (LB)
No. 4 (Beverly)	25.1	15,272	Public launching ramp, picnic area, restrooms, parking (LB)
No. 5 (Luke Chute)	34.15	19,851	Public launching ramp, picnic area, restrooms, parking, camping (RB)
No. 6 (Stockport)	40.15	23,501	Public launching ramp, picnic area, restrooms, parking (LB)
No. 7 (McConnelsville)	49.5	23,220	Picnic area, restrooms, parking (LB)
No. 8 (Rokeby)	57.6	31,188	Picnic area, restrooms, parking (LB)
No. 9 (Philo)	68.6	23,757	Water (Philo picnic area on LB) (RB)
No. 10 (Zanesville)	76.6	68,122	Picnic area, tie-ups, Muskingum River Parkway's Park Office (LB)
No. 11 (Ellis)	85.9	36,809	Launching ramp, picnic area, restrooms, parking (RB)
Total		314,514	

1/ Source: Ohio Department of Natural Resources, Muskingum River Parkway Facilities List; Ohio Department of Natural Resources, Monthly Attendance and Use Report.

2/ Attendance is for the period of January to November 1987. The attendance total given includes the number of boaters, anglers, picnickers, and other visitors at each of the lock and dam areas operated by the Ohio Division of Parks and Recreation.

3/ Nearest town shown in parentheses.

4/ LB indicates left descending bank; RB indicates right descending bank.

Table 3.6.4-2. Fishing license sales and boat registrations issued during 1986 in counties along the Muskingum River. 1/

County	Lock and dam	Fishing licenses	Boat registrations
Washington	No. 2-5	11,341	3,114
Morgan	No. 6-8	3,656	525
Muskingum	No. 9-11	11,017	2,907
Coshocton	(above Dresden)	3,636	1,470

1/ Source: Ohio Department of Natural Resources, Division of Watercraft and Division of Wildlife.

Table 3.6.4-3. Number of boat lockages at each of the lock and dam structures operated by the Ohio Division of Parks and Recreation on the Muskingum River Parkway in 1987. 1/

Lock and dam number	Number of boat lockages
2	1,600
3	1,567
4	877
5	976
6	1,346
7	1,509
8	1,646
9	1,593
10	871
11	450
Total	12,435

1/ Source: Ohio Department of Natural Resources, Monthly Attendance and Use Report.

2/ Use figures are for January through November 1987.

smaller islands having herbaceous ground cover. The largest island (unnamed), located about 300 feet downstream of the dam and 100-200 feet from the bank, is about 1000 feet long and 200 feet wide (approximately 4 acres). The island and its backchannel provide important shelter and feeding areas for aquatic and terrestrial habitat. Exposed root masses, snags, submerged trunks of dead trees, and overhanging trees and shrubs provide cover for a number of small mammals, songbirds, and fishes. Vegetation on the islands and along the shoreline include grasses, annual and perennial flowering plants, silver maple (Acer saccharinum L.), cottonwood (Populus deltoides Marsh.), oak (Quercus sp.), sycamore (Platanus occidentalis L.), and willow (Salix sp.). The shallow bars on the islands also are important habitat for mussel species.

3.6.6 River Navigation and Hydraulics

Barge navigation is no longer maintained on the Muskingum, but recreational boating is important. The lock at dam No. 3, where the only hydropower project for the Muskingum is proposed, is approximately 3100 feet downstream of the dam on a small separate navigation channel. Because the proposed project at dam 3 would not remove any of the existing dam, flooding is not expected to be an issue on the Muskingum (Section 4.6.6).

4. ENVIRONMENTAL CONSEQUENCES

4.1 PROJECTS AS PROPOSED (ALTERNATIVE 1)

4.1.1 Water Quality

4.1.1.1 Dissolved Oxygen

Maintenance of adequate dissolved oxygen (DO) concentrations is crucial to the biological integrity of the study rivers (Section 3.1.3, Section 4.1.2). Oxygen is provided to the water from surface aeration (dissolution of oxygen from the air into the water at the surface of the navigation pools); from algae, which create DO as a product of photosynthesis; and from aeration at the dams. Oxygen is removed from the water by the biological decay of organic and nitrogen-containing matter in the water column and in the river sediments, and by aquatic organisms, which use DO for respiration. The organic and nitrogen-containing matter which undergo biological decay is referred to as biochemical oxygen demand (BOD). BOD is measured by how much DO the BOD-containing materials remove from the water while being decayed; for instance, a waste that would result in the removal of 10 pounds of oxygen from the water during its decay has a BOD content of 10 pounds. Sources of BOD include wastewater discharges, non-point source runoff, materials deposited in river sediments, and decaying organisms such as dead algae. The difference between the rate at which DO enters the water from surface aeration, algal photosynthesis, and dam aeration, and the rate at which it is consumed by biological activity determines the DO concentration.

DO concentrations are also highly controlled by the saturation concentration (C_s). The saturation concentration is the concentration that occurs when air is in equilibrium with water; that is, when water is mixed with air until a constant DO concentration occurs, that concentration is C_s. The DO saturation concentration changes inversely with temperature; for instance, at 20°C (68°F) C_s is 9.1 milligrams per liter (mg/L) and at 30°C (86°F) C_s is 7.5 mg/L. The saturation concentration also decreases with increasing elevation. Concentrations of DO in rivers are commonly modeled and measured using the DO deficit, which is the difference between the actual concentration and the appropriate value of C_s.

The proposed hydropower projects would change DO concentrations by changing the amount of aeration that takes place at the dams. This is due to the diversion of the majority of river flows through the powerhouse and the resulting reduction or elimination of flows spilled over the dam or through the gates. Studies on the Ohio River have shown that little if any aeration takes place at existing hydropower plants when river flows are diverted through the powerhouse (AEP, 1969; 1987). The project characteristics that affect aeration are (a) the amount of water spilled through the gates or over the crest of the dam, compared to the total river flow (for simplicity, the term 'spill flow' is used for flow spilled through the gates of a gated dam, or over the crest of a fixed-crest dam, when hydropower is in operation; spill flow does not include flow used for lockage or flow that leaks through the dam); (b) the minimum river flow at which the project would operate (at flows below this minimum all flow except lockage and leakage would be spilled); and (c) the maximum flow which the turbines can use (river flows in excess of this maximum generating flow would be spilled).

Assessment Methods

Determining the impacts of the proposed projects on DO concentrations requires two steps. First, the amount of aeration provided by the dams must be determined, so that the change in the amount of DO caused by hydropower can be determined. Second, the effects of this change on DO concentrations throughout the river system must be determined.

The amount of DO provided by dams was quantified by using field data from each dam to fit a statistical model. The DO concentration and water temperature were measured above and below each of the navigation dams in the study area, including those where no hydropower is proposed. The measurements were made at a number of different flow rates and temperatures, generally during the summer season of low flows and high temperatures when DO concentrations are lowest. These field measurements showed that there was generally a constant linear relation between the DO deficit above the dam (D_a) and the deficit below the dam (D_b). The aeration provided by dams was modeled using the equation:

$$D_b = M\,D_a - b\ ,$$

where M and b are coefficients determined for each dam from the field data. The values of these coefficients are in Table 4.1.1-1. If no aeration takes place at a dam, the value of M would be one and the value of b would be zero. Low values of M and high values of b describe dams that are efficient aerators. A dam that provided DO concentrations at or above C_s for all values of D_a would have M equal to zero. Figure 4.1.1-1 is an example plot of D_b vs D_a. Details on how the values of M and b were determined for each dam are given in Appendix B.

Table 4.1.1-1. Model parameters for dam aeration, flow, and water temperature.

Dam	Dam aeration constant, b	Dam aeration coefficient, M	7Q10 Flow,* (cfs)	Est. temperature exceeded 10% of time in August (^{0}C)
Allegheny L&D No. 9	0	0.58		25
Allegheny L&D No. 8	0.62	0.61		26
Allegheny L&D No. 7	-0.13	0.9	2250	27
Allegheny L&D No. 6	0	0.82	(2250)	27
Allegheny L&D No. 5	0	0.57	(2250)	27
Allegheny L&D No. 4	0	0.56	2900	27
Allegheny L&D No. 3	0.67	0.92	(2900)	28
Allegheny L&D No. 2	0.92	0.12	2900	28
Tygart Dam			340	24
Opekiska (Mon.)	0.15	0.8	340	27
Hildebrand (Mon.)	0.1	0.32	(340)	26
Morgantown	0.21	0.65	(340)	27
Pt. Marion (Mon.)	0.64	0.4	345	27
Monongahela 7	0.1	0.36	480	27
Maxwell (Mon.)	0.22	0.69	(520)	27
Monongahela L&D No. 4	0.18	0.61	550	27
Monongahela L&D No. 3	-0.14	0.81	(550)	32
Monongahelà L&D No. 2	0.2	0.93	1310	29
Emsworth	0.19	0.77	4730	28
Dashields	0.67	0.72	4730	28
Montgomery	0.61	0.78	5830	28
New Cumberland	0.5	0.38	5830	29
Pike Island	0.23	0.72	5830	29
Hannibal	0.28	0.89	5830	29
Willow Island	0.17	0.97	5830	29
Belleville	0	0.89	6470	29
Gallipolis	0.1	0.84	8850	29

*Source: Ohio river Division, Corps. Values in parenthesis are estimated by FERC staff.

The dam aeration equation applies to the spill flow—the water that passes through the gates or over the crest of a dam. Without hydropower, all flow except for that used for lockage and the flow that leaks through the dam passes through the gates or over the crest of the dam. With hydropower, flow other than the spill flow is diverted through turbines, or used up in lockage and leakage, and receives no aeration. For any given value of D_a, the value of D_b without hydropower can be determined by applying the aeration equation (assuming the lockage and leakage flows are negligible compared to total river flow). The value of D_b with hydropower can be determined by (a) determining what D_b is for the spill flow by applying the aeration equation to it; (b) assuming that the rest of the flow receives no aeration, so $D_b = D_a$; and (c) determining the final D_b after the spill flow and turbine flows have remixed by calculating the average D_b, weighted by flow rate.

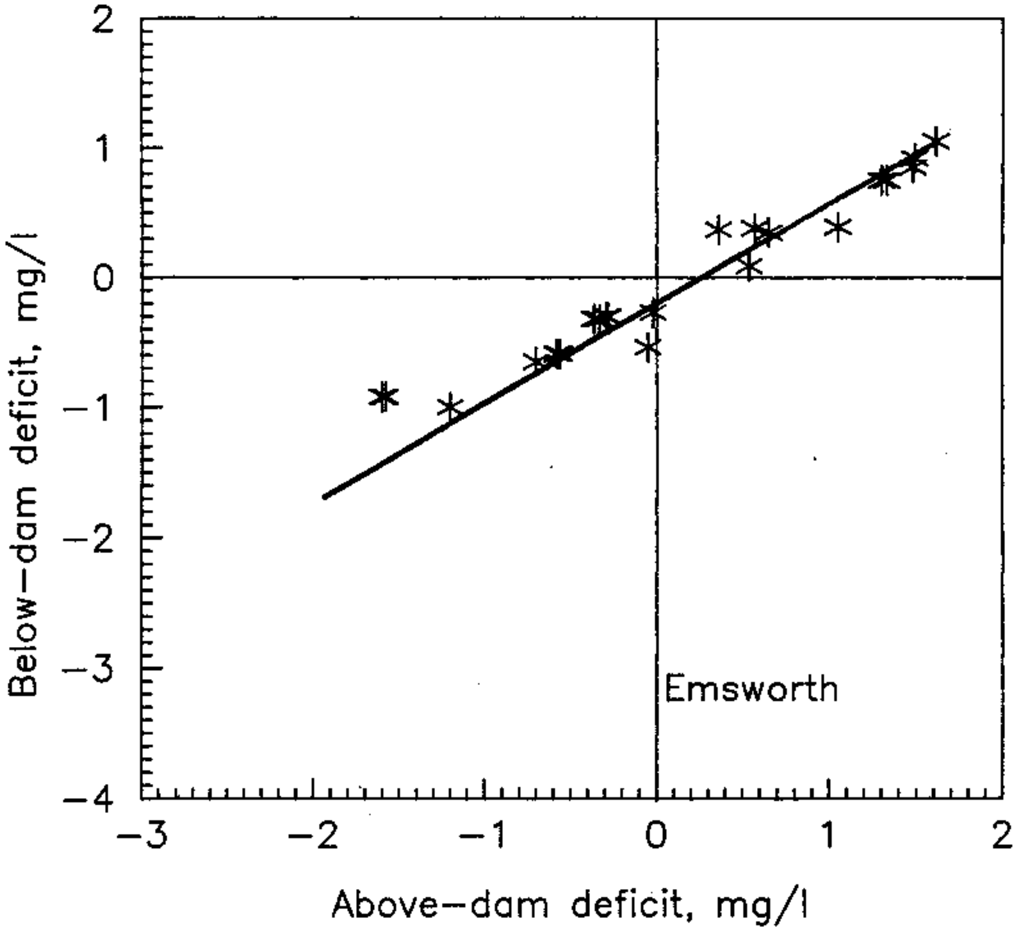

Figure 4.1.1-1. Plot of DO deficits below dam vs DO deficit above dam at Emsworth Dam.

For an example of how the changes in deficits caused by hydropower are calculated, assume there is 10,000 cfs of river flow at Emsworth dam, with a deficit above the dam (D_a) of 2 mg/L (that is, the DO concentration is 2 mg/L less than C_s). The values of M and b for Emsworth are 0.77 and 0.2 mg/L, respectively. Without hydropower, the deficit below the dam (D_b) is found: $D_b = M D_a - b$, or $D_b = (0.77 \times 2$ mg/L$) - 0.2$ mg/L, or $D_b = 1.3$ mg/L (the effects of lockage and leakage are neglected because these flows are small compared to the total). The dam provides 0.7 mg/L aeration (equal to the difference between the deficit above and below the dam). Now assume that hydropower would divert 7,000 cfs through turbines, leaving a spill flow of 3,000 cfs. For the spill flow, which is aerated, the value of D_b is determined as above to be 1.3 mg/L. For the flow through the turbines, D_b is equal to D_a, or 2 mg/L, because this flow is not aerated. The final D_b after the spill and turbine flows are remixed is equal to the spill flow rate times D_b for the spill flow, plus the turbine flow rate times D_b for the turbine flow, all divided by the total flow. The final D_b is therefore equal to:

$$\frac{(7{,}000 \times 2 \text{ mg/L}) + (3{,}000 \times 1.3 \text{ mg/L})}{10{,}000},$$

which equals 1.8 mg/L. With hydropower, the dam provides 0.2 mg/L aeration, compared to 0.7 mg/L without hydropower, so hydropower reduced aeration by 0.5 mg/L, averaged over the entire river flow.

The preceding discussion shows that the amount of DO provided by a dam depends on the DO deficit above the dam. To determine how changes in aeration at each dam where hydropower is proposed would affect DO concentrations in the entire study area, a mathematical model of DO was developed. The model uses simple equations to describe the rates at which DO is removed by BOD and replenished by surface aeration; these equations were originally developed by Streeter and Phelps (1925) in their study of the Ohio River. The model assumes that the rate at which BOD removes DO (mg/L of DO per day) is equal to a constant times the concentration of BOD, and that the rate at which surface aeration replenishes DO (mg/L of DO per day) is equal to a constant times the DO deficit. The amounts of DO consumed and produced by algae and other aquatic organisms are assumed to be minor and are not modeled (Appendix B). The model assumes that the rivers are completely mixed vertically and horizontally across the channel, but that no mixing occurs longitudinally along the channel. Hydraulically, the model assumes that the navigation dams maintain a constant pool elevation, so the river velocity is equal to the flow rate divided by the cross-sectional area of the channel.

The sources of BOD included in the water quality modeling are 11 major industrial and municipal wastewater treatment plants (there are many other wastewater discharges, but others are either too small to have a detectable impact on DO concentrations or else do not have sufficient BOD data available to model), and BOD loads that simulate non-point sources of BOD such as runoff, sediment oxygen demand, and decaying algae.

The model was calibrated to unpublished data collected in the summer of 1983 by the Pittsburgh District of the Corps and ORSANCO. Calibration required adjustment of the estimated BOD load to the rivers and the rate at which BOD decays. Details of how the model was formulated, parameterized, and calibrated are in Appendix B.

<u>Assessment Results</u>

The impacts of the proposed hydropower projects on DO concentrations were analyzed for several sets of conditions (river flows, water temperatures, BOD loadings, etc.). In all cases the hydropower projects in the study area that are already licensed (at Allegheny L&D Nos. 5, 6, 8, and 9, Hannibal, and Racine) were assumed to be in operation. For each set of conditions, the model was run to determine what DO concentrations would occur without hydropower, and what DO concentrations would occur if the projects were constructed and operated as proposed by the applicants. At dams where two competing applications have been filed, the lowest proposed spill flow was simulated. Two sets of river conditions were analyzed.

Case 1: Low summer flows. This case simulates conditions expected to cause very low DO concentrations. River flows are those that are not expected to be exceeded for seven consecutive days with a return period of 10 years (the 7Q10 flows). The 7Q10 flows (Table 4.1.1-1) are commonly used to represent extremely low flows, though they have no particular hydrologic or biologic significance. Water temperatures are those estimated to be exceeded only 10 percent of the days in August (Table 4.1.1-1); the values were estimated from the ORSANCO electronic monitors (Sections 3.3 through 3.5). The BOD loadings and BOD decay rates are those obtained from calibration of the model.

The results for Case 1 are shown in Figures 4.1.1-2, 4.1.1-3, and 4.1.1-4. All of the proposed Allegheny River projects would operate at the 7Q10 flows, but at all of the proposed Monongahela River projects and all the Ohio River projects except Dashields, Belleville, Willow Island, and Gallipolis, the 7Q10 flow is less than the proposed minimum generation flow, when lockage and leakage flows are subtracted. Therefore under 7Q10 flows no hydropower projects would operate on the Monongahela, and only the projects located at Dashields, Belleville, Willow Island, and Gallipolis would operate on the Ohio River.

Because no projects would operate on the Monongahela River, there are no impacts at 7Q10 flows. On the Allegheny, the proposed hydropower projects would eliminate much of the aeration that currently takes place at L&D Nos. 2, 3, and 4. As a result, the DO in the Allegheny L&D No. 3 pool is reduced by about 0.5 mg/L, in the Allegheny L&D No. 2 pool by about 1 mg/L, and in the Allegheny arm of the Emsworth pool by about 1.3 mg/L. The already licensed projects at L&D Nos. 5 and 6 prevent DO concentrations from reaching 7 mg/L in the L&D Nos. 4 and 5 pools. The low spill flows proposed by the applicants at L&D Nos. 3 and 4 would not provide enough aeration to prevent a further decrease in DO until L&D No. 2 is reached. The applicant at L&D No. 2 has proposed a higher spill flow, and the dam is a very efficient aerator. Therefore, even with hydropower, a significant increase in DO would occur at L&D No. 2.

On the Ohio River, the proposed projects reduce DO concentrations in the first 60 miles. The Allegheny River projects cause a decrease of about 0.8 mg/L in the DO at Pittsburgh, after mixing with the Monongahela River. The proposed project at Dashields reduces aeration at a point where the waste load from Pittsburgh causes low DO concentrations, so this project would further reduce DO concentrations by about 1 mg/L, to values less than 4 mg/L. The other proposed projects on the Ohio River that would operate at 7Q10 flows (Belleville, Willow Island, and Gallipolis) occur at dams that do not provide much aeration, so their impacts on DO are minor. The difference in DO with and without the proposed projects at the end of the study reach (Greenup Dam, at RM 341) is predicted to be about 0.2 mg/L, which is minor compared to natural variability.

For Case 1, without the operation of any of the proposed hydropower projects, there are approximately 80 RM with DO concentrations below 5 mg/L, and 365 miles with DO below 6.5 mg/L, of a total of 550 RMs modeled. The proposed projects would result in approximately 115 miles with DO concentrations below 5 mg/L and 380 miles with DO below 6.5 mg/L. The proposed projects would reduce DO concentrations by about 0.5 mg/L or more for approximately 80 miles of river.

Case 2: Moderate summer flows. This case simulates conditions when the proposed projects are expected to have the most impact on DO concentrations. River flows are approximately the lowest flows at which all of the proposed projects would operate. These flows are generally 2.6 times higher than the 7Q10 flows, except flows in the Monongahela River start at 1,800 cfs so the proposed Hildebrand project would operate. Temperatures and other model parameters are the same as for Case 1.

The results for Case 2 are shown in Figures 4.1.1-5, 4.1.1-6, and 4.1.1-7. On the Monongahela River, the Opekiska project is expected to slightly increase DO concentrations. Opekiska Dam does not aerate the river, but instead causes stratification and low DO concentrations in the Hildebrand pool (Section 3.4.2). Hydropower is expected to reduce stratification below Opekiska because the power plant would withdraw water from the entire water column, not just from the bottom layer as the dam does. The reduced stratification would increase DO concentrations below Opekiska. However, the proposed projects at Hildebrand, Morgantown (the modeling assessment assumed that a hydropower application will be filed at Morgantown), and Point Marion prevent the complete recovery of DO concentrations from the low levels above Opekiska. Monongahela L&D No. 7, where no project is proposed, brings DO concentrations close to where they would be with no hydropower. Model results not presented here indicate that at higher flows DO concentrations increase in the Monongahela River, and that Monongahela River DO concentrations at Pittsburgh do not vary much with changes in either flow or hydropower development. The stability of DO concentrations in the Monongahela River at Pittsburgh is caused by Monongahela L&D Nos. 2 and 3, where no hydropower is proposed, and by

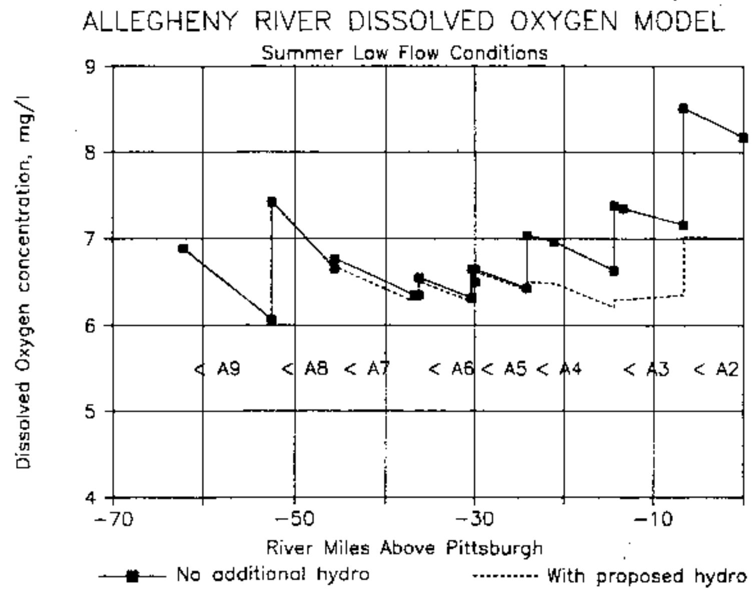

Figure 4.1.1-2. Allegheny River DO model results for summer low flow conditions for projects as proposed.

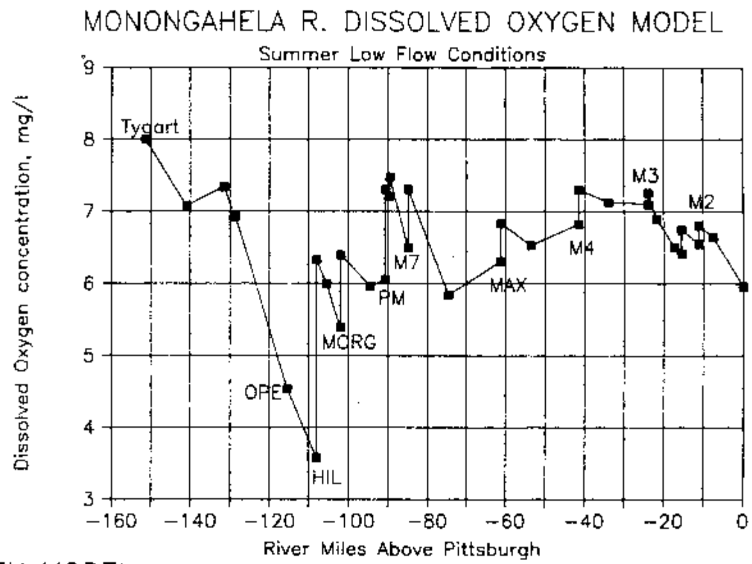

Figure 4.1.1-3. Monongahela River DO model results for summer low flow conditions for projects as proposed. No proposed projects would operate at these flows.

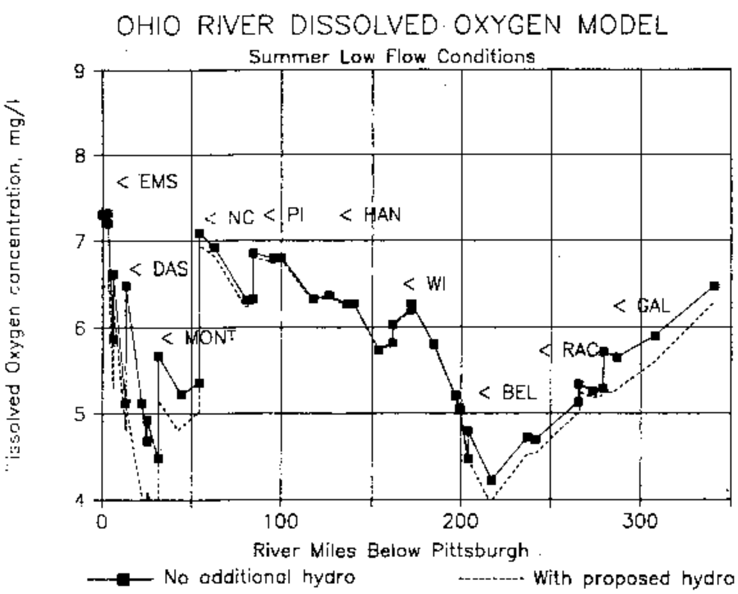

Figure 4.1.1-4. Ohio River DO model results for summer low flow conditions for projects as proposed.

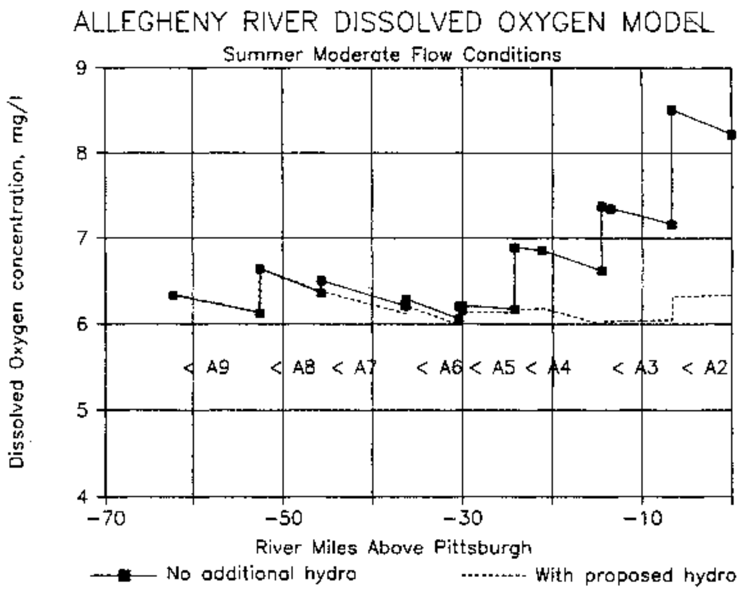

Figure 4.1.1-5. Allegheny River DO model results for summer moderate flow conditions for projects as proposed.

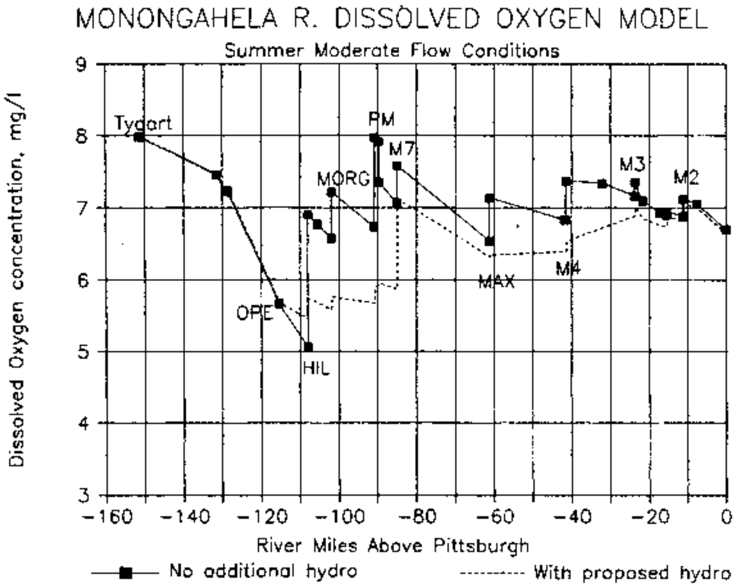

Figure 4.1.1-6. Monongahela River DO model results for summer moderate flow conditions for projects as proposed.

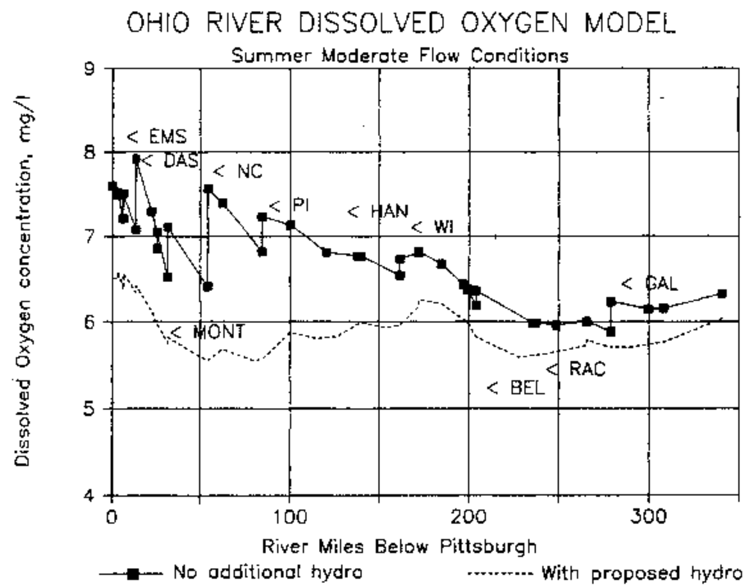

Figure 4.1.1-7. Ohio River DO model results for summer moderate flow conditions for projects as proposed.

dilution from the Youghiogheny River, a large tributary at Monongahela RM 15.5. At flows less than those modeled in Case 2, the proposed project at Hildebrand would not operate and the aeration from Hildebrand would increase DO concentrations.

On the Allegheny River, modeled DO concentrations at moderate flows are lower than those at low flows. In the modeling, the licensed projects at Allegheny L&D Nos. 8 and 9 were assumed to be operating with a spill flow equal to the 7Q10 flow (2,250 cfs), which would provide less aeration as flows increase and cause the spill flow to become a smaller fraction of the total river flow. Model results not presented here indicate that Allegheny River DO concentrations would continue to decrease slightly at flows above those used in Case 2 but would not fall below about 6 mg/L. The other licensed projects at L&D Nos. 5 and 6 and the poor aeration provided by dam 7 prevent DO concentrations from recovering from the decreases below L&D Nos. 8 and 9, even without the proposed additional hydropower projects. The proposed projects at L&D Nos. 2, 3, and 4 pass the low DO concentrations on down to the end of the Allegheny River. Although the proposed hydropower would not cause extremely low DO concentrations on the Allegheny River, it would cause a large decrease in DO concentrations at Pittsburgh, compared to concentrations without hydropower, which then have major effects on Ohio River concentrations.

The cumulative reductions in DO concentration from the Allegheny River projects result in a total reduction in Ohio River concentrations of about 1 mg/L at Pittsburgh. The proposed projects at Emsworth, Dashields, Montgomery, New Cumberland, and Pike Island dams eliminate the aeration that otherwise would maintain DO concentrations around 7 mg/L in the first 200 miles of river, where DO is reduced by the waste discharges from Pittsburgh. The proposed projects at Willow Island, Belleville, and Gallipolis have little effect on DO concentrations, compared to concentrations without hydropower, because these three dams provide little aeration even without hydropower. Model results not presented here indicate that DO concentrations in the Ohio decrease as river flow decreases and that concentrations of 5 mg/L occur in the Dashields and Montgomery pools when the flow is below about 9,000 cfs (Section 4.2.1). At the end of the study reach (Greenup Dam), the proposed projects would reduce DO concentrations by about 0.3 mg/L, which is minor compared to natural variability.

For Case 2, without any additional hydropower, there are no river miles with DO concentrations below 5 mg/L in the entire 550-mile study area and only about 200 miles with DO below 6.5 mg/L. The proposed projects would result in no miles with DO concentrations below 5 mg/L and 465 miles with DO below 6.5 mg/L (including the entire 340-mile reach of the Ohio River). The proposed projects would reduce DO concentrations by about 0.5 mg/L or more for approximately 260 miles of river.

The effects of the proposed Muskingum L&D No. 3 project on DO concentrations in the Ohio River were not included in the system DO model, because there are insufficient data on DO concentrations and other model parameters for the Muskingum River. The aeration provided by Muskingum L&D Nos. 2 and 3 was modeled using the same technique as for the other dams. L&D No. 3 appears to be a very efficient aerator, although the field measurements made there are highly variable. The flow in the Ohio River is large enough, compared to the Muskingum River, to ensure that major changes in DO in the Muskingum River would cause only minor changes in Ohio River DO concentrations.

Without hydropower, the outflow from Tygart Reservoir is generally cool and well aerated (Sect. 3.4.2). The proposed hydropower project would withdraw from low in the reservoir, slightly above the elevation of the existing outlet gates. During summer periods when the reservoir is stratified the water discharged by the hydropower plant would be cool but may have low DO concentrations. The proposed hydropower projects would not aerate the water as the existing outlet structure does, so DO concentrations would be significantly lower in the tailwater. Tailwater DO concentrations are important because below the dam, the river enters a long deep stretch where surface aeration is expected to be relatively low. The river receives a wastewater discharge in this reach, which reduces DO concentrations. Mitigative measures which could prevent these impacts to DO concentrations include spill flows through the gates; installation of a multi-level intake structure that would allow the project to mix the well-aerated surface water with the cool water from deep in the reservoir; the use of turbine, penstock, or in-stream aeration; and spillage of the turbine outflow over an aeration weir.

The proposed projects at Tygart Dam could also affect water quality in the reservoir and downstream by increasing the size of the layer of stagnant, cool water with low DO concentrations on the bottom of the reservoir. Because the proposed hydropower projects would withdraw water from higher than the existing gates do, flushing through the bottom of the reservoir would be reduced. Reduced flushing would decrease DO concentrations and increase concentrations of undesirable compounds such as iron, manganese, and sulfur in the bottom layer. These undesirable compounds would be washed out of the reservoir when flow through the existing gates occurs (such as for flushing of walleye) and would cause water quality impacts downstream; these compounds are especially undesirable in water supplies. These impacts could be mitigated by using a multi-level intake structure or by spilling water through the existing gates during summer.

Model results not presented here (but see Appendix B for simulations based on monthly mean flows and water temperatures) predict that at lower temperatures, when the DO saturation concentration is higher, the proposed projects would still cause changes in DO concentration similar in magnitude to those in Case 2, although the actual DO concentrations would be higher. The proposed projects are predicted to cause DO concentrations low enough to be of concern to aquatic life only during the summer and fall months of warm water temperatures and relatively low river flows. During most of the year, especially when higher flows are available for generation, it does not appear that the proposed projects would cause critical DO concentrations to occur.

If licensed with the spill flows as proposed by the applicants, many of the hydropower projects would cause cumulative decreases in DO concentrations that would be significant in magnitude (with decreases of 1-2 mg/L occurring in parts of each of the three main rivers), would occur over many river miles, and would occur over a wide range of river flow and temperature conditions. These changes are caused by proposed projects at dams which are effective aerators, and especially at dams such as those below Pittsburgh where BOD concentrations are high. Projects proposed at dams that are not effective aerators are not expected to cause significant changes in DO concentrations. The predicted cumulative decreases in DO concentrations would have major adverse impacts on aquatic life (Section 4.1.3.6); and significant adverse socioeconomic impacts on industries and municipalities that discharge wastewater to the study rivers (Section 4.1.6.3). The projects as proposed could eliminate much of the improvement in water quality that has resulted from major investments in waste treatment in recent decades.

Acceptability of Proposed Mitigation

Most of the applicants for the pending hydropower projects have proposed to include mechanical aeration systems or provisions to install such systems if they are needed (Section 2.2). These aeration systems are proposed to replace some of the dam aeration that would be lost during hydropower generation. The proposed aeration systems would pump air into the water either through nozzles in the turbine draft tube or through some kind of diffuser in the tailrace.

The feasibility of replacing dam aeration with mechanical aeration at a navigation dam is unknown. At several high-head hydropower plants in the United States, turbine aeration has successfully provided high DO concentrations, and there are no obvious reasons why turbine aeration should not be feasible at the proposed projects. However, turbine aeration has not been successfully demonstrated in the low-head bulb turbines proposed for the upper Ohio River basin. A turbine aeration system was installed at the existing Racine plant at RM 238 of the Ohio, but tests of the system showed it to be severely underdesigned and incapable of altering DO concentrations (AEP, 1987). Diffusers placed in the tailrace are also of questionable reliability; diffusers tend to be subject to clogging, and the high sediment loads and turbulence in a turbine tailrace can be expected to aggravate clogging.

A large air compressor capacity is required to aerate the study rivers. The volume of air required depends on the river flow, the DO deficit, and the percent of the oxygen supplied that actually dissolves into the water (the oxygen transfer efficiency). The oxygen transfer efficiency for aeration at the proposed projects is unknown. At high-head dams, TVA has obtained oxygen transfer efficiencies of about 35 percent (personal communication, E. D. Harschbarger, Tennessee Valley Authority Engineering Laboratory, Norris, Tennessee, February 22, 1988). However, because the DO deficits in the Ohio are generally lower than those that cause TVA to be concerned, somewhat lower oxygen transfer efficiencies (15-30 percent) can be expected at the proposed projects. Even lower transfer efficiencies can be expected for tailrace aeration because the air bubbles would be at lower pressures (being injected at shallower depths) and would be trapped in the water for less time.

If 20 percent of the oxygen provided by the aeration system is dissolved, approximately 1,000 standard cubic feet per minute of air supply is required for each 1,000 cfs of river flow for each 1 mg/L the DO is increased. Therefore, to increase the DO concentration by 1 mg/L at the August mean flow on the Ohio at Pittsburgh (13,000 cfs) with an oxygen transfer efficiency of 20 percent, the aeration system would require 13,000 standard cubic feet per minute. Relatively high air pressures would be required because of the depth to which the turbines are submerged. Compressors that can provide this much aeration are estimated to cost between $150,000 and $200,000, require 1,000 to 1,500 kilowatts to operate, and may be expensive enough to eliminate the profitability of aeration when compared to spill flows.

The proposed mechanical aeration, if proven technically and economically feasible, may offer the ability to generate power under conditions when the plants would otherwise cause unacceptable degradation of DO concentrations. Mechanical aeration may also offer the ability to provide aeration at dams that provided little aeration even without hydropower. The feasibility of mechanical aeration should be determined. However, because the feasibility of mechanical aeration has not been proven, it cannot be assumed to be an adequate measure to mitigate the loss of aeration caused by hydropower generation.

Some developers have proposed basing spill flows on instantaneous DO and temperature conditions, using electronic monitors to measure DO and determine if spill flow is necessary. Such "real-time" monitoring and mitigation systems would be effective only if they account for the cumulative effects of all interacting projects in the basin and only if DO concentrations throughout the basin are known continuously. For example, a project that operates using a real-time monitor downstream of the dam to maintain DO concentrations above a certain standard may still cause DO decreases sufficient to cause violations of the standard below other dams downstream. A real-time monitoring system that considers basin-wide conditions in determining spill flows at individual dams offers the advantages of allowing higher power generation (because spill flows are based on the current conditions, not on conservative design conditions) and better water quality management.

4.1.1.2 Toxic compounds

Volatile compounds, such as organic solvents, many aromatic hydrocarbons, trihalomethanes, and ammonia, can be removed from water by mixing with air. The rate at which such compounds leave the water is limited by the amount of mixing in the water and by the surface area between air and water. Dams that provide much mixing and aeration can be expected to volatilize compounds at a much higher rate than would occur over the same time in the pools. In general, dams that provide good aeration (Section 4.1.1.1) are expected to be efficient at stripping volatile compounds from the water, and dams that are poor aerators because little air entrainment occurs are expected to have negligible effects on volatile compound concentrations. However, it is not expected that the volatile stripping rates of dams would be directly proportional to the aeration rates because the deep plunging of air bubbles, which promotes transfer of oxygen from the air into the water, could inhibit transfer of volatiles from the water to the air. As with aeration, diversion of the river flow through the proposed power plants would eliminate at least some of a dam's ability to strip volatile compounds.

It is not known whether the amount of volatiles stripped from the water at dams is significant compared to total river concentrations. Although ORSANCO monitors the concentrations of many volatile compounds, there are no adequate data to estimate the rate at which any of the dams in the study area remove volatile compounds.

Although no data are available to quantify the impact of the proposed projects on the concentrations of volatile compounds, the loss of stripping at dams is a well-defined mechanism which could contribute to such impacts. Therefore, it is reasonable to assume that the projects, as proposed, would decrease the removal rate of volatile compounds from the rivers, resulting in increased concentrations of such compounds. The greatest changes are expected to be in the same areas where project impacts on DO concentrations are the greatest (Section 4.1.1.1). The ambient and drinking water limits for many volatile compounds are extremely low, so that almost any detectable concentrations are of concern to water management agencies. Although concentrations of volatile compounds are relatively low in the Ohio River system, any increase in concentration would be of significant concern because of the high toxicity of some of these compounds. The compound of most concern is chloroform, because (a) it is highly volatile and can be expected to be removed at dams, and (b) it is the compound for which the health criteria is most commonly exceeded (ORSANCO, 1987b).

Reductions in pool elevations caused by hydropower projects at fixed-crest dams (Section 4.1.5.2) could increase the rate at which groundwater flows into the river. Lowering the pool elevation increases the gradient in elevation between the adjacent groundwater and the river. If the river banks are relatively porous, significant rates of groundwater flow into the river can occur, especially when pool elevations are low. In situations where the shallow groundwater adjacent to the river is contaminated with toxic compounds, in a pool controlled by a fixed-crest dam where hydropower is installed, the lowering of pool elevations could increase rates at which the toxic compounds enter the river. The installation of flashboards or crest gates would mitigate this potential impact by preventing the lowering of pool elevations. The proposed project sites where this potential impact could occur are Allegheny L&Ds 7, 4, and 2; and Dashields (the proposed project at Allegheny L&D 3 includes flashboards or crest gates).

ORSANCO is currently studying the effects of contaminated groundwater on water quality in the Ohio and its tributaries, as part of their Toxic Substances Control Program. There are several locations where known groundwater contamination occurs in pools that could be lowered by the proposed projects. At Neville Island in the Dashields pool, contamination from a chemical plant, petroleum terminals, and a waste dump site affects water quality (personal communication, S. Harper, Pennsylvania Department of Environmental Resources, Sept. 6, 1988). A chemical plant near Allegheny RM10, in the Allegheny L&D 3 pool, has contaminated groundwater adjacent to the river (personal communication, A. M. Tempero, Pennsylvania Department of Environmental Resources, Sept. 7, 1988).

4.1.1.3 Sediments

River sediments could be resuspended into the water column in several ways by the construction and operation of the proposed hydropower projects. Suspension of sediments into the water can result in the sediments being redeposited in undesirable locations, and in water quality degradation if the sediments are contaminated. According to data collected by the Corps (Corps, 1981; and unpublished data Corps collected by the Huntington and Pittsburgh districts) in support of their channel maintenance programs, sediment contamination is not a severe and widespread problem in the upper Ohio River basin. However, pockets of contamination have been found, and the deep, slow moving water above the navigation dams is a likely place for contaminated sediments to collect. In addition, several of the proposed projects are proposed to be constructed at heavily industrialized sites where contamination of sediments and the river banks is likely.

Construction of the hydropower projects would require excavation of large amounts of river material (Section 4.1.6) and disturbance of the river bottom near the powerhouse site. Since construction would occur partly in the area above the dam and along the bank where sediments are likely to collect, the possibility of resuspension of potentially contaminated sediments exists.

Hydropower projects at fixed-crest dams would reduce the normal pool elevation above the dam (Section 4.1.5). This reduction in pool elevation may increase the need for channel maintenance dredging in places. However, the amount of additional dredging is expected to be minor because the projects would not lower pool elevations below their present low-flow elevations and because the bed of the Allegheny River, where most of the fixed-crest dams are located, is relatively stable. Channel maintenance dredging causes water quality impacts such as sedimentation (Corps, 1975), so any additional dredging caused by the operation of hydropower at fixed-crest dams may affect water quality.

The reduction in pool elevations at fixed-crest dams also increases the river's velocity and sediment transport capacity pool (Section 4.1.5).

These potential sources of sediment resuspension and movement of contaminated sediments could cause local impacts at all the powerhouse sites and minor changes in sediment movement throughout the navigation channel of the Allegheny River and the Dashields pool of the Ohio River. Compliance with dredging permit requirements under Section 404 of the Clean Water Act should prevent significant spreading of contaminated sediments.

4.1.2 Fisheries

4.1.2.1 Assessing the Impact of Dissolved Oxygen Change on Fish

Oxygen is necessary for respiration and metabolism of aquatic organisms. The needed oxygen is extracted from that dissolved in the water; the amount of DO in water varies with the water temperature, the amount of oxygen-consuming materials in the water including the fish, and the sources of replenishment for oxygen consumed (Sections 3.1.1 and 4.1.1). The need for DO by fish and other aquatic life is generally greatest in summer when water temperatures, and thus metabolic rates, are highest. This is also a time when DO is usually lowest in the water because its physical solubility is lower at higher temperatures and because the oxygen is consumed at the highest rates then by all components of the aquatic ecosystem.

As discussed in Section 4.1.1, development of hydroelectric facilities at navigation dams on the upper Ohio River system has the potential for reducing DO concentrations available to aquatic life, largely through reduction in oxygen replenishment (aeration) at dams. A 3-tiered approach is taken to analyze the impacts of reduced DO content of river water on fishes (for additional discussion of the methodology see Appendix E). Effects of DO change on freshwater mussels is discussed in Section 4.1.2.5 and Appendix I. The three tiers range from a simple standards-based approach at the lowest tier to an integrative and quantitative modeling approach at the third tier. Tier 3 includes many biological and environmental variables that interact to determine effects of lowered DO concentration on fish growth. For each tier, three DO cases were analyzed, corresponding to the cases in Section 4.1.1. The first case is the 7Q10 condition of low summer flows. This set of conditions could occur at any time in July, August, or early September, although we have assumed it to occur in July, with the remainder of the summer the same as Case 2. The second case is one of summer moderate flow conditions that might occur continuously for the whole July through September period. The third case considers the historical monthly average conditions of flow, temperature, DO, and other environmental variables.

4.1.2.1.1 State Standards (Tier 1)

The first, most simple, tier is to compare predicted DO concentrations (Section 4.1.1) with applicable state water quality standards. DO standards enforced by the states are designed to reflect the needs of aquatic life as reviewed by a National Technical Advisory Committee in the late 1960s (FWPCA, 1986) and the National Academy of Sciences/National Academy of Engineering in the early 1970s (NAS/NAE, 1973). Most state standards still reflect scientific judgement as of those dates. A classic study of DO concentrations and aquatic life conducted in the Ohio River established the notion that 5 mg/L was the boundary condition between little fish life and a reasonably productive community of mixed warmwater species (Brinley, 1944, as cited in USEPA, 1986). In Pennsylvania, Ohio, and West Virginia, the current DO standard is 5 mg/L.

Case 1 (7Q10 conditions)

In the Allegheny River (Figure 4.1.1-2), all plants will operate at these low flows; there will be depressions in oxygen concentration below Allegheny L&D No. 4, but it is not predicted to fall below the standard. Under extreme high-temperature, low-flow summer conditions, DO concentration in the Monongahela River (Figure 4.1.1-3) can now fall below the 5.0 mg/L standard for protection of aquatic life in the deeper water of Opekiska and Hildebrand pools due to the deep, hypoxic discharges from Opekiska L&D (to a low of about 3.5 mg/L; Section 4.1.1). Because all hydropower facilities on the Monongahela River propose to cease operation at the 7Q10 flows, the existing condition will remain unchanged for this case. DO concentrations in the mainstem Ohio River (Figure 4.1.1-4) can fall below the standard without hydropower (to about 4.3 to 4.5 mg/L) in two reaches of the study area—the lower Montgomery pool (about 10 miles) and the reach between the lower Belleville pool and the middle of the Gallipolis pool (about 60 miles). Hydropower installations operating at these flows (Section 4.1.1.1) would further depress concentrations in each of these reaches (to 3.7-3.9 mg/L) and lengthen the distance over which the standard is violated (to about 20 and 70 miles, respectively). The greatest change over the greatest area will be in the Montgomery pool.

Case 2 (Summer Moderate Flow conditions)

The 5 mg/L DO standard is not violated under these conditions anywhere in the study reach (Section 4.1.1). In the Monongahela River (Figure 4.1.1-6), no values fall below the standard, despite DO depression below the pre-hydropower condition in the reach from the Hildebrand discharge to the mouth. Conditions for aquatic life in the Hildebrand pool are improved from the near-standard, pre-hydropower condition. Likewise in the Allegheny River (Figure 4.1.1-5) and the Ohio River (Figure 4.1.1-7), no standard violation is projected at these flows even though depressed oxygen conditions at Allegheny L&D No. 4 pool after hydropower installation are retained to the mouth and continue through the whole of the Ohio River past Gallipolis.

Case 3 (Average conditions)

No DO concentrations in the upper Ohio River system (either currently or as depressed with proposed hydroelectric installations) would fall below state standards of 5.0 mg/L under the monthly average flow and temperature conditions (Figures B-9 to B-17 in Appendix B).

Summary: Meeting State Standards

Hydropower development as proposed would cause unacceptably adverse degradation of DO concentrations to below minimum State standards for protection of aquatic life in the Ohio River under 7Q10 low flow conditions. An alternative development and operation plan will be necessary to protect aquatic life at these or lower flows.

4.1.2.1.2 Current Dissolved Oxygen Criteria (Tier 2)

The second analytical tier compares the estimated DO concentrations along the river length to the data presented in the latest USEPA water quality criteria document for DO (USEPA, 1986). This criteria document includes species-specific data on the life stages generally thought to be most sensitive to low oxygen content of water (juveniles), and it recommends levels of protection more stringent than current state standards. Both survival and growth rate are used as indicators of impairment.

Over the past several years, there have been several water quality criteria documents that have reviewed DO effects data and derived guidelines for protecting fishes. These documents differ in concentrations recommended and the time-frame over which measurements are made (e.g., instantaneous low, 7-day average, running 5-day averages, etc.). Even the latest document (USEPA 1986) contains inconsistencies, as has been pointed out by applicants in their comments on the DEIS. It was beyond the scope of the EIS to reevaluate the quality of all research that has contributed to DO criteria for aquatic life or to reanalyze all of the criteria documents. Staff thus has accepted the values of USEPA (1986), after consultation with its author, as benchmarks for this evaluation.

Data on effects of DO on survival and growth of nonsalmonid, warm-water, and cool-water fishes typical of the study area show some species to be relatively tolerant; whereas, others are nontolerant (USEPA, 1986). Figure 4.1.2-1 illustrates survival data for the most sensitive stages of selected warm-water and cool-water fishes and illustrates variation among species. Among the more tolerant game species important in the Ohio River system are the largemouth bass and white bass. Nontolerant species include channel catfish, walleye, northern pike, and smallmouth bass. These experimental results are consistent with observations in the Ohio River system that gradual improvements in water quality, especially in DO concentrations, over the past two decades have been paralleled by expansion of populations of these more sensitive species (Pearson and Krumholz, 1984). These are the species, including the sauger for which there are little experimental data, that would most likely be depressed or lost by a return to low oxygen concentrations in the Ohio River.

The following list indicates levels of impairment to be expected for fishes at two age classes in nonsalmonid waters at different DO concentrations (USEPA, 1986):

a. Early Life Stages

- No production impairment = 6.5 and above
- Slight production impairment = 5.5
- Moderate production impairment = 5.0
- Severe production impairment = 4.5
- Limit to avoid acute mortality = 4.0

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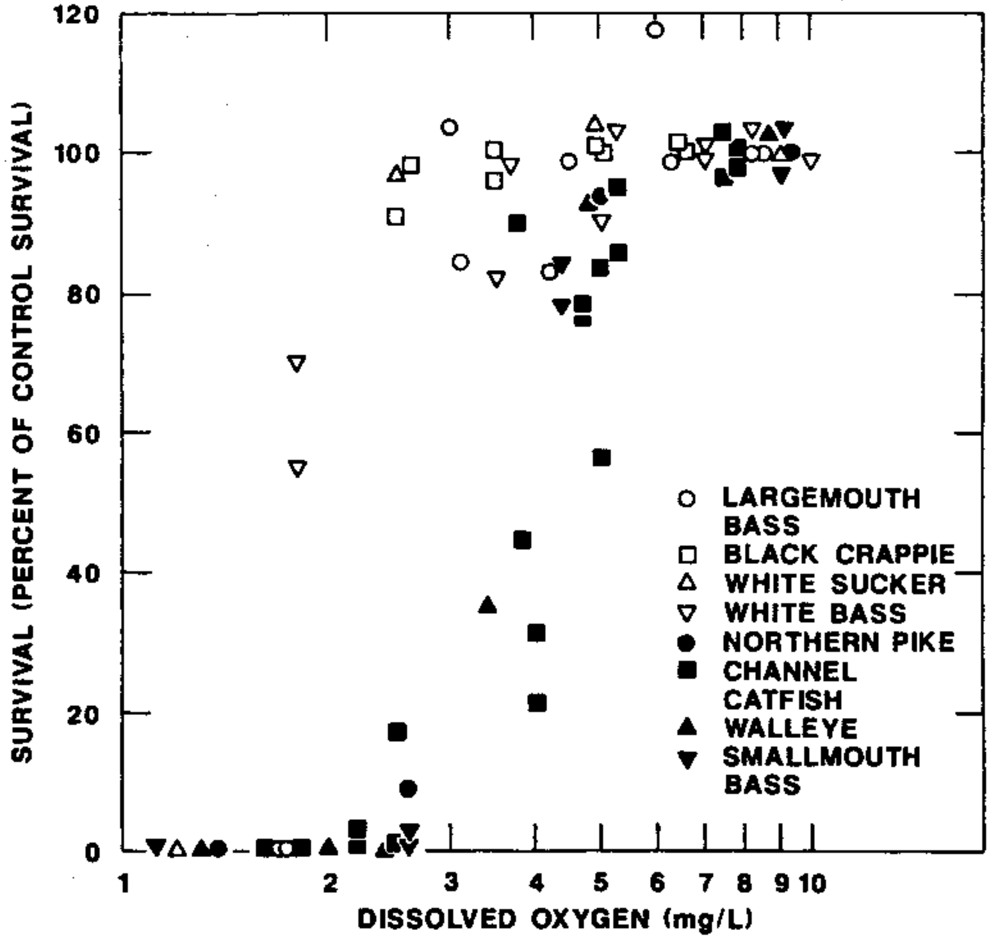

Figure 4.1.2-1. Effect of continuous exposure to various mean dissolved oxygen concentrations on survival of embryonic and larval stages of eight species of nonsalmonid fish. Minimal DO recorded in these tests averaged about 0.3 mg/l below the mean concentrations. From EPA 1986.

b. Other Life Stages

- No production impairment = 6.0 and above
- Slight production impairment = 5.0
- Moderate production impairment = 4.0
- Severe production impairment = 3.5
- Limit to avoid acute mortality = 3.0

Case 1 (7Q10 conditions)

In the Allegheny River, both pre- and post hydropower conditions depress oxygen concentrations below 6.5 mg/L in the lower pools of Allegheny L&D Nos. 4, 5, and 6 (Figure 4.1.1-2). Addition of hydropower causes values to stay below the 6.5 mg/L level, suggesting slight impairment of early life stages, until Allegheny L&D No. 2. Under current low-flow conditions, the Monongahela River is predicted to fall below 6.5 mg/L from the Opekiska pool to Point Marion, in the upper Maxwell pool, and in the Emsworth pool (Figure 4.1.1-3). In this length, concentrations in the lower Hildebrand pool drop to levels causing acute mortality of early life stages and moderate production impairment of other life stages (3.6 mg/L). Because hydropower facilities would not operate during the 7Q10 conditions, there would be no change.

Except for isolated sections (near Emsworth and in the approximately 50-mile New Cumberland-to-mid Hannibal pool reach), most of the Ohio River now falls below the 6.5 mg/L level for slight impairment of early life stages of fish during summer low flow conditions (Figure 4.1.1-4). This situation is made more acute with reduced aeration caused by hydropower facilities. Reaches generally between Dashields and New Cumberland (approximately 50 miles) fall in the range of moderate to severe impairment without hydropower and into the range of acute mortality (about 10 miles of the Montgomery pool) with hydropower. Lack of aeration at Belleville with hydropower (even though this is not a particularly good aerator; Section 4.4.1) may, assuming zero aeration at the hydropower facility, extend a 10-mile reach of severe impairment of early life stages to about 30 miles and creates a short zone of acute mortality. Hydropower facilities at Gallipolis may extend the zone of moderate production impairment downstream by about 25 miles. Downstream of about RM 200, however, predicted changes in DO are less than model uncertainty (Section 4.1.1).

The DO concentrations and effects just described only consider conditions averaged across the channel and may not adequately represent other fish habitats. Weedbeds, for example, can have daily fluctuations in oxygen concentration that extend to lower levels at night than in the general waterbody. A depression of open-water concentrations of DO (as reflected in the DO model runs) may cause values in these other fish habitats to sink to more damaging levels.

Case 2 (Summer moderate flow)

Summer moderate flows and temperatures, at which all plants on the system are proposed to operate, would result in reduction in DO to less severely damaging levels for biota in the Allegheny and Ohio Rivers that the summer low flows (7Q10), but over a longer river length. There would also be effects on the Monongahela River. DO depression is generally into the zone of slight production impairment for early life stages, i.e., between 5.5 and 6.5 mg/L (Figures 4.1.1-5 through 4.1.1-7).

In the Allegheny River, hydropower as proposed keeps DO concentrations in the 5.5 to 6.5 mg/L range of slight impairment downstream of the Allegheny L&D No. 7 pool, amounting to nearly 50 miles (Figure 4.1.1-5). Without hydropower as proposed, only the upper half of this reach is in the growth impairment range, with reaeration at L&D No. 4 and downstream raising DO levels to satisfactory levels for biota (>6.5 mg/L).

On the Monongahela River, hydropower as proposed in summer would cause DO concentrations to rise in the Hildebrand pool (a benefit) but to fall into the range of slight impairment below 6.5 mg/L in the 18-mile reach between the Hildebrand Dam tailwater and Monongahela L&D No. 7 (Figure 4.1.1-6). The decline is largely due to downstream transport, with little areation, of the hypoxic deep water (hypolimnion) of the Opekiska pool. Hydropower also reduces DO into the range of slight production impairment of early life stages of fish in the 25-mile reach between the lower Maxwell pool and Monongahela L&D No. 4.

DO concentrations in the upper Ohio River would be entirely below 6.5 mg/L (in the range of slight impairment for early life stages) with development of hydropower as proposed. This amounts to significant degradation of about 200 miles of river that is now within non-impairing DO concentrations for aquatic life, i.e., from Pittsburgh to Belleville L&D. There could be a fraction of a mg/L reduction of DO from Belleville L&D downstream, all within the range of slight impairment, although the DO modeling estimates are imprecise at this point.

Case 3 (Monthly average conditions)

The Allegheny River monthly average DO concentrations (Figures B-9 to B-11) decrease to just the top of the zone of slight production impairment for fish early life stages (6.5 mg/L) in August in the pool of Allegheny L&D No. 2. By this time, most young fish may have entered the more tolerant older life stages. Other concentrations throughout the year are above the levels causing impairment. In contrast, without hydropower no concentrations are in the zone causing any production impairment.

Monthly average DO in the Monongahela River (Figure B-12 to B-14 in Appendix B) is in the zone of slight production impairment for early life stages (5.5-6.5 mg/L) in July and August in the reach from the Opekiska tailwater to Monongahela L&D No. 7. The pattern of production-suppressing water quality for early life stages continues in September between Opekiska and Morgantown, although fish will be older and more tolerant by this time. Without hydropower, only the Opekiska tailwater and the Hildebrand pool are in the zone of impairment, which occurs during July through September.

Hydropower generation as proposed in the mainstem Ohio River would lower DO concentrations sufficiently, even under monthly average conditions, to induce slight production impairment for early life stages of fish over extensive reaches in summer (Figures B-15 to B-17). The growth-depressing condition attributable to hydropower development would be most pronounced from the mid-Montgomery pool to Racine. The cumulative effect further depresses DO and thus fish production in the Belleville-to-Gallipolis reach; these minor effects persist below Gallipolis, although the extent has not been determined.

Under current monthly average conditions without hydropower, concentrations fall below 6.5 mg/L (into the zone of slight production impairment) from the lower Racine pool to the lower Gallipolis pool (about 50 miles), with oxygen concentrations higher than 6.5 mg/L in the Gallipolis tailwater (Figures B-15 to B-17). With hydropower as proposed, DO is projected to fall to the 6.5 mg/L level or slightly below by June from upstream of the Racine L&D to the Gallipolis L&D (about 100 miles). By July, all of the upper Ohio River below the middle of the Montgomery pool falls below 6.5 mg/L and in the zone of slight impairment in fish production (greater than 5.5). This is a period of abundant early life stages of fish of many species (Figure 3.1.4-2). The production-depressing water quality condition persists in August and September (although the Willow Island L&D tailwater is generally close to or slightly above 6.5 mg/L). Suitability of monthly average water quality for fish improves in late summer both because of rising DO levels in September and October and the growth of fishes to ages that are more tolerant of low DO. Assuming that all fish are older than the "early life stages" by September, DO levels that are in the 6.0 to 6.5 mg/L range then would not cause production impairment by these tier 2 criteria.

Summary: Meeting Current D.O. Criteria

Hydroelectric development, as proposed, has the potential for reducing DO concentrations to acutely lethal conditions for early life stages of fishes over about 10 miles below Dashields L&D and for a shorter distance below Belleville L&D should low flows and high temperatures match the 7Q10 conditions in early summer. Under these conditions, the lower Allegheny River would experience concentrations that fall in the zone of slight production impairment.

Under more typical summer low flows, hydropower as proposed would cause less severe conditions for fish (generally only a depression of oxygen concentrations into the range of slight production impairment of early life stages), but the effect would be over a much longer river length. In the Monongahela River, the hypoxia of Opekiska pool is propagated downstream, causing slight production impairment over about 50 additional miles. The lower Allegheny River would see additional slight production impairment over 25 additional miles. The Ohio River would see the entire 200-mile reach from Pittsburgh to Belleville fall into the range of slight production impairment for early life stages, and some additional depression of production as far downstream below Gallipolis as these analyses were conducted.

These conditions were projected to include the seasonal changes in the environment and fish through the summer period, using monthly average conditions as the example. Hydropower development induces an earlier suppression of production (June) and extends the duration of production suppression for any early life stages present in September. Additional production impairment attributable to hydropower is most severe in the early summer when early life stages of fish are present (older stages are more tolerant of low DO). Therefore, hydroelectric development as proposed is judged to be significantly adverse by staff on the basis of the best current biological criteria for effects of lowered DO concentration.

4.1.2.1.3 Growth Model (Tier 3)

A drawback to the second tier of analysis is the inability to quantify impairment in fish production more than in general categories. These categories tend to be unrealistically discrete (i.e., specific DO concentrations often measured over somewhat arbitrary time periods). A more continuous measure, integrated over long time periods, would be preferable for predicting impacts. Even slight impairment of growth rate is acknowledged to have the potential for large decreases in accumulated annual growth, if the duration of impairment is long enough (USEPA, 1986). Water temperature, which varies seasonally and across the study region, has an important effect on fish production, with higher temperatures exacerbating the adverse effects of low DO on growth rate of fish (USEPA, 1986). It is, therefore, of interest to know in greater detail how much impairment might occur over an annual growing season (even in general terms for the open water condition) so that the relative impacts of hydropower scenarios might be judged for significance.

The third tier of analysis for DO effects on fishes invoked bioenergetics modeling as a means of developing quantitative estimates of relative production impairment for different scenarios over an annual growing season. The energetics of juvenile fish growth is dependant on oxygen concentration, temperature, fish size, and other water quality features such as dissolved ammonia concentration (as well as food supply). Growth was modeled to estimate relative magnitudes of fish biomass production over a typical growing season under current conditions and with projected effects of several alternative hydroelectric development scenarios on DO concentrations of the upper Ohio River system. Bioenergetics models have attained widespread use for estimating impacts of environmental conditions on fishes. Staff used the model of Cuenco et al. (1985a,b,c) originally developed for pond culture of channel catfish, one of the species in the study area that is sensitive to low DO (see Appendix B).

For purposes of this assessment, the upper Ohio River system is considered to be composed of 55 "ponds," each either the upper or lower half of a navigation pool. The upper half is the tailwater of the upstream dam (at present often having DO values elevated above those in the lower section because of aeration at many dams). Water quality input values for the fish growth model (Section 4.1.1) were averaged within the half-pools. Daily DO values for these segments of the upper Ohio River system as estimated by water quality modeling for various flow conditions and the no-hydropower and operating scenarios (Section 4.1.1) drove the fish growth model. DO was estimated at representative times over the fish growing season, allowing interpolation of daily DO values. The summer low- flow, high-temperature condition (Case 1; 7Q10) was assumed to occur in July; the summer moderate-flow condition (Case 2) was assumed to occur throughout July-September, monthly average conditions were used for other times. Temperatures used in the water quality modeling were also used for estimating fish growth.

A hatch of juvenile fish prior to the summer-fall critical period for DO in the system was assumed in each half-pool according to the life history of the fish species. For simplicity, 3-gram fish (ave) were assumed at the start. The growth of a sample population of fish in each half-pool was followed through the growing season as the half-pool's temperatures and DO concentrations for the modeled scenario changed.

Each half-pool "pond" ended the growing season with a set of values describing growth of the DO-sensitive juvenile fish there, including channel catfish (for which the model was initially parameterized by Cuenco et al. 1985a, b, c) and a generalized cool-water fish species such as sauger or walleye. Differences in total accumulated biomass, as a percent reduction in fish growth with hydropower development compared to the existing conditions, was plotted along the river system on figures that paralleled the oxygen sag curves (Figures 4.1.2-2 and 4.1.2-3).

The model is used as a comparative measure of relative fish growth performance under different scenarios. It can be argued that a model developed and validated for ponds cannot

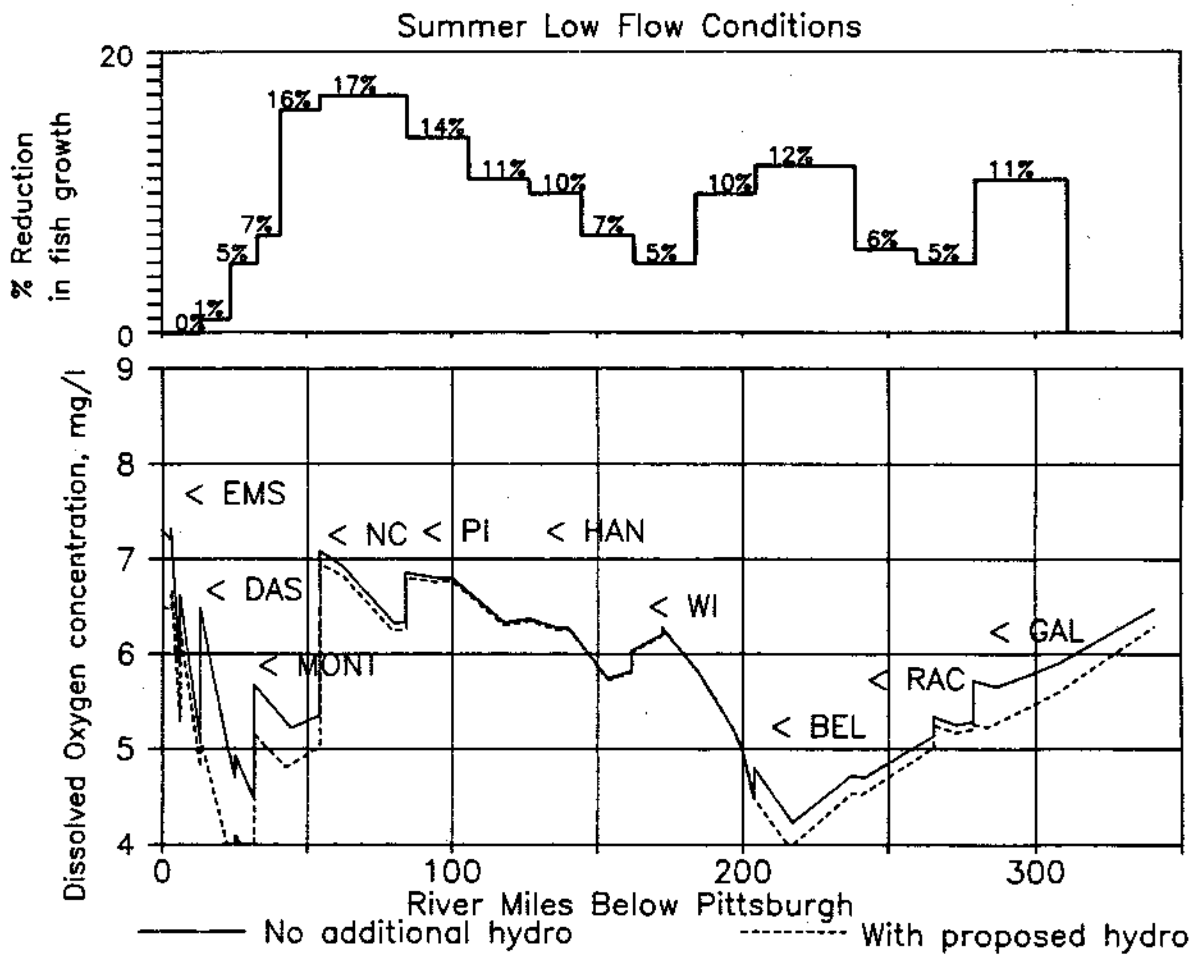

Figure 4.1.2-2. Percent reduction in annual catfish growth on the Ohio River as estimated by a bioenergetic model for summer low flow conditions for projects as proposed, shown with DO concentrations for the respective river reaches. Locks and Dams are indicated by arrows. The summer low flow conditions shown in the lower panel were assumed to occur for one week in July. During the remainder of July-September, the summer moderate flow conditions were followed (Figure 4.1.2-3). Historic monthly average conditions were used in June and October-November.

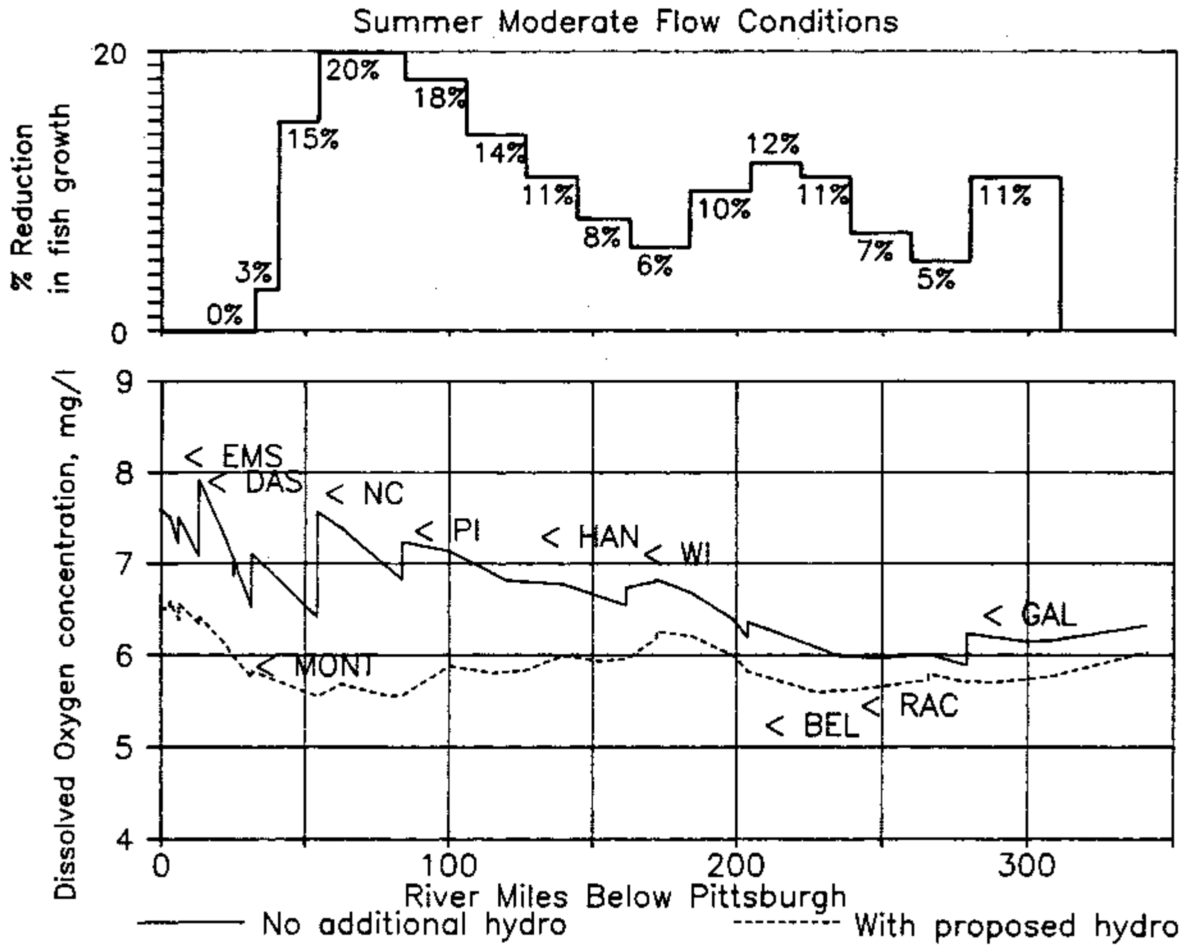

Figure 4.1.2-3. Percent reduction in annual catfish growth on the Ohio River as estimated by a bioenergetic model for summer moderate flow conditions for projects as proposed, shown with DO concentrations for the respective river reaches. Locks and Dams are indicated by arrows. Summer moderate flow conditions were assumed to occur throughout July-September, with historic monthly average conditions in June and October-November.

truly simulate the Ohio River. This is true. However, the environmental factors influencing growth are of the same types. When the model structure and its assumptions are kept the same, runs with different input values for DO, temperature, etc. can provide useful comparisons without intending to fully reproduce the new environment. Such comparative runs were made for the Ohio River using different scenarios, principally with changes in DO. The actual values of biomass production are not important and do not reproduce actual values for the Ohio. The relative results are important for these analyses (Appendix E).

Case 1 (Summer low flow; 7Q10)

For this case, a seasonal curve of DO concentrations and temperatures was created for each segment that represented normal moderate summer flows (Figures 4.1.1-5 to 4.1.1-7) punctuated by one week of extreme low flows (7Q10; Figures 4.1.1-2 to 4.1.1-4) in July. The seasonal cycle was completed by the monthly average conditions in April, May, half of June, half of September, October, and November (Figures B-9 to B-17, Appendix B). Summer moderate-flow conditions occurred in the second half of June, 3 weeks in July, all of August, and half of September. Because many hydropower facilities would not operate in the extreme low flow conditions (Section 4.1.1) the DO concentrations were often better for fish growth in the extreme week than under the normal moderate flow conditions when all plants would operate.

The Ohio River showed the only significant adverse change in annual accumulated growth of channel catfish between the no hydropower and with hydropower scenarios (Figure 4.1.2-2). Despite the shutdown of many plants in the extreme low-flow conditions, the general summer low flows caused reductions in accumulated annual growth of this species of up to 18 percent, which staff considers a significant adverse change. The most severe growth suppression was in the reach between New Cumberland L&D tailwater and Pike Island L&D tailwater. A suppression of annual channel catfish growth amounting to more than 10 percent due to operation of upstream hydroelectric facilities was indicated for water leaving the study area at the Gallipolis tailwater (although the accuracy of DO estimates at this point is low; Section 4.1.1).

When the model was run for a representative cool-water fish, growth suppression by hydropower as proposed was evident on both the Allegheny and Ohio Rivers. Growth was suppressed by nearly 20 percent downstream of Allegheny L&D No. 4, and by 33 percent at the river mouth. In the Ohio, the pattern of growth suppression along the river length was similar to that for channel catfish although it was as great as 36 percent and often more than 25 percent.

Case 2 (Summer moderate flow)

For this more typical summer low water case, an annual curve of DO concentrations and temperatures was created for each segment that represented normal moderately low summer flows (Figures 4.1.1-5 to 4.1.1-7) from mid-June to mid-September. The seasonal cycle was composed of the monthly average conditions in April, May, half of June, half of September, October, and November (Figures B-9 to B-17).

There was a maximum loss of 2 percent of annual catfish growth in the lower Allegheny River but 33 percent loss of growth of cool-water fish. Suppression of channel catfish growth amounting to 4 to 9 percent and of cold-water fish amounting to 25 percent was evident in the DO sag zone of the Hildebrand pool and tailwater of the Monongahela River. In the Ohio River, loss of annual catfish growth from hydroelectric development amounting to up to 20 percent was evident (Figure 4.1.2-3). The greatest deterioration occurred between the New Cumberland pool and Pike Island tailwater, although greater than 10 percent growth suppression was evident below Belleville L&D and again below Gallipolis L&D. The pattern was similar for the Ohio when the growth model was run with parameters for a typical cool-water fish; annual reduction in growth in the New Cumberland - Pike Island reach was as great as 36 percent, with most of the 300 miles showing growth reductions of more than 15 percent. Staff considers these losses to be an adverse and significant change.

Case 3 (Monthly average conditions)

Under monthly average conditions of temperature and estimated DO in each of the three rivers, the bioenergetics model predicts no differences in accumulated annual growth of channel catfish between the scenarios of no-hydropower and with hydropower as proposed. There are differences, however, from the cooler headwaters to the lower Ohio River, due to a longitudinal gradient in temperature. Although DO values are often lower in the with-hydropower scenario, they are insufficiently low to trigger oxygen-related growth suppression of this species in the model. The model was not run for a cool-water fish.

Summary: Growth Model

Integration of estimated DO concentrations with other factors that influence fish growth over an annual cycle has shown significantly adverse growth suppression for the moderately low flow summer condition with hydropower as proposed. Cessation of generation during 7Q10 extremes fails to change the pattern markedly.

4.1.2.2 Tailwater Habitat Evaluation

Tailwaters of navigation dams now provide nearly the only rapids-like habitat in the upper Ohio River system, which has been converted to a stairstep of pools. As such, tailwaters have been categorized by the U. S. Fish and Wildlife Service (USFWS) as Resource Category 2 (habitat that is of high value and is relatively scarce or becoming scarce).

There will be a general change in flow regimes downstream of the navigation dams where hydroelectric projects are operated. Currently, flows predominate over the full width of the dam (at fixed-crest dams) or across much of the width according to the choice of gates opened (at gated dams). With hydropower development, the tailwater flow during significant periods of the year (moderately low flow periods of summer and fall, especially) will occur mostly along the river side occupied by the powerhouse (Figures 4.1.5-1, 4.1.5-2, and 4.1.5-3). The discharge from the powerhouse will flow as a broad fan oblique to the river channel and fill the river at a distance downstream approximately equal to the length of the dam. Under most lower-flow conditions at most sites, a slowly recirculating back eddy will be formed along the dam face where there had been higher flows. A similar condition occurs now when gates are opened only at one end of a gated dam. At high and low flows (turbine operations are curtailed at most dams during lowest flows), water will flow through gates and over fixed crests in the normal manner. These flows will periodically scour the substrate and maintain the typical rocky tailwater bottom.

Typically, tailwater habitat consists of a deep scour zone followed by a shallow shoal or rapids prior to the deeper and slower-moving downstream pool. The scour zone extends about 200 feet downstream of the dam; bottom material is large rock or bedrock (based on bottom profiles that were supplied by most applicants). Downstream of this scour zone is a shallower shoal composed of gravel and having typical riffle characteristics of rapid water flow (this shoal may have islands that extend above the normal river elevation). Beyond this zone, the water deepens again, velocity slows, and bottom materials are sand, silt, and mud. Turbine discharges are generally proposed to reenter the river at the point where the scour zone shallows to form the shoal area. At some sites, the shoal will need to be dredged for construction of the tailrace; elsewhere, the flow is released to find its own return channel across the shoal or into the deeper scour zone along the dam face.

All river flow will not flow through turbines at all times, however. Minimum flows at some of the proposed projects are to be maintained through gates or over fixed crests during low-flow periods, but these are unlikely to be sufficient to generate currents in the tailwaters comparable to present conditions. During parts of the year, flows will exceed powerhouse capacities, and flow will continue over dam crests and through gates, with the specific annual cycle depending on the particular hydropower facility's capacity and the river flows. Some projects anticipate ceasing operation at low flows, thus causing areal shifts in flow distribution in tailwaters. Such shifts will also occur when units are removed from service for repairs or modifications, which occurs often at existing plants.

These changes in areal and temporal distribution of flow velocities will affect suitability of the tailwater habitat for certain fishes. Tailwaters now attract sauger, walleye, and white bass; certain species prominent in all habitats of the rivers are also found there (e.g., freshwater drum and channel catfish). Upstream migrations for spawning in spring cause most of these species and paddlefish, which are spreading upriver, to concentrate in rapidly-flowing tailwaters. Indications of flow velocities suitable for many fish species in the upper Ohio River system (primarily adults) are found in Habitat Suitability Index Models published by the USFWS. The art of such habitat suitability quantification is, however, in its infancy.

Considering that hydroelectric developments are proposed for nearly all navigation dams on the upper Ohio River system and that the tailwaters are the locations of the most intense fisheries, alteration of tailwater habitats throughout the river system might cause a significant adverse fish habitat change. For estimating impacts, the turbine tailwaters must be compared with the existing regimes, which often include restricting flows to one or a few dam gates. For mitigation, the value and location of fishery enhancements will be determined, in part, by their relation to zones of fish-attracting flows.

Quantification of tailwater habitat loss can be addressed in two parts: (1) estimating the flow regimes of tailwaters, and (2) interpreting the changes in flows in the light of habitat suitability criteria for the important fish species.

4.1.2.2.1 Estimating Flow Regimes of Tailwaters

Tailwater flow regimes for proposed hydropower projects can be estimated by analogy with other projects for which detailed hydraulic information has been developed (e.g., the Racine and New Martinsville projects) and by predictive mathematical models. Two-dimensional, mathematical flow models for rivers are available for applications such as dam tailwaters (e.g., Yeh, 1980; Normandeau Associates, 1986a). These models use shoreline and bottom topography, volume of river flow, and locations of intakes and discharges to calculate vertically-averaged flow vectors and speeds. An analysis would include the present and modified regimes at several typical river discharge rates. A graphical presentation of this type of analysis gives a striking perspective on probable flow changes at a site (Figure 4.1.2-4).

Site-specific mathematical modeling is not needed at each site to develop a general understanding of major habitat change in the upper Ohio River system. Many projects have essentially the same project configuration and downstream channel geometry, and flows would be little different from one project to another. Proposed projects can be compared to models of a generic condition and developed sites to provide order-of-magnitude estimates.

Tailwater velocity regimes vary greatly depending on river flow. The Corps operates gates alone or in groups and at different degrees of opening to accommodate a wide variety of river discharges. With few gates open, the tailwater may resemble the discharge from a hydropower turbine. Thus, the departure from normal after hydropower is installed may simply be the location of discharge.

Individual site effects differ where unique features of the river channel deviate markedly from the norm. Such deviations include downstream islands and gravel bars. In these cases, the hydraulic flow analysis is useful also for estimating the potential for erosion or deposition, impacts on wetlands, and obstacles to river navigation. Section 3.1.4 described such special features at each project tailwater. The Corps requires that the physical hydraulic models be constructed and tested to closely describe tailwater flow regimes. These models will assist in final design of tailwaters, including appropriate mitigation structures, if needed.

For this analysis, a subjective view was taken of each project. We used available site-specific hydrographic data obtained from applicants and the Corps, aerial photographs of the tailwater area, and general knowledge from developed sites.

4.1.2.2.2 Evaluating Fish Habitat Changes in Altered Flow Regimes

Formal Habitat Evaluation Procedures (HEP) are available that have been developed by the Western Energy and Land Use Team (now National Ecology Center) of the USFWS, 1980. Habitat Suitability Indices (HSI) and curves have been developed through detailed literature reviews for some of the species of concern in the upper Ohio River basin, including walleye (McMahon et al., 1984), channel catfish (McMahon and Terrell, 1982), white bass (Hamilton and Nelson, 1984), smallmouth bass (Edwards et al., 1983), carp (Edwards and Twomey, 1982), gizzard shad (Williamson and Nelson, 1985), largemouth bass (Stuber et al., 1982), spotted bass, and paddlefish (Hubert et al., 1984). In addition, preliminary habitat suitability index curves have been developed for sauger by a Delphi technique of canvassing expert opinion in the absence of sound data (Crance, in press).

The Habitat Evaluation Procedures are not fully satisfactory as a quantitative analytical tool. The procedures are designed as a team approach for the involved parties (e.g., the

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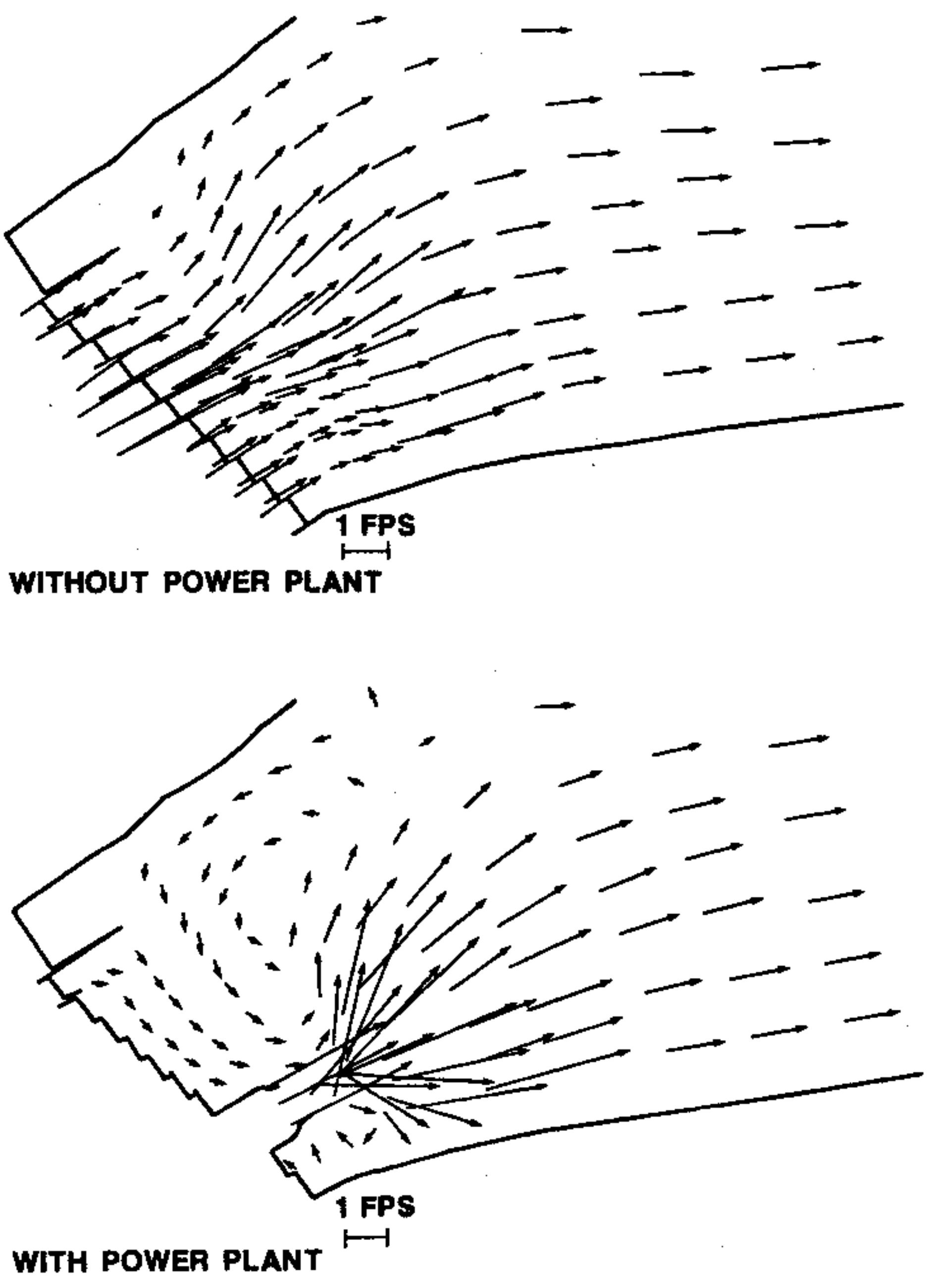

Figure 4.1.2-4. Comparison of results of a velocity discharge model with and without hydroelectric development at 30,000 cfs through Lock and Dam 15 of the upper Mississippi River as an indication of probable effects at dams on the Ohio River system. Arrow length is proportional to flow velocity (see scale); arrow direction indicates direction of water movement. All values are averaged over water depth. After Normandeau Assoc., Inc. (1987).

applicant, state natural resource agencies, USFWS, and the FERC) to join in weighing the HSI values for applicability in a particular situation. The HSI models are not proven cause-and-effect relationships for species and habitats, and the HSI Model series is introduced with the caveat that model accuracy is unknown and likely to be low because of many general assumptions (Schamberger et al., 1982). HSI models are not fully compatible with available hydraulic models, for average velocity calculated by hydraulic models does not reflect velocities behind cover (e.g., logs, boulders) or in other microhabitats on which fish depend. Some HSI models, even for rivers, do not include velocity (e.g., walleye) and the suitability index considers low velocity to be most suitable even though walleye are attracted to dam tailwaters.

For these reasons, this analysis did not attempt to be strictly quantitative in its translation of hydraulic patterns into fish habitat suitability. Alternatively, it viewed estimates of the general, average flow patterns before and after hydroelectric generation for changes in channel geometry and areal loss of swift tailwater.

4.1.2.2.3 Habitat Losses

In the general case, staff expects about half of the normal low-flow, swift-water habitat to be lost at any one time, when hydropower units are operating, in the zone extending one dam-width downstream of a fixed-crest spillway. For gated spillways, the loss will be less; this is because the low flow is now discharged through one or a few gates not unlike the expected turbine flow. However, the turbine flow will be at one location; whereas, the gated flows are usually shifted operationally among gates on a preset schedule of gates and specific openings. Inconsistency of hydropower operations due to seasonal low flows and outages for repairs will affect habitats by shifting flows between the turbine discharges and gates or spillway.

There should be little (if any) loss of spawning habitat in tailwaters, due to the seasonal flow pattern. Flows over spillways and through gates will remain high in spring runoff periods when major tailwater species spawn. Summer habitat for swift-water species will diminish as estimated above; concentration of flows along a shallow shoreline may, however, extend the rapids habitat downstream farther and into areas where fishing opportunities can be improved (midchannel gate releases are unavailable to bank anglers who can have access to the shoreward turbine flows).

Mussel habitats may be altered, a circumstance that is especially important in situations that affect the endangered species, Lampsilis abrupta (Appendix I). Although no flow or bottom habitat modifications at the Greenup pool mussel beds are anticipated by hydropower development at the Gallipolis L&D and above, the habitat will be altered by the project proposed at Muskingum No. 3. The tailwater of this proposed facility will be significantly altered with reduction in habitat for all mussels, including L. abrupta if it occurs there. Habitat change could be in the form of a shift of current flow to one side of the river with significant reduction in flow of the existing tailwater for a distance of about 1 mile downstream. This change could occur in spite of the minimum spillage over the dam of 1520 cfs agreed to by the USFWS and the applicant (Appendix I). Channel erosion by the diverted flow is expected to cause substrate instability and sedimentation until the channel reequilibrates. These impacts may be severe enough to significantly reduce the available habitat for a period of time long enough to severely reduce or eliminate the local population of L. abrupta.

Elimination or reduction of spillage flows at Opekiska, Willow Island, Belleville, and Gallipolis in low-water periods because these dams are poor aerators (Section 4.1.1.1) would nonetheless affect downstream habitat for fish. The loss will be small, however, and adequate flows should be available in the turbine discharge.

Notable changes in tailwater habitats at specific sites are expected, if not altered in conjunction with physical model studies, as follows:

Allegheny L&D No. 7 - Downstream of the scour zone below this fixed-crest dam is a 14-acre shoal (shallow water habitat) on the powerhouse side that has a small permanent island. This shoal and island are in direct line with the proposed powerhouse, and they will interrupt the generalized fan of flow from the discharge. The shoal has a narrow backchannel that may receive a large portion of the turbine discharge, or the flow may be directed to the right and parallel to the dam and into the main center channel. The flow pattern will depend on how the exit is dredged. Some form of riffle habitat for fish will persist, although its orientation after the bottom stabilizes in the new flow regime is difficult to predict.

Staff concludes that there will be significant adverse effect of turbine tailwaters and dredging of a discharge channel on the shallow-water habitat at this site. No alternative orientation of the discharge seems to be capable of mitigating the anticipated adverse effects without affecting navigation.

Allegheny L&D No. 4 - The shoal zone that extends across the river downstream of the dam (except at the lock) is particularly shallow. The turbine discharge will need dredging to pass through this shoal. This could cause the deep scour zone below the dam to be substantially cut off from recirculating flow, and it could have little if any current. With careful discharge design, the adverse effects at this site may be mitigated.

Allegheny L&D No. 3 - Major changes could occur in the tailwaters of this fixed-crest dam. The powerhouse will discharge into a channel dredged through a 500 foot-wide, shallow riffle on the backchannel side of a 2-mile-long chain of downstream islands (Appendix C). Reorientation of nearly all water at moderately low flows to this backchannel side will alter the entire tailwater region for at least the 2-mile length of islands. The turbine flow may rejoin the main river channel across the shoal between Fourteen Mile and Twelve Mile islands, or it may continue down the backchannel, or both. Some turbine discharge water can be expected to flow leftward, over the tops of submerged cofferdams (cut to below the waterline and left in place) and parallel to the dam face. This water would flow toward the main channel just upstream of the lower Fourteen Mile Island (Fourteen Mile Island was cut in two by the dam), even though the turbine discharge channel is to be oriented downstream toward the backchannel. The large differences between the orientations of the turbine flows and the normal river may cause considerable bed erosion before the channel comes to a new equilibrium (if it can do so with shifting flows as hydropower units are placed in and out of service).

Fish habitat may suffer initially as the channel stabilizes to new conditions. There may actually be more shallow riffle habitat available around the island complex after the flows change to the backchannel, although this is not clear. Deflection of flows to the backchannel will leave the main channel with only low flows, making the deep scour zone below the dam into a pool.

Staff concludes that there will be significant, adverse, and non-mitigable effects to the downstream habitat at this site. Staff believes, however, that shallow, riffle habitat created in the zones between Fourteen Mile and Twelve Mile islands and at the margins of these islands would adequately replace habitat lost in the tailwater of the fixed-crest dam. Habitat management would be necessary as a mitigative measure to assure that there is "in-kind" replacement of habitat of equal value.

Allegheny L&D No. 2 - The turbine will discharge into the side of the river occupied by Six Mile Island, about 1/3 mile downstream. The tailwater is scoured across the dam width upstream of the island, and the island and its associated shallow-water habitat probably receive the products of that scour. Turbine discharges may flow leftward through the scoured deep area to rejoin the main channel, or they may tend to spread more across the island's shoal zone. If the latter is the case, there may be considerable erosion and restructuring of riffle habitat. If the deeper scour zone is followed, then there may be little change from pre-hydropower conditions. Detailed discharge design should be capable of protecting the existing habitats.

Emsworth - A shoal below the main channel dam is identified by the USFWS as a habitat of concern. This shoal is along the powerhouse side and extends from about 700 to 3500 feet below the dam, with the maximum projection into the channel occurring about 1500 feet downstream of the dam. The applicant proposes to construct a porous dike downstream of the turbine discharge which staff believes suitable to deflect the major turbine flow toward the main channel and not across this shoal. Except for this situation, the general case seems to apply to all other dams on the mainstem Ohio River.

Muskingum L&D No. 3 - Because of the location of the navigation channel and lock in a diversion canal, the entire width of tailwater of fixed-crest Muskingum L&D No. 3 below the immediate scour zone is a one-mile long, shallow rapids interspersed with several small islands. Endangered species of freshwater mussels are reported from this tailwater, including the pink mucket pearly mussel (Stansbery, 1985). The proposed turbine discharge at the right side of this zone and about 700 feet downstream of the dam would require dredging and major relocation of flows along the right bank. Aquatic habitat changes would be inevitable, particularly in two zones (1) the scour pool and riffle extending approximately 1000 feet below the dam which would have little flow (1500 cfs minimum spill proposed by applicant) and be partially dewatered, and (2) the right bank where most of the river will flow at high velocity and channel reequilibration will occur. Alternative designs proposed by the applicant to locate the powerhouse more upstream could have less impact on the first zone.

In response to concerns expressed by staff, the applicant (letter from William S. Fowler of Mitex, Inc. to Kenneth F. Plumb of FERC, dated November 6, 1987) noted that the flow velocities in the shallow (2 to 4 foot ave.), island-filled tailwater reach below the dam vary from 0.5 to 1.5 feet/sec in a very complex fashion. Velocities with the project operating are expected to be closer to 5 feet/sec in the island backchannel that must be dredged for the turbine discharge. These high velocities and the large volume of water in the backchannel are likely to cause erosion of this island. The applicant has agreed to provide shoreline protective measures sufficient to preserve the large island, in the form of conventional rock rip-rap and possibly live root stabilization (e.g., willow plantings).

Staff concludes that significant, adverse modification of the tailwater habitat between the Muskingum L&D No. 3 and the navigation channel about one mile downstream is inevitable with hydropower development as proposed, even with mitigative measures to reduce erosion that are suggested by the applicant. This modification is expected to be detrimental to fish resources and to rare and endangered freshwater mussels.

Belleville, Willow Island, and Gallipolis - The downstream pools of each of these dams have been identified by the USFWS as important mussel habitat where the federally endangered pink mucket pearly mussel (Lampsilis abrupta) may be found (letter to James Keany, FERC, from Charles J. Kulp, USFWS, dated September 28, 1987). The mussel is known to occur in a reach 13 miles below the Gallipolis tailwater (near RM 292), and it may occur in the dam tailwater, which has not been surveyed. The Belleville pool contains many mussels, and its tailwater may also harbor rare or endangered species. There could be some habitat changes in pools above fixed-crest dams. The reduction in pool elevations at fixed-crest dams could increase the river's velocity and sediment transport capacity (Section 4.1.5.2). These changes may alter some benthic habitats for fish and freshwater mussels. There is no indication that such changes would be major or significantly adverse.

4.1.2.3 Entrainment and Turbine-Induced Fish Mortality

As river water is passed through hydroelectric turbines, any aquatic organisms in the water that do not swim away from the intake are entrained and pass through the facility. Such organisms include phytoplankton, zooplankton, fish eggs and larvae, and juveniles and adults of certain open-water or migratory fishes. There are three principal risks associated with such passage. The first risk is the possibility of the organism being physically struck by the turbine blades that rotate through the water passage. Fish can be cut in two or be subjected to severe trauma. The second risk is the possibility of being damaged by the rapid changes in water pressure associated with the hydraulic system that transfers energy from the flowing water to the turbine blades; because fish usually have an air bladder for maintaining buoyancy, they are susceptible to internal damage such as bladder rupture from such pressure changes. The third risk is shear, or a tearing action, associated with passing close to the solid walls or turbine blades; shear is exerted wherever water flows at greatly different velocities in a short distance, and usually occurs near solid surfaces. Shear can rip fish apart, usually at the isthmus at the gills. These damaging effects can be manifested immediately, as in decapitation, or by delayed mortality.

Entrainment of fish in hydroelectric turbines has been studied extensively (Olson and Kaczynski, 1980; Turback et al., 1981; Knapp et al., 1982; Dadswell et al., 1986; Stone and Webster Engineering Corp., 1986; Eicher Associates, Inc. 1987), although the greatest emphasis has been on types of turbines other than the bulb-type turbines to be used on the upper Ohio River navigation dams. Studies of the impacts of bulb turbines have been conducted at Rock Island Dam on the Columbia River (Olsen and Kaczynski, 1980), at the Annapolis Tidal Power Project in Nova Scotia (Dadswell et al., 1986), at the Essex Dam on the Merrimack River, New Hampshire (Knight and Kuzmeskus, 1982), and at the Racine project (WAPORA, Inc., 1987b) and Greenup/Vanceburg project (Olson and Kuehl, 1988; Olson et al., 1988) in the Ohio River. Discussions about entrainment impacts at hydroelectric facilities and methods to prevent or alleviate them have been held at several workshops recently, both national (EPRI, 1987) and organized for this study (Section 1.3).

The results of studies of turbine-induced fish mortality are highly varied. They ranged from spectacular damages suffered by high numbers of large and important fish species (American shad, striped bass) in the Bay of Fundy to evidence of very low mortality of downstream migrating salmon in the Columbia and Merrimack rivers. The effects are clearly influenced by fish size (larger ones are more likely damaged), species (clupeids are most sensitive, juvenile salmon are more hardy), and behavior (e.g., herrings that moved in and out of the tidal embayment on a daily cycle were badly affected). Fish passage devices installed before local fish behavior was understood were ineffective at the tidal power project. Only the Columbia River studies used a technique, mark and recapture at downstream dams, that adequately accounted for long-term survival. Spring, summer, and fall studies at the Racine and Greenup/Vanceburg projects on the Ohio River showed compatible results, even though techniques were much different; although few game fish were affected, many juvenile gizzard shad and freshwater drum were entrained. Lack of winter sampling in these studies is a major drawback to concluding little overall gamefish entrainment. These turbines killed a small percentage of the large numbers of the small, sensitive forage fish and a high percentage of any large game fish entrained.

A telemetry study at Greenup Dam (Olson and Kuehl, 1988) suggested that there may be mortalities in passing the existing gates that could be comparable to that in turbines (most work now assumes that only the turbines can damage fish). However, both the Corps and WVDNR believe that there is little mortality in passing through existing gates. No studies of eggs and larval fish have been made at operating projects, although extensive entrainment research at Steam Electric Stations (SES) and in laboratory simulations has indicated high tolerance of early life stages for physical stresses.

All entrainment field studies conducted to date are deemed incomplete and inconclusive for answering impact questions on the upper Ohio River system quantitatively, despite extensive effort. A firm basis for making estimates of impacts at proposed facilities awaits better results. The increased complexity and cost of studies to adequately quantify entrainment rates and effects of any fish losses in turbines lead some analysts to the logic of simply installing fish protection devices instead of doing extensive studies. Others suggest that quantification of entrainment rates, without determining effects, would be sufficient to develop a appropriate compensation for assumed losses in consultation with resource agencies.

Fish protection and guidance devices have been investigated that attract, repel, or physically screen fish from the intake. These devices include lights, electric fields, noise, physical barriers, screens, and bar racks. Through EPRI funding, Stone and Webster Engineering Corp. (1986) has both reviewed the literature and participated in field tests across the United States. No techniques seem to be universally effective. In the northwest U.S., the Northwest Power Planning Council and the Bonneville Power Administration (1987) have concluded that installation and maintenance of currently available turbine screening systems are expensive and must be tailored to the site. Most present screen systems have not been tested sufficiently to be characterized as proven. Existing designs and new designs must be evaluated to determine which designs are biologically and economically efficient. There is a high research and development priority in the Northwest to provide acceptable fish screen designs with general applicability for regional hydropower developers. Trash in the Ohio River system is seen as a major obstacle to effective fish guidance systems. It is clear that there must be much more development work before a fish protective or guidance device can be selected for the Ohio River system projects that has a good likelihood of being effective at a reasonable cost.

Accurately measuring fish entrained is also difficult with present technologies. Conventional netting techniques are logistically awkward in turbine wells and discharges (WAPORA, Inc., 1987b; Olson et al., 1987). Acoustic sampling provides more continuous monitoring, but species identification is not reliable (Olson et al. 1987). Techniques show promise of significant improvement, however.

Staff has analyzed the problem at proposed hydropower projects largely by analogy with available literature and in three parts. One part concerned the susceptibility of various organisms and life stages to being entrained in the turbine flow. The second considered the likelihood that damages would occur to individuals entrained and their populations. The third part concerned methods for preventing or reducing entrainment.

Accumulated effects of potentially large fish mortalities at many sites on the upper Ohio River system can be considered to be a cumulative impact, although entrainment damages would be local. Because all applicants propose nearly identical turbine-generator units except for size and minor details (many of which are not final), site-specific differences relate mostly to local influences on susceptibility of species to being entrained.

4.1.2.3.1 Vulnerability to Entrainment

The percentage of river water that will pass through turbines at a site varies seasonally and is only rarely 100 percent even when spill flows for other reasons (Section 4.1.1.1) are not considered. Thus, fish will have passage alternatives. At flows greater than the project units alone can pass through the dam, the Corps will release water in a planned sequence of gate openings or the water will spill over fixed-crest dams. At high river flows, the rise in tailwater elevation will be sufficient to reduce the project's head to a point where the turbines cannot operate efficiently, and they will be shut down. Outages for maintenance will further reduce the percentage of time turbines pass the full river flow.

Operating conditions at the Racine project illustrate the percentage of time in each month that water and fish would be obliged to pass through turbines (Table 4.1.2-1; Figure 4.1.2-5). The table, derived from design head conditions and four years of actual tailwater data (no maintenance outages), shows three flow regimes: (1) when all river flow less lockage and leakage is through one and both of the two units at the project and the dam gates are closed, (2) when river flow is through the units and the dam gates, and (3) when all river flow is through dam gates and the units are shut down. The figure illustrates the flow and head combinations that allow turbine operation.

The table shows that there would be some flows bypassing turbines in all months. The maximum time all flow passes through turbines would be in September (64 percent); in contrast, nearly one-third of the time in March the flow will be entirely through dam gates. During lower river flow months (June through October), water will bypass the turbines less of the time compared to higher flow months (December through May).

Table 4.1.2-1. Monthly operating conditions at Racine. 1/

	Operating Time as a Percent of Month			
	No Flow Through Dam Gates		Flow Through Dam Gates	
	1 Unit Operation	2 Unit Operation	Flow plus 2 Unit Operation	All flow through Gates, No Generation
January	2	23	63	12
February	5	23	62	10
March	2	6	61	31
April	0	0	75	25
May	1	10	75	14
June	7	38	55	0
July	34	35	31	0
August	22	48	30	0
September	21	64	15	0
October	17	55	27	1
November	7	36	57	0
December	1	10	77	12

1/ Based on tailwater data for mean of years 1978, 1979, 1983, 1984; adapted from WAPORA, Inc., 1987b.

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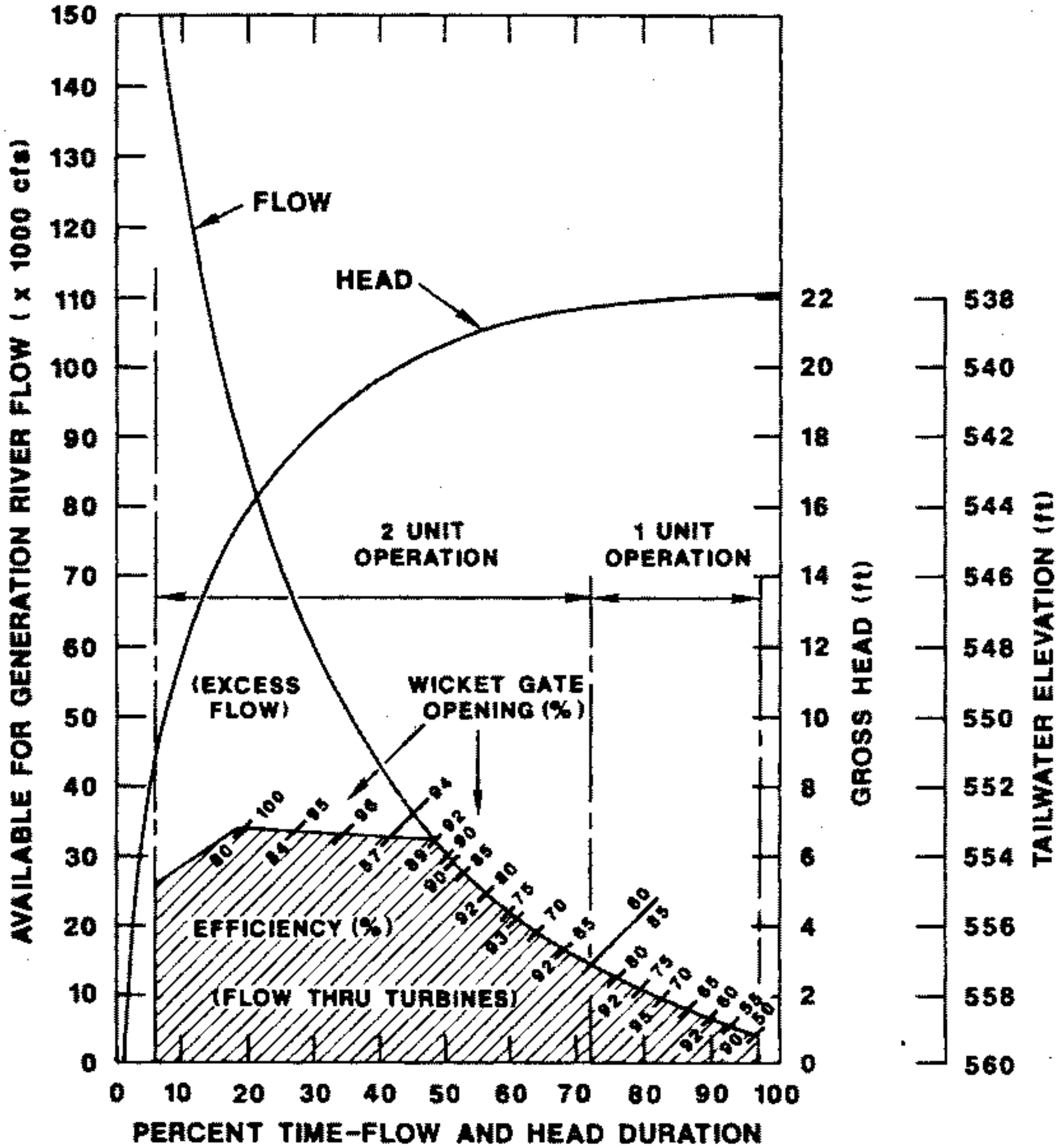


Figure 4.1.2-5. Relationships of water flow, head, and unit operation at the operating Racine Plant, Ohio River (FERC Project No. 2570). Wicket gate openings represent highest efficiency for each operating point. From WAPORA, Inc. 1987.

Each proposed project will have an operating schedule that is unique in detail to its own combination of flows and project design; however, the general pattern remains very similar.

The susceptibility of fishes to entrainment for biological reasons also varies seasonally, and it varies greatly among species and life stages. Holland et al. (1984) summarized existing information on adult fish movements through dams on the upper Mississippi River, where considerable research has been conducted and the species composition is similar to the upper Ohio River system. These data were further analyzed by Normandeau Associates, Inc. (1986b). The movements of most gamefishes except walleye do not take them through dams (Section 3.2.2), and most interpool movements that occur do so in high flows when turbines would not operate or considerable flow is bypassed. Exceptions may be the striped bass and striped bass X white bass hybrids that have been stocked in the upper Ohio River and which make long-distance movements downriver, although the timing of these movements has not been determined in the Ohio (in the Tennessee River, these fish tended to make most long-range movements in the fall, winter, and spring; Cheek et al. 1985). Studies at Racine during warmer months of the year showed that occasional gamefishes are entrained. Migratory eels have recolonized the study area, and their downstream adult spawning migrations may cause them to pass through turbines.

Early life stages (eggs, larvae, and pelagic juveniles) of several species are essentially planktonic, and they drift with water flow during the spring and summer spawning periods [Section 3.2.2 (ESE 1987)]. Early in the spawning period, there will be high flows that will bypass the shut-down turbines. During June through August, however, one-half to two thirds of these early life stages in the river may pass through turbines.

Vertical and horizontal differences in fish density may affect entrainment susceptibility. Extensive study of entrainable early life stages by the steam-electric power industry has shown higher densities along shorelines, where powerhouses are generally to be placed [Section 3.2.2 (ESE 1987)]. Open-water species such as gizzard shad, the dominant species entrained at Racine (WAPORA, Inc., 1987b), occur largely in the surface 10 feet (3 m). A second-phase powerhouse in the lock chamber at Gallipolis could place powerhouses on both shorelines, thus essentially doubling the susceptibility of pool fishes to entrainment.

Site differences may affect susceptibility to entrainment. The larger Ohio River contains more of the open-water species that are easily entrained than does the smaller and shallower Allegheny. Whereas the pools above most projects have the straight-bank, deep channel riverine habitat that is not particularly productive of gamefishes, some have islands and tributaries that are highly productive and from which fish emigrate to the main channel. The Montgomery L&D site, in particular, has a unique, large embayment just upstream of the proposed powerhouse; an especially large number of species that normally inhabit backchannels and tributaries may be vulnerable to entrainment there (e.g., largemouth bass, spotted bass, walleye in summer, sunfishes).

Habitat, cover, and flow velocities may influence whether fish are entrained in turbine flows or pass through gates. Shaded bypass entrances seemed to attract downstream migrating salmon in studies in the Connecticut River (Stone and Webster Engineering Corp. 1986). No information is available to quantify such influences on Ohio River Basin fishes.

Studies at Racine attempted to quantify rates of fish passage (WAPORA, Inc., 1987b). These studies were conducted only in the warmer seasons. Methodological problems, such as inability to census fish in the upper 3 meters of the intake water column and capture of downstream residents in the tailwater net, make the passage estimates highly debatable and inconclusive. The results have not been universally accepted by the USFWS and state agencies as a basis for regulation (agency comments appended to WAPORA, Inc. 1987b).

In summary, the fishes most vulnerable to entrainment are early life stages (larvae and juveniles) of those species, principally gizzard shad and freshwater drum, which occupy the open water habitat in the low-flow periods of summer. One-half to two-thirds of these organisms in the river flow at these times may pass through turbines, based on water volumes alone. Game species are not particularly vulnerable except where highly productive backchannel/tributary habitat is immediately upstream of the powerhouse, although occasional individuals will be entrained at all sites. No reliable, quantitative estimate of passage rates for sites on the upper Ohio River system is presently available.

Staff concludes that, in the absence of well-defined fish passage rates at existing projects, monitoring at new projects will be necessary to determine these rates.

4.1.2.3.2 Turbine-Induced Damages

The mechanisms by which fish can be damaged by turbine passage in hydroelectric facilities are well understood, in principle (USFWS, 1984a; Dadswell et al., 1986). The probability of objects of potential fish sizes being within the shear zone of walls, wicket gates, and runner blades and being struck by the runner blades has been calculated based on turbine geometry and hydraulics (Figure 4.1.2-6). Specific turbine design features (number of blades, blade spacing, tip speed, blade shape, elimination of cavitation, etc.; USFWS 1984a) influence the theoretical effects on fish, although most turbines in the projects proposed for the upper Ohio River system are fairly similar. They are designed for hydraulic efficiency, which generally means increased fish survival. Wicket gates have a broad leading edge (4 to 6 in.) and induce mostly trauma or shear; runner blades have a sharp leading edge (1 to 2 in. at the tips) and tend to cut. Larger fish have a greater probability of damage than do smaller ones, based simply on geometry.

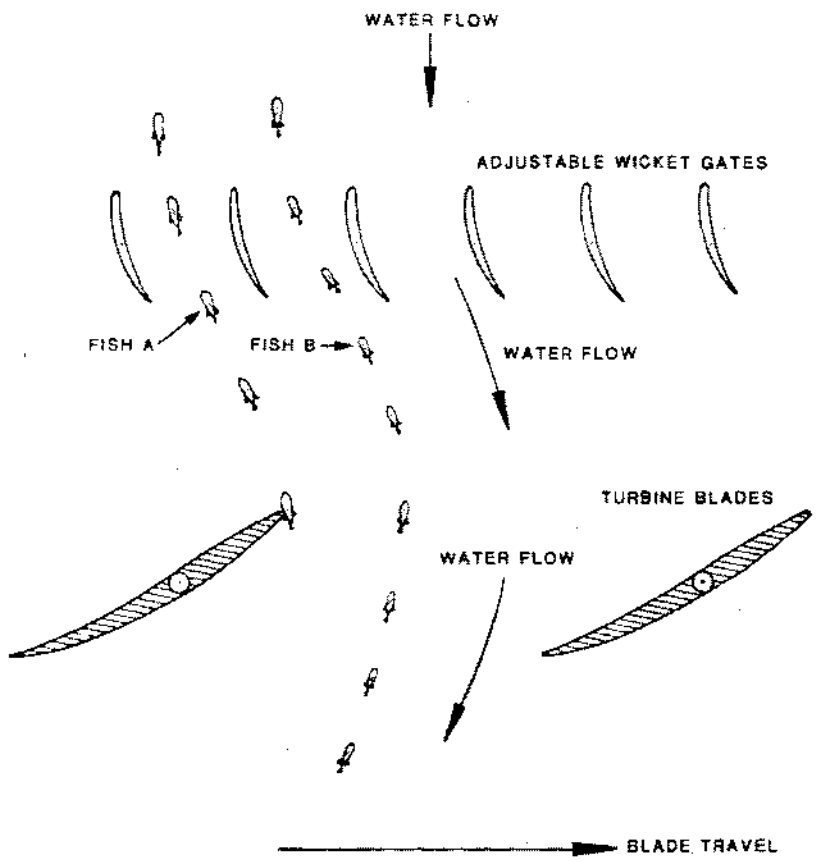
Fish survival results at some operating facilities may be misleading for Ohio River applications. The turbine studied by Dadswell et al. (1986) had fixed turbine blades, whereas both wicker gates and turbine blades will be adjustable in Ohio River projects. Because of this design difference, turbine efficiency is less in the Annapolis project studied by Dadswell et al. (1986). The Annapolis project also operates on a tidal system with changing head, so that turbine efficiency is at maximum for only a short period of time in a daily cycle. Higher turbine efficiency for longer periods of time, due to adjustable blades, will yield higher fish survival in the Ohio River projects.

Attempts to quantify turbine-induced mortality at operating facilities on the Ohio River system have been unsatisfactory, despite considerable effort. At Racine, an extensive 2-year study indicated that about 1 percent of the fish exhibited lateral body marks indicating a cutting action of the turbine blade. About 13 percent showed some form of trauma that could have been from turbine passage or from damage in the collection system; some of the latter was known to occur. An unknown percentage of these would have succumbed to latent mortality. Most of these fish were small gizzard shad and freshwater drum. Evidence from other studies with similar turbines (Dadswell et al., 1986) indicates that larger fish such as adult American shad and striped bass sustained much higher proportions of damage.

There have been no direct studies of the effects of passing eggs and larvae through hydroelectric turbines, even though many of these organisms will be entrained. Considerable research was conducted at steam electric stations, however, and in laboratory simulations of condenser passage (Kedl and Coutant, 1976; Cada et al., 1981, 1982; Schubel and Marcy, 1978). Morgan et al. (1976) estimated from laboratory studies that these organisms would be susceptible to damage. Other research, however, has shown quite conclusively that these stages are hardy and not likely to be damaged by the stresses of passing through condenser tubes of steam electric stations. One can assume that the shear stresses of a hydroelectric turbine would be less damaging than 1-in.-diameter condenser tubes, although it would be useful to have this assumption and its significance tested for entrainment in hydropower turbines.

Whereas the potential for damage to entrained organisms (mostly fish) has been demonstrated in principle and with field studies, the results of studies at several sites are inconsistent and are viewed as inconclusive for quantifying expected effects with any certainty. For young gizzard shad and freshwater drum, the predominant fish entrained at Racine, during the months of the study (mostly the warmer season), staff accepts an upper mortality figure of about 10 percent provisionally, including both immediate and latent effects as a generalization of the Racine results. The losses may be less, as they were during some Racine tests. Since all seasons were not studied, the semi-quantitative estimate applies only to the warmer months. Staff does not anticipate any demonstrable damages to planktonic early life stages.

The population and ecosystem impacts of losses of about 10 percent of young gizzard shad and freshwater drum and the occasional larger fish passed through turbines during the Racine study periods can only be estimated qualitatively. Both gizzard shad and freshwater drum are prolific spawners and serve the remainder of the fish community largely as forage (food source). Their high reproductive potential makes it unlikely that losses from turbine damages would impair their populations. It is known that prolific spawners can compensate for heavy losses, and population models to describe such capabilities and estimate compensatory reserve are being developed (Van Winkle, 1977). Serious questions remain about population effects on larger fishes, some which must be stocked (e.g., striped bass). Moderate numbers of killed and



FISH PASSAGE THROUGH WICKET GATES AND TURBINE IN A BULB UNIT
POSSIBLE BLADE STRIKE AREA

NOT TO SCALE

Figure 4.1.2-6. Paths of fish movement through hydropower turbines of the bulb type. Fish typically orient their heads upstream while being carried downstream. Some fish pass successfully through the openings, while others may hit the wicket gates or be struck by the rotating turbine blades. Sources: American Electric Power Corp.

injured fish undoubtedly contribute to predation in tailwaters and thus to sustaining the highly productive predator populations there (a feature well documented at hydroelectric facilities on the Columbia River, for example).

Staff concludes that mortality of juveniles and adults of the species most often entrained, gizzard shad and freshwater drum, will be near 0 to 10 percent of those passing through each project and that this loss will likely be insignificant for populations because of high reproductive potential of these species. Little damage, if any, is expected to fish eggs and larvae. Damage to larger fishes, particularly gamefishes, will be greater than 10 percent of those entrained, and the loss of a percentage of those damaged could be significant for fishable populations depending on the numbers that pass through the turbines and the survival percentages.

4.1.2.3.3 Fish Diversion and Protection Devices

Most applicants have proposed installation of a fish diversion system of unspecified design at the intake. This is in accord with the USFWS national intake protection standards (USFWS, 1984a). Generally, a louver system or angled bar rack is identified as a possible choice. In such a system, a rack of vertical steel bars or louvers spaced 2 to 4 inches apart is placed in the intake and angled to the direction of water flow and fish movement. Fish, mostly salmonids, have been shown in studies elsewhere to respond to such a system in several ways, all of which tend to stimulate them to move laterally along the rack and into an alternate fish passage (Jenson, 1974, 1978; Nettles and Gloss 1987). The fish may respond to the rack visually or to the "bow wave" of velocity changes. Such a diversion system is recommended by the USFWS service for installation at each project and has provided a generalized conceptual design (Figure 4.1.2-7).

Several drawbacks to the louver or bar rack system have been identified for their application in the upper Ohio River system. First, there has been little experience with the species most affected by entrainment there in the warmer months studied (gizzard shad, freshwater drum) and warmwater gamefishes (such as walleye, sauger, smallmouth bass) to validate the guidance system's assumed effectiveness. Conventional screening techniques at steam electric station condenser water intakes impinge large numbers of shad rather than guide them safely away from entry. Second, orientation of a louver system so that an angle to water flow is maintained and fish are properly guided to a bypass can be difficult at the ends of dams where powerhouses are to be located. Flows entering the powerhouse at the Racine project did not match predictions, the generic design for a fish bypass would not have produced a barrier at an angle to flow. Third, the most numerous fish to be protected are generally small and would require a narrow bar spacing that could impede the operating head of the facility (although targeting the gamefishes, which were less frequently entrained in the months studied at Racine, for protection would allow a wider bar spacing).

Perhaps the most compelling drawback for louvers in the upper Ohio River system is their apparent incompatibility with large debris and ice loads that are common. Ice and debris can damage and clog louvers and fish bypass channels. Debris of sizes from leaves to large tree trunks and including much material of human origin (e.g., tires, lumber) now accumulates at the upstream side of all dams. Trash accumulations are a major problem for the intakes of hydropower installations already on the river; trash removal at Racine has amounted to up to two semitrailer loads per day and required installation of heavy construction equipment on the intake for its handling. To prevent damage from debris, the guidance system must be built behind a substantial debris screening system. To maintain the angled orientation to flow, the systems for fish guidance and trash removal may need to be built on a sturdy structure separate from the powerhouse. No applicant has carried design plans to sufficient detail to evaluate their proposal fully for feasibility, effectiveness, or cost.

Staff is skeptical that design and performance of louver/bar systems are well enough understood to warrant blanket acceptance as a cost effective feature of hydroelectric facilities on the upper Ohio River system. These fish protection systems are incompletely designed for evaluation of their environmental impact or of their potential effectiveness for mitigating damages that might occur were they not installed.

An innovative concept for fish protection that has been proposed for the Emsworth project is a porous dike upstream of the powerhouse intake. Here, a 1600-foot-long rock dam with open interstices between the rock fill constitutes a barrier between the river channel and an intake

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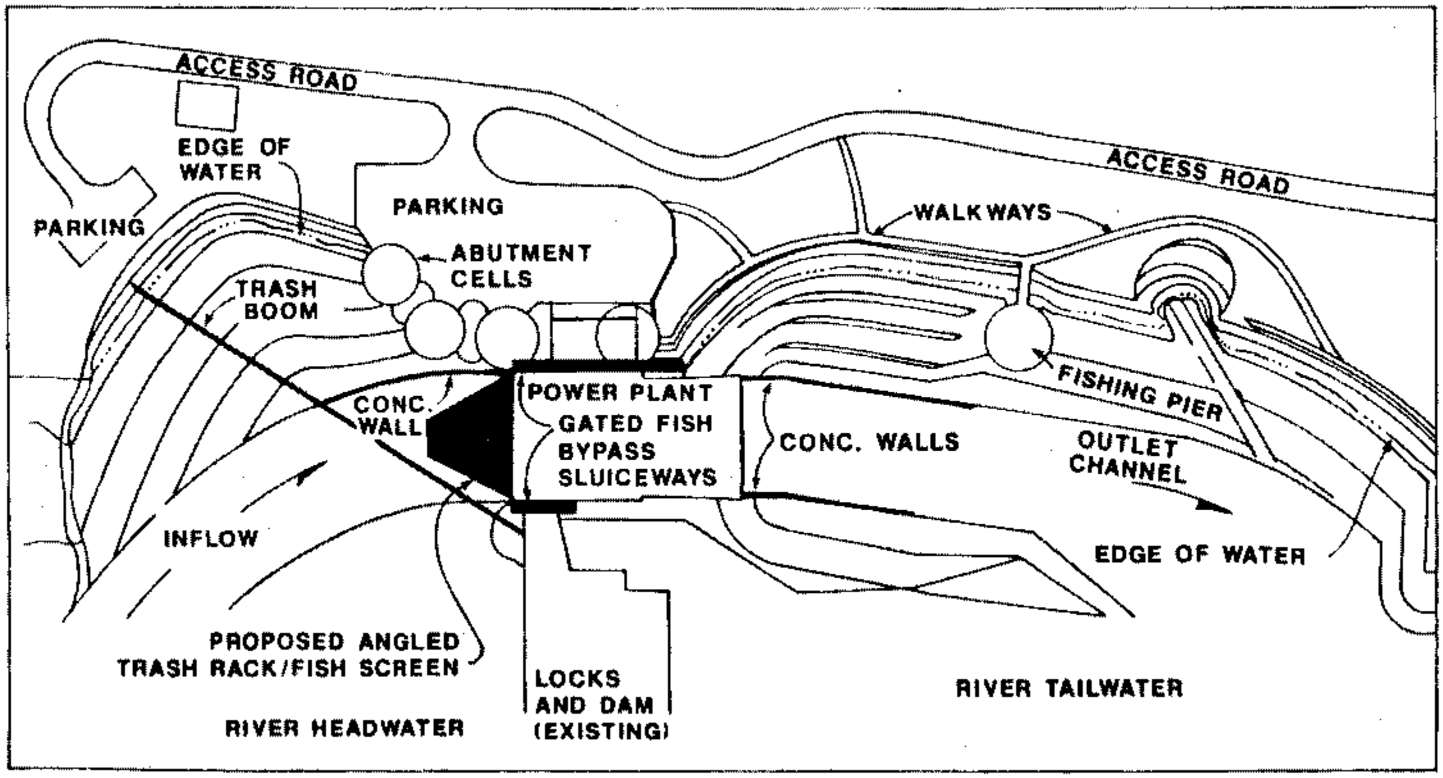

Figure 4.1.2-7. Conceptual plan for installation of angled fish screen, trash rack, and fish bypass system at a hydroelectric power plant on the upper Ohio River system. Adapted from transmittal by B. Rizzo, USFWS, to W. Perry, FERC, July 1, 1987.

forebay. All water entering the intake must pass through this porous dike. In principle, fish see the dike as the shoreline and are not drawn to the powerhouse.

This system has received prototype evaluation studies at the Brayton Point Station, Somerset, Massachusetts, following its proposal in the mid-1970s for fish protection at steam electric stations (Ketschke and Toner, 1982). The evaluation was for a relatively clean estuary rather than for the silty and debris-laden Ohio River system. The prototype was nearly 100 percent effective in screening out juvenile and adult fish, but it killed zooplankton and fish eggs and larvae, presumably by having them eaten by filter-feeding organisms living in the rock dike. There was only a small suggestion that larval fish or zooplankton could avoid entrainment, as the juvenile and adult fishes did effectively. Flow diminished through the study as pores became clogged, but backflushing removed some of the accumulation. Organic debris was a major problem at the upstream end of the dike. The deeper the dike vertically, the more it clogged. Head tended to stay the same as the dike clogged, but the volume of flow was markedly reduced (these pumped flows were much less than hydroelectric turbine flows). Rock size made little difference in performance.

Without prototype testing under conditions of the Ohio River, we do not believe that the porous dike can be assured of providing a net benefit to Ohio River fishes. Although the test situation at Brayton Point was unlike the Ohio River, the problems that were identified suggest similar or more acute problems for the Ohio. The possible tradeoff of near complete mortality of eggs and larvae for protection of juveniles and adults seems questionable for maintaining ecosystem quality.

In summary, no devices proposed for protection of fish from turbine entrainment at the projects in the study area seem well enough designed, tested, and evaluated to be considered adequate for assuring their effectiveness in the Ohio River and its tributaries. This does not conclude that they must be ineffective, rather that more work at developing and evaluating experimental prototypes will be necessary. Any installation at a proposed project would need to be considered as an experiment and not as mitigation required to prevent significant adverse impacts.

4.1.2.3.4 Staff Conclusions on Entrainment

Open-water species such as gizzard shad and freshwater drum seem to be the fishes most vulnerable to entrainment, based on sampling at Racine during only the warm months. Occasionally game fish (relative to numbers of shad and drum) are entrained, but the numbers of them entrained may be large in relation to game fish populations. A large ichthyoplankton entrainment rate is expected. Monitoring would be needed to determine entrainment rates throughout a year to assure these rates are acceptable.

Entrainment mortality may be 0 to 10% of juveniles and adults entrained, with adult gamefish likely to be near the high end of the range. Little entrainment mortality is expected to ichthyoplankton, based on studies at thermal power plants.

Staff concurs with the state and federal fish resource agencies that many of the unresolved and difficult-to-answer questions of entrainment rates and fish damages at these hydroelectric projects could be made moot if an effective fish diversion device could be installed and operated at each site. Were such a device available that is suitable for effective application regionally, staff would support its use. However, there appears to be no such device that has received adequate field testing in large river conditions similar to the upper Ohio basin and with the warmwater fish species assemblage found there. Nor are there such proven designs for other regions of the country such as the Pacific Northwest.

The prudent course would seem to be one of marshalling regional resources to select, construct, test, and evaluate engineering prototypes of fish guidance systems that may prove effective for minimizing fish entrainment in hydroelectric turbines in the upper Ohio basin. If the designs work on a prototype scale, then they can be installed at full scale on newly constructed and operating projects. In the meantime, monitoring of operating facilities for the numbers of fish entrained and mortality estimates and some form of compensation to the states for fish losses can occur. If no systems are proven effective, or entrainment losses are determined by annual fish passage and entrainment mortality monitoring to be low at operating sites, then compensation can continue as the alternative long-term mitigation.

Monitoring of entrainment mortality has proven to be expensive with reliable results difficult to obtain (WAPORA Inc. 1987). Therefore, monitoring of mortality should be attempted only when there are adequate estimates of annual fish passage and these estimates indicate a distinct need to quantify mortality/survival percentages.

A bioengineering test facility located at one project (or at most, a few) would be needed for evaluating fish protection technologies. The facility should be planned and operated by qualified fishery and engineering professionals in consultation with the state and federal fish resource agencies of the region. A high priority for study would be the designs (e.g., the angled louvers) that have shown promise elsewhere and with other species. The results of the prototype evaluations would be evaluated periodically by the resource agencies and FERC for possible implementation at the projects.

Adequate estimates of annual fish passage are prerequisite for testing and evaluating fish bypass or protective systems. These data help define the objectives to be met by such systems. It may take 2 years of monitoring entrainment rates at a site before performance goals for a site-specific mitigation device could be well defined. Monitoring of fish passage at a few representative sites could, however, indicate the general goals and allow performance testing of potentially useful structures to begin.

These recommendations apply to large juveniles and adults but they do not resolve questions of impacts on fish eggs and larvae. Although these is abundant scientific evidence from studies of thermal electric stations that eggs and larvae are resilient, this should be demonstrated for hydropower turbines in the upper Ohio River Basin. It seems necessary to conduct fish passage and entrainment mortality studies at a selection of representative sites.

Since installation of fish protection devices may be determined to be practical and effective, then hydropower projects need to consider that possibility in their initial designs. Fish-bypass orifices can be designed into powerhouses from the start, even though they may not be used. Intake abutments can be designed with sufficient strength and gear anchors to attach and hold additional equipment. It is obviously not possible to foresee the future of fish protection developments, but some foresight in design could aid later installations.

Compensation is not universally accepted as an approach to mitigate impacts such as fish passage mortality. Resource agencies are divided: the USFWS considers it the least preferred approach whereas the WVDNR considers it the most desirable approach, for example. Staff considers compensation essential during the phase when prototype fish protection and/or guidance facilities are tested in the Ohio River basin. This temporary compensation may be considered as a permanent alternative to engineered solutions if such solutions prove unsatisfactory. Thus, staff recognizes a sequential mitigation process involving compensation. Negotiations between licenses and resource agencies will be necessary to assure compensation for full replacement value. FERC must assure that the agreed-upon compensation is a license condition that is the responsibility of the licensee.

Because state and federal fish resource agencies have expressed concern over the effect of entrainment mortality added to all of the sources of mortality for fish populations, some form of population monitoring would be useful. This monitoring would not define impacts from entrainment alone, but would provide an index to whether all sources of mortality are excessive and populations show decline. If so, then appropriate management actions can be taken and the specific source(s) of excessive mortality can be sought with more effects-specific studies. Population monitoring could be routine, and similar to creel censuses or annual surveys conducted by the agencies now.

Although the physical facilities and risk to fish from entrainment are similar at most other sites, the Tygart Dam is an exception. Here, the type of turbine likely to be installed in this high-head storage dam is different from those installed at the low-head navigation dams, and higher mortalities may result. Also, a planned flushing of water from the reservoir is now included in agreements between the Corps and the WVDNR to transport juvenile walleye from the reservoir to downstream river reaches. Staff concludes that spillage through gates will be required during times of existing flushing flows to assure the needed successful fish passage.

4.1.2.3.5 Entrainment at Montgomery (FERC No. 2971)

One proposed site, Montgomery L&D, poses particularly high risk to fish from entrainment (see Sections 4.1.2.3.5 and 4.1.2.3.6). Entrainment at this project could have significant impacts on fish entrainment, due to its proximity to an important fish spawning and nursery area in the Montgomery Embayment, 500 feet upstream. Juvenile and adult fish attracted to, or spawned in, the embayment are expected to be especially susceptible to mortality in turbines at the proposed project. Mitigation believed adequate to prevent such impacts has not been developed. Hydropower development at this site is considered by staff to cause significant adverse effects. However, the records of correspondence show that important questions remain to be answered at this site to the satisfaction of state and federal resource agencies and the Corps, that include (1) how quantitatively important the Montgomery Embayment is as a fish nursery for the Montgomery Pool and the region; (2) what impacts the proposed project would have on fish populations associated with the embayment; and (3) that mitigation sufficient to avoid such impacts can be installed and operated.

<u>Special site characteristics</u>

The aquatic environment near the Montgomery L&D is contrasted from the typical Ohio River open channel habitat by a prominent embayment that lies on the north (right) side of the river immediately upstream from the dam (Figures 2.1-17 and C-12, Appendix C). The embayment extends nearly east-west for about 3,300 feet, is about 400 ft across at its maximum width and is up to about 7 feet deep (Allegheny Electric Cooperative, Inc. 1984, 1987). Its narrow (80-foot wide) mouth joins the main river about 500 feet upstream of the north abutment of the dam; this is the abutment in which the hydropower project would be built. The embayment is probably a relict river channel that was flooded when the river elevation was raised by the Montgomery Dam. The embayment and the wooded wetland that lies between it and the river channel occupy the inside of a gentle bend in the river. As is typical of such areas, there is a shallow zone in the river extending about 250 feet from shore that was identified in the bottom surveys conducted by the applicant.

The embayment is populated by aquatic wetland plant species and abundant fish, based on two limited surveys, one by the Pennsylvania Fish Commission (PFC) and the Pennsylvania Bureau of Water Quality Management (PBWQM) on September 2, 1979 and the other by the applicant's consultant on August 30, 1983. The shallow waters hold submerged aquatic plants and the shorelines contain emergent vegetation. There are also submerged aquatic plants in the 500-foot zone extending from the embayment mouth to the dam; this habitat is, in essence, an extension of the aquatic wetland of the embayment into the relatively slow-moving shoreline waters immediately above the dam. Gamefish populations include largemouth bass, spotted bass, channel catfish, white bass, white crappie, walleye, sunfishes (green, bluegill, pumpkinseed), and introduced tiger muskellunge (according to unpublished surveys by PFC/PBWQM and applicant's consultant; letter from C. Blake Weirich to F. Paul Richards, August 30, 1983). There are abundant prey species including several species of minnows and shiners, gizzard shad, freshwater drum, and quillback carpsucker. Substrates in the embayment are conducive to spawning by centrarchids. There is firm substrate in the western end near the mouth and sand and gravel in a strip along the northern shore at the east end (Allegheny Electric Cooperative, Inc., 1984, p. E-36). Despite this characterization, there has been no systematic determination of the composition, abundance, and life histories of fish populations through biological studies or creel censuses funded either by the applicant or the resource agencies. Most of the information is subjective.

The Montgomery embayment is believed to be important because of the relative rarity of this habitat in the Ohio River mainstem (USFWS 1983 and letters of August 22 and 30, 1983 from Edward Perry to F. Paul Richards; Pennsylvania Fish Commission's many letters and personal contacts documented in the application; letter from C. W. Bier, the Western Pennsylvania Conservancy (WPC), to F. Paul Richards, August 19, 1983). Most of the Ohio River is a fairly unbroken river channel; this is the only embayment in the Pennsylvania portion of the river. As such it was believed by the PFC, WPC, and USFWS to be important regionally for fish spawning and as a nursery area, with the progeny presumably populating the nearby Montgomery pool. The WPC specifically requested the applicant to conduct additional field investigations of the aquatic fauna of this "special habitat/community," and the USFWS stated that there was not enough information to make definitive recommendations.

The fish populations of the region have been surveyed at locations that are only indirectly relevant to the embayment. Lock surveys at the Montgomery site were conducted in 1968-1970, but none have been done more recently; the locks are at the opposite shore of the river, away from the embayment mouth. Lock surveys have been conducted more recently at the upstream Dashields and downstream New Cumberland dams (19 and 22 miles away, respectively; Allegheny Electric Cooperative, 1984, Table E.3-2). The Beaver Valley power station 2.8 miles downstream of the dam has conducted studies of its site related to thermal effluents, and found a healthy and diverse fish fauna (Allegheny Electric Cooperative, 1984, Table E.3-3).

<u>Impacts</u>

The principal impacts to fishes of the embayment would come from locating the hydropower turbine intakes along the shoreline 500 feet downstream of the embayment mouth. An intake channel would be dredged in the shoreline zone from the dam to a point approximately 50 feet downstream of the embayment mouth (Figure 2.1-17). The present condition of slow water flow and silty, weedy bottom would be replaced with a swift current that carries most of the river flow close to shore. Water flow entering the turbines would pass directly in front of the embayment mouth, creating a zone of rapid crossflow for fish entering or leaving the embayment. A direct consequence of the dredging would be loss of about 200 feet of the submerged aquatic plant bed between embayment mouth and the dam with its probable fish spawning and the soft-bottom organisms living there (mostly oligochaete worms and chironomid fly larvae which are widespread and have no special significance). The riverbank and intake channel would be stabilized with rock rip-rap.

The major source of damage to fish populations from the intake location is presumed to be entrainment in the turbine flow and mechanical injury during passage through the plant (letters from USFWS , EPA, and PFC at several stages of the application process). The close proximity of embayment mouth and the turbine intake increases the likelihood that gamefishes not normally associated with the pelagic waters such as largemouth bass will be entrained. Several of the species caught in the embayment in the surveys are mobile species that can be assumed to move frequently in and out of the embayment mouth, including white bass, channel catfish, and freshwater drum. With mortality of larger fishes in turbines being significant (>10%) based on studies at Racine, the importance of this impact for the riverine fish populations hinges on their site-specific susceptibility to being entrained. There is also concern that the water withdrawals at the powerhouse would lower the water level to the point where fish spawning in the embayment itself is hampered (letter from Jack G. Miller, PFC, to Kenneth Plumb, FERC, December 4, 1986).

The applicant has stressed that the design and operation of the Montgomery turbines will promote fish passage with minimal damage. The first characteristic is high turbine operating efficiency. Available data on passage of salmonids links successful passage to high turbine efficiency (Turbak et al. 1982). The Montgomery turbines are to be >80 percent efficient virtually all the time, >85 percent efficient about 60 percent of the time, and >90 percent efficient about 40 percent of the time (Allegheny Electric Cooperative 1984, p. E-48). Second is the depth of turbines, which is low enough underwater (centerline about 17 feet, with blade tips varying from 7 to 27 feet below water elevation) that hydrostatic pressure will prevent cavitation, a feature that is known to be especially damaging to fish. The large water passage is believed to minimize direct contact and shear at the walls. The low design head should minimize the pressure changes experienced by a fish during passage, other than those generated near the turbine blade. Wide blade and wicket clearances and the low revolution rate (62 RPM) should lower the probability of a fish being hit directly compared to narrow clearances and rapid revolution of alternate turbines. Staff agrees that these design and operating characteristics do lessen fish damage compared to alternatives, but refers to studies at the similar Racine plant where larger fish still suffered high levels of damage.

The applicant also claims a superior turbine survival capability of the warm-water fishes at Montgomery compared to the salmonids that have been most often tested in turbines (Allegheny Electric Cooperative 1984, p. E-51). The argument holds that lake fishes, being more tolerant of low DO and high temperature than salmonids, will also be more physically robust. Staff believes that this is incorrect; to the contrary, salmonids should be the more robust. Salmon juveniles have evolved to successfully negotiate the rigors of downstream migration in rivers that are often turbulent and full of physical obstacles. Lake fishes such as those in the Montgomery Embayment are adapted to quiet waters with little turbulence and physical stress. Body shapes and fin developments clearly differentiate these groups.

Staff does not agree with some of the agencies who commented on the entrainment issue as discussed in the DEIS (Appendix J). Some of these comments imply that water flow through the embayment will entrain fishes. In fact, there should be little direct flow of turbine water from the embayment, which is a blind bay. The issue is more properly directed at the movements of fishes in and out of the embayment during normal intrapool movements, spawning aggregations at the embayment, or dispersal of young from the embayment's spawning and nursery area to the Montgomery pool. It is in the course of these movements in and out of the embayment that vulnerability to entrainment in the turbine intake is believed by staff and other agency commentors to be markedly increased. These movements have not yet been characterized or quantified by any of the parties.

Staff requested that the applicant supply two items of information relevant to fish entrainment at the embayment mouth in addition to that in the application on p. E-58 (letter from Quenton Edson to William F. Mattson, August 2, 1985). These items were (1) flow patterns at the embayment mouth and plans for mitigating the entrainment susceptibility (Item 1 of list in letter), and (2) evidence that the turbine entrainment would not affect the walleye and tiger muskellunge stocked in the embayment (item 3 of list). The request was in line with letters from the agencies commenting on the application (USEPA, FWS, PFC, Corps, and Pennsylvania Game Commission) that concerns remained over entrainment of fish at the embayment mouth. The EPA officially rated the application as ER-2 (environmental reservations, insufficient information). Answers from the applicant were non-responsive, and merely restated the applicant's position that studies of water velocity at the mouth of the embayment would be conducted as part of the detailed design phase after the license had been granted, and that any increased vulnerability to entrainment could be mitigated successfully with dikes, walls, and the like (letters from W. L. Mattson to K. F. Plumb, October 10 and 29, 1985, and from M. A. Hosko to K. F. Plumb, November 14, 1986).

The applicant generally dismissed the feasibility and need for fish guidance and bypass devices. This position was criticized by commenting agencies, particularly the USEPA (letter from J. Pompanio to W. F. Mattson, May 4, 1988) and the Corps (letter from J. L. Richards to W. F. Mattson, May 25, 1984).

In Appendix C of the applicant's responses to the agency comments (letter from M. A. Hosko to K. F. Plumb, November 14, 1986), a three-point program is proposed:

1. A fish guidance device will be designed into the project, although a system to pass affected species is not believed to exist. Screens and mercury lights for attraction to a bypass were suggested. Study of fish bypass would be conducted as part of the hydraulic modeling study after licensing. A plan was suggested to flush any resident fish in the intake forebay through the turbine chamber prior to activating the turbines.

2. Turbine machinery as non-damaging as possible will be selected and operated in accord with highest survival.

3. Fish would be stocked in each pool and the embayment, including walleye in the tailwater, tiger muskellunge in each pool, and largemouth bass in the Montgomery pool and the embayment.

Conclusions

Staff concludes that there is a high likelihood of significant, adverse damages from turbine passage to fish that are entrained in the turbine intake flow while passing in or out of the high quality fish habitat of the Montgomery Embayment. The embayment is regionally important for fish spawning and juvenile rearing due to the scarcity of its particular habitat even though the aquatic community is not unique or its species endangered. Fish movement is believed by commenting agencies and staff to be unusually high in the area of the embayment mouth compared to other locations upstream of dams on the Ohio River, and the applicant has not conducted water velocity or fish movement studies to evaluate this issue. Mitigation suitable for reducing fish entrainment in the turbine intake flow or from bypassing fish away from the turbines has not been presented.

4.1.2.3.6 Entrainment at Montgomery (FERC No. 3490)

The situation is not markedly different for the competing application (FERC No. 3490) than that discussed in the previous section. This application does include additional information on the fishery resource of the embayment and provides a form of mitigation.

Information on fish is provided from a survey conducted by the PFC on September 10 (gillnets) and 12 (electroshocking), 1984. It is not clear whether the applicant for FERC No. 2971 used this survey, but the species listing is similar. Walleye and sauger were abundant, as were both black and white crappie. Yellow perch and the stocked tiger muskellunge were found. There was considerable movement of fishes, especially walleye and sauger, into the embayment at night, presumably to feed.

The USFWS representative added new insight into the issue of flows out of the embayment during an interagency meeting with the developers. When lockage occurs at river flows less than 11,000 cfs, there was documented drainage of water from the embayment, which would draw fish into the powerhouse intake when installed.

A porous dike is proposed by the applicant as a mitigative measure for fish entrainment. A 400-foot-long dike would be placed across the embayment mouth with an opening to the pool at the upstream end. Fish would be diverted to an upstream area and are presumed to be less susceptible to being drawn into the intake channel. The exact performance of the dike in diverting flows would not be determined until the hydraulic modeling studies to be conducted after licensing. There was no indication of attempts to study fish movements.

Although the USFWS and PFC are more amenable to the dike as a mitigation procedure, their concerns over entrainment remain (letter from J. G. Miller to K. F. Plumb, July 1, 1987).

Staff believes that the porous dike may mitigate some problems at this site, but its effectiveness is unproven and significant problems with porous dikes are expected (see Section 4.1.2.3.3). Relocating the point of fish passage into and out of the embayment upstream about 300 feet may not alleviate the tendency of fish to be drawn into the intake currents. Without estimates of flow velocities that would come from hydraulic modeling studies, it is impossible to contrast velocities (and compare to fish swimming speeds) with and without the mitigation device.

Conclusion

The potential for significant, adverse impact to fish populations remains with this competing application, and the proposed mitigative measure is unproven in the Ohio River.

4.1.2.4 Pool Habitat Loss for Fish Above Fixed-Crest Dams

Installation of hydroelectric turbines at fixed-crest dams can lower pool elevations during normal summer low flows (Section 4.4.1). This lowering may decrease the amount of shallow-water habitat available for fishes. Spawning, juvenile rearing, and habitat for adults of species like spotted bass, largemouth bass, and the sunfishes could be affected. On the other hand, lowering of water level may simply shift the shallow-water habitat toward the channel, with no net loss. Staff has calculated the potential change in water of three feet or less based on cross sectional profiles of the river (Section 4.1.4) and concludes that the loss of aquatic habitat will be insignificant.

4.1.2.5 Assessing the Impact of DO Change on Freshwater Mussels

4.1.2.5.1 Tolerance of Mussels to Low DO

There is a general belief that freshwater mussels as a group are tolerant of low dissolved oxygen concentrations. Cole (1926) established that *Anadontoides ferrussacianus* Lea, a species found in organic mud and silt, could survive at nearly zero dissolved oxygen concentrations for several days in an early experimental study. *Anodonta implicata* (Say 1829) could survive when the dissolved oxygen concentration was exhausted (Eddy and Cunningham 1934), and Hiestand (1938) demonstrated that *A. imbecilis* could respire normally at about 0.73 mg/L of oxygen. The largest mussels had the lowest metabolic rate and thus were the least sensitive to low oxygen concentrations (Hiestand 1938). Imlay (1971) found a pool species, *Amblema plicata*, survived for 10 weeks at 0 mg/L.

Two traits seem to assist in tolerance of hypoxia--(1) behavioral, structural, and metabolic adaptations that allow mussels to clamp their shells together very tightly to seal themselves off from adverse conditions and maintain a lowered metabolic rate of dormancy and (2) a physiological amplitude for surviving at low oxygen tensions, seen mostly in the Anodontae (Fuller 1974). Freshwater mussels exhibit "rest periods" during which their oxygen consumption is much lower than during periods of activity, although it does not drop to zero (Salanki and Lukacsovics 1967). Studies of these adaptations are further discussed in Appendix I.

Riffle species may not fit the pattern observed for the more common slack-water species, however. Imlay (1971) examined the low oxygen tolerances of several unspecified "riffle species" of mussels in the laboratory and found that they required 2.5 mg/L of dissolved oxygen for survival at temperatures corresponding to summer. Imlay (1971) expressed the opinion that all species (both riffle and pool) require 6 mg/L for normal growth, based on as-yet-unpublished experiments. Ellis (1931) reported that mussels became inactive when the saturation level of dissolved oxygen was less than one-fifth of atmospheric. Grantham (1969) found no live mussels in the Mississippi River where oxygen concentrations dropped as low as 3 mg/L even for short periods.

Low dissolved oxygen concentrations below some dams is providing an in situ experiment that indicates mussel sensitivities. J. Jenkinson (Tennessee Valley Authority, pers. comm.) indicated that mixed mussel communities exist below TVA dams where there has been periodic low dissolved oxygen. He described a survey in 1986 that showed no mussel mortalities at several sites when there was a minimum of 1 mg/L recorded at monitoring stations for more than one week. However, in 1988 there was 0 to 0.5 mg/L dissolved oxygen below Watts Bar Dam (Tennessee River) for two weeks and adult mussels were killed. The kill was not species-specific.

Reproduction causes strains on mussel respiration which might affect survival. Portions of the gills are used in producing the dispersal phase, the glochidia, which renders these gill portions unsuitable for gas exchange (Matteson 1955, Fuller 1974).

S. Ahlstedt (Tennessee Valley Authority, pers. comm.) expressed the opinion that the juvenile mussel, immediately after release from the gills of the host fish, is the life stage most sensitive to low dissolved oxygen. He bases this opinion on unpublished observations of laboratory cultures in which mortality of early juveniles was high. Isely (1911) included abundant dissolved oxygen as a requirement for successful colonization of riffle substrates by juvenile mussels released from host fish. He reported that mussels radiate to other, more sandy or silty habitats as they grow larger.

In summary, freshwater mussels that inhabit riffle habitats probably need fairly high DO, perhaps near 6.0 mg/L, for normal growth and production. Quiet-water species, that have come to dominate the mussel fauna of the Ohio River and its major tributaries, may be more tolerant of low DO. The adults of all species may be capable of tolerating quite low concentrations for periods of time that could extend to a few days. Juveniles may be more sensitive. Low DO concentrations in the Ohio River have probably exceeded the mussel fauna's tolerance durations in historical times.

4.1.2.5.2 Impacts of Changed DO

Installation of hydroelectric turbines on 18 navigation dams in the upper Ohio River basin has the potential for reducing dissolved oxygen concentrations in the rivers where mussel beds are located (Section 4.1.1.1). Average daily dissolved oxygen (DO) concentrations could be depressed to below 6 mg/L in the Monongahela River from Opekiska to L&D 7 (Figure 4.1.1-6) and in much of the upper Ohio River (Figure 4.1.1-7) when all upstream projects operate as proposed under summer moderate flow conditions. From Willow Island downstream, DO could decrease by a maximum of approximately 0.5 mg/L; the decline would be 1-2 mg/L elsewhere. The estimated maximum depressions could cause current DO concentrations that are above 6.0 mg/L to be depressed to slightly below 6.0 mg/L. At the summer low flow conditions (7Q10; Figure 4.1.1-4), a similar DO decrease is estimated below Gallipolis L&D, but occurring between 5.5 and 6.0 mg/L, and small declines (mostly , <0.5 mg/L) would depress DO to levels well below 6 mg/L from Dashields to New Cumberland and below Belleville. At these lower flows, many projects cease operation.

Duration of low DO concentrations can be estimated from the ORSANCO monitor at Gallipolis L&D. DO concentrations at Gallipolis have fallen below 6 mg/L about 25% of the time in the critical high temperature-low DO summer months of July to September over the period 1980 to 1986 (Figure 3.5.2-5). A deficit of about 0.5 mg/L there due to hydropower could extend the duration to 30 to 40 % of the time. This extended duration may be typical for the rest of the Ohio River as well.

The estimates of current and project-impacted DO concentrations over most of the study area during typical summer conditions straddle the 6.0 mg/L DO concentration believed necessary for long-term growth of freshwater mussels, although this value is poorly substantiated, as discussed above (Imlay 1971). Thus, some small reduction in growth of mussels may occur. Daily fluctuations, although reported to be small historically (Section 4.1.1), could further lower instantaneous mussel growth. The DO concentrations in most of the area are not projected to be reduced to anywhere near what could be considered an acutely lethal level for mussels.

Summer low flow conditions (7Q10) present a more severe pattern for freshwater mussels. DO concentrations are estimated to fall to near 4.5 mg/L below Dashields and Belleville both with and without hydro, with a differential due to hydro of only a few tenths of a mg/L below Belleville (within model error) but 1-2 mg/L below Dashields. This level would be inimical to long-term productivity of mussels but could probably be tolerated for short periods. Such levels may be a limiting factor currently during periods of low flows and high temperatures.

In summary, projects as proposed could cause DO levels in a portion of the Monongahela and much of the upper Ohio rivers during moderate summer flows to fall into a DO range just below the minimum level thought necessary for normal growth. The criterion is uncertain and growth declines would likely be small. Under extreme low flow conditions of summer, hydropower reduces already low DO levels by a small amount, but levels are unlikely to fall to lethal concentrations. Additional discussion related specifically to the endangered Lampsilis abrupta is found in Appendix I.

4.1.2.6 Assessing Loss of Host Fish for Mussels

Mussels require a discrete fish species as an intermediate host for the glochidia reproductive stage. Known host fish for mussel species were tabulated by Fuller (1974). There seems to be confusion over the host for the endangered L. abrupta, although it is most likely the sauger (Appendix I).

Historical reproductive failure of mussels in the upper Ohio River system may have been caused by decline in populations of the required fish host, because it is well documented that the fish fauna, including the sauger, became depauperate in the Ohio River during years of severe pollution (Pearson and Krumholz 1984). There are now abundant fish species known to be mussel hosts in much of the upper Ohio River basin.

Some losses of host fish might occur if the projects are built and operated as proposed. Reductions in DO of magnitudes discussed above could affect the growth and production of coolwater fish according to USEPA (1986) and a bioenergetics model applied by FERC staff (Section 4.1.2.1), although levels are not in the acutely lethal range. The zones with the greatest impact of low DO on fish would be in the reach below Dashields and Belleville L&D. There, DO levels for the maximum expected impact under summer moderate flow conditions are depressed to the zone of slight production impairment for all fish life stages. Under summer low flow (7Q10; Figure 5b), conditions both with and without hydropower are well into the zones of moderate to severe growth and production impairment below Belleville, with hydropower causing little further DO decrease. Below Gallipolis and Willow Island, there would be slight production impairment. Slight to moderate reduction in growth and production might result in fewer numbers of host fish in the river, although the relationship is speculative.

Entrainment of larger host fish through the hydropower turbines is likely to kill from 0 to 10 percent of those entrained, although experimental evidence for that range is poorly supported (Section 4.1.2.3). Small fish have a much lower mortality rate. Vulnerability of sauger to entrainment may be low, for Holland et al. (1984) found movements of sauger in the Mississippi River usually did not take them through the dams, and most interpool movements occurred at high water when turbines would not operate. Elsewhere, e.g., in the Tennessee River, combined navigation-hydropower dams are not detrimental to sauger populations, for the most productive fisheries for the species are below them. Fish protection devices with proven effectiveness for excluding host fish from turbines under conditions such as the Ohio River are not available (Section 4.1.2.3). Therefore, there may be residual losses of fish hosts that cannot be mitigated with present technology.

Although entrainment in hydropower turbines will kill some fishes, it is uncertain but viewed as unlikely that this source of additional mortality would significantly reduce populations of the fish host, including the sauger, Stizostedion canadense, apparently required by the endangered Lampsilis abrupta. There is no information available, however, relating fish numbers to the strength of mussel populations.

4.1.3 Recreation

Cumulative impacts to recreational fishing and boating use in the upper Ohio River Basin associated with the development of hydroelectric facilities include (1) impacts to tailwater anglers due to the replacement of shoreline presently available to tailwater anglers with a powerhouse, (2) impacts to tailwater fishing success due to the alteration of river flow patterns, (3) impacts to the tailwater sport fishery during construction, (4) impacts to tailwater anglers during powerhouse shutdowns, (5) impacts to recreational boating due to the alteration of reservoir pool elevations, and (6) impacts to the existing quality of recreational fishing resulting from diminished water quality, turbine induced mortality, and changes in fish habitat quality. Potential changes in recreation days of use are discussed in this section for each navigation pool and for the overall system. For most of the project sites in the study area, recreation use statistics are available for an entire project/pool area. Tailwater-specific data related to recreation use is limited to those sites surveyed by the WVDNR (WVDNR, 1983; WVDNR, 1982b) and project sites managed by the Huntington District Corps (Willow Island, Belleville, Gallipolis). Therefore, the ability to quantify changes in recreation use is limited. Those areas where river access is needed in conjunction with areas of high fishing pressure and larger population centers are highlighted. Areas of concentration of fishermen such as the confluence of tributary streams, bridges, boat access sites, and any accessible areas along the river in urban areas are given more priority for nondegradation and mitigative enhancement.

4.1.3.1 Assessing Potential Changes in Recreational Access to Tailwater Areas

Recreational fishing is currently active along the nonlock sides of the dams where hydroelectric facilities are proposed. Construction of hydroelectric facilities would replace a section of shoreline presently available to tailwater anglers with a powerhouse and would shift the flow patterns at the tailwaters of the L&D to a turbine tailrace. Table 4.1.3-1 summarizes the applicants' recreation proposals for preserving or enhancing recreational access opportunities at the project sites. Proposed enhancement measures include parking, fishing piers and platforms, structures to create currents attractive to fish and accessible to anglers (e.g., shoreline undulations, underwater deflectors, terraces, rockpiles, dikes), boat launch construction/renovation, improved roads to the site, walkways to and along the shoreline, interpretive displays, and handicapped access provisions. Other enhancement measures noted in the right margin of the table include (1) fishing access to the riverward side of the power plant (e.g., via an access bridge over the intake); (2) maintaining fish attraction flows in the tailrace during periods when the power plant is inoperative through bypass pipes or sluices; (3) fishing access during construction (e.g, temporary dikes, parking, shoreline access); and (4) ancillary recreational facilities, such as fish cleaning facilities, lighting, restrooms, potable water, picnic and other public offstream facilities.

The following discussion examines the proposed recreational facilities in the context of the existing recreational access at the site and in terms of the predicted impact such development would have in the region. At each project site staff recommends a minimum level of recreational development that includes a fishing pier(s), multi-level grouted/paved walkways parallel to the shoreline, access to riverward coffers, fish attractant structures (e.g., bank undulations, reefs), parking, access paths from the parking lot to the shoreline fishing areas, restrooms, a fish cleaning shelter, provisions for handicapped use, solid waste disposal, lighting to permit night fishing, and drinking water. Copies of diagrams showing applicants' plans for enhancing recreational facilities are provided in Appendix F.

Allegheny River L&D No. 7 (FERC No. 7914)

Existing use of the project area takes place along the shoreline and at the Isle of White recreational refuge, immediately downstream of Allegheny L&D No. 7. Access to the Isle of White is obtained by boating/mooring on the island and by wading from the shore (left bank) to the island near the upriver end of the island. During heavy use periods there are over 50 shore anglers and 20-30 anchored boats on the island (letter to J.C. Bianchi from Armstrong Conservation District, October 28, 1987). The applicant is proposing that a parking area be set aside for the public. A paved access road would be constructed to the proposed parking area from Water Street in the Borough of Kittanning. An asphalt footpath is proposed from the parking area to the tailrace area, where three fishing platforms are proposed. The walkway and

Table 4.1.3-1. Recreation enhancement measures proposed by the applicant of each of the proposed projects included in the Ohio River Basin EIS. 1/

Project name	FERC project no.	Parking	Fish pier/ platform	Fish attr.	Boat launch	Improved roads	Walkways/ shoreline access path	Interp. displays	Handicap access	Other
ALLEGHENY RIVER										
Allegheny River L&D No. 7	7914	+	+	0	0	+	+	+	+	
Allegheny River L&D No. 4	7909	+	+	0	0	0	+	+	0	
Allegheny River L&D No. 3	4474	0	0	0	0	0	+	0	+	Allegheny No. 3: fencing along tailrace retaining wall, picnic facilities.
Allegheny River L&D No. 2	4017	+	+	0	0	+	0	0	+	Allegheny No. 2: eliminate fee for access.
MONONGAHELA RIVER AND TRIBUTARIES										
Tygart Dam	7307	+	+	0	0	+	+	+	+	Tygart Dam (7307) (a) fish cleaning and sanitary facilities.
Tygart Dam	7399	+	+	+	+	0	+	+	0	(b) renovation of park facilities. (c) landscape at power plant.
Opekiska L&D	8990	+	+	+	+	0	+	0	+	Tygart Dam (7399) (a) guardrail for fishermen upstream of dam. (b) stairway for fishermen upstream of dam.
Hildebrand L&D	8654	+	+	+	+	0	+	0	0	Hildebrand & Opekiska: (a) access bridge across intake. (b) fish cleaning shelter, lights, water restrooms.
Point Marion L&D	7660	+	0	0	0	+	+	0	+	(c) flow passage through powerhouse when turbines are not generating (Hildebrand). Point Marion:
Maxwell L&D	8909	+	0	0	0	+	+	+	+	(a) lights for night fishing. (b) fishing access during construction. Monongahela No. 4 & Maxwell:
Monongahela L&D No. 4	4675	+	0	0	0	+	+	+	+	(a) landscape at powerhouse. (b) improve access over RR tracks (Maxwell).

Table 4.1.3-1 (continued)

Project name	FERC project no.	Parking	Fish pier/ platform	Fish attr.	Boat launch	Improved roads	Walkways/ shoreline access path	Interp. displays	Handicap access	Other
OHIO RIVER AND TRIBUTARIES										
Emsworth L&D	7041	+	+	0	0	+	+	0	+	Emsworth: relocate/enhance employee picnic area. New Cumberland (6901) (a) restrooms/lighting. (b) fish cleaning facilities. New Cumberland (10332) and Willow Island (9999) and Gallipolis (10098) (a) Access bridge across intake. (b) bypass flow when plant is not on. (c) fish cleaning shelter, lights, restrooms. (d) fishing access during construction. Pike Island (a) observation deck. (b) restrooms/lighting. Willow Island 6902: (a) picnic shelter. (b) play area. (c) restrooms. (d) bypass flows when plant is not on. Gallipolis 9042: (a) fishing, cleaning facilities, lighting, restrooms. (b) bypass flows. (c) fishing access during construction.
Dashields	7568	+	+	0	0	0	+	0	0	
Montgomery L&D	2971	0	0	0	0	+	+	0	0	
Montgomery L&D	3490	+	+	0	0	0	+	0	0	
New Cumberland L&D	6901	+	+	0	0	+	+	0	+	
New Cumberland	10332	+	+	+	0	0	+	0	+	
Pike Island L&D	3218	+	+	0	0	+	+	0	+	
Willow Island L&D	6902	+	+	0	0	+	+	0	0	
Willow Island L&D	9999	+	+	+	+	+	+	0	0	
Belleville	6939	0	+	+	0	0	0	0	0	
Gallipolis L&D	9042	+	+	+	0	+	+	0	0	

Table 4.1.3-1 (concluded)

Project name	FERC project no.	Parking	Fish pier/ platform	Fish attr.	Boat launch	Improved roads	Walkways/ shoreline access path	Interp. displays	Handicap access	Other
OHIO RIVER AND TRIBUTARIES										
Gallipolis	10098	+	+	+	+	0	+	0	+	(a) Access bridge across intake. (b) bypass flow when plant is not on.
Muskingum River L&D No. 3	6998	0	+	0	0	0	+	0	+	(c) fish cleaning shelter, lights, restrooms. (d) fishing access during construction.

1/ This table should not be misconstrued as being a comparison of the merits of the projects.

+ = proposed

0 = not proposed

fishing platforms would have hand railings on the river side. An information board is proposed with illustrations of the proposed hydroelectric project (Figure F-1, Appendix F).

The project/pool area has the third lowest recreational land area per shoreline mile of all the nineteen proposed projects. Although the recreational fishing enhancements proposed at the site could be beneficial to recreational users, the enhancements do not compensate for the potential impact to the Isle of White recreational refuge (Section 4.1.4.2).

Allegheny River L&D No. 4 (FERC No. 7909)

There are no existing recreational fishing facilities at the project site, although fishing is popular along the dam abutment. The applicant is proposing to construct an access pathway, a public parking area, an information board explaining the hydroelectric project, and two fishing platforms located downstream of the project tailrace, one about 10 feet above the minimum downstream pool, and the other about 4 feet above the downstream pool. Both the footpath and fishing platforms would be separated from the river by a low open-type handrail with a kick board attached. A high chain link fence will separate the powerhouse facilities from the recreational access facilities (Figure F-2, Appendix F). The recreation plan is adequate aside from the need to provide ancillary facilities, such as restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The second largest number of fishing days of use along the Allegheny River occurs at the L&D No. 4 project/pool area. The area has the eighth largest number of fishing days of use when compared with all of the proposed projects in the study area (Table 4.1.3-2). As with all of the proposed projects on the Allegheny River, there is a small amount of land area available at the project site for development. The provision of fishing facilities would likely increase the present recreational use of the project site.

Table 4.1.3-2. Number of recreational days of use at each proposed project area ranked by the percentage of use in the study area.

Project	Total Recreation Days of Use	Fishing Days of Use	Boating Days of Use
Allegheny 7	14	16	16
Allegheny 4	10	8	9
Allegheny 3	8	10	8
Allegheny 2	4	4	3
Tygart	1	2	1
Opekiska	5	5	7
Hildebrand	16	18	17
Point Marion	16	18	18
Maxwell	6	9	5
Monongahela 4	12	14	12
Emsworth	3	7	4
Dashields	7	12	6
Montgomery	13	15	14
New Cumberland	9	13	10
Pike Island	11	11	13
Willow Island	9	6	15
Belleville	2	1	2
Gallipolis	3	3	11
Muskingum 3	15	17	19

Allegheny River L&D No. 3 (FERC No. 4474)

Fishing is popular on the dam abutment, the gravel areas along the shoreline, and on Fourteen Mile Island. Under low flow conditions, anglers can wade across the right channel to fish directly below the dam and the outer edge of the downstream portion of Fourteen Mile Island. Wading across the channel below the dam to Fourteen Mile Island would be impossible with the excavation of the tailrace and project flows. Under high flow conditions, anglers use the small backwater area behind the dam abutment. Steep pathways near the Cemline Corporation buildings are used for access to the river along the dam abutment and the shoreline. The applicant proposes to construct a recreational area for fishing and picnicking. The proposed recreational area would measure 70 feet by 350 feet, with approximately 125 feet of shoreline available to anglers (Figure F-3, Appendix F). The right abutment tailrace retaining wall would have a fence along the entire length of the wall to protect the public from the high velocities of the tailrace. A public access path would lead from the existing parking area adjacent to the Cemline Corporation building to the proposed public recreational area. A new parking lot would be constructed at the powerhouse, but priority use of the limited parking space would be given to maintenance personnel (Borough of Cheswick and Allegheny Valley North Council of Governments, 1984). The proposed recreation plan lacks many of the standard provisions that staff recommends, such as a fishing pier, restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

Allegheny L&D No. 3 has more recreational land area per project/pool shoreline mile than any of the other proposed projects on the Allegheny River (Table 4.1.3.3). The project area has the eighth lowest recreational land area, however, when compared with all the projects in the study area. There is a large demand for recreation opportunities in the project area, due to the site's proximity to downtown Pittsburgh. Disruption of the existing fishing opportunities at Fourteen Mile Island could impact the existing users of the site. Concern regarding the potential loss of recreational wading to Fourteen Mile Island was expressed by the Corps at a recreation workshop held on November 2, 1987. The provision of new public fishing access facilities, as specified above, could potentially compensate, however, for the loss of recreational wading to Fourteen Mile Island. A revised recreation plan should be filed with the commission after consulting with state and federal agencies regarding any additional recreational compensation measures that may be needed.

Table 4.1.3-3. Amount of recreational land area per project/pool shoreline mile ranked by the percentage of recreational land per shoreline mile in the study area.

Proposed Project	Rank
Allegheny 7	17
Allegheny 4	15
Allegheny 3	12
Allegheny 2	16
Tygart Lake	3
Opekiska	7
Hildebrand	11
Point Marion	10
Maxwell	8
Monongahela 4	9
Emsworth	14
Dashields	18
Montgomery	19
New Cumberland	6
Pike Island	5
Willow Island	4
Belleville	1
Gallipolis	2
Muskingum 3	13

Allegheny River L&D No. 2 (FERC No. 4017)

The small peninsula below Allegheny L&D No. 2 is used currently as a fishing area. No parking is available on the peninsula; users park in Sharpsburgh Borough and walk through Chieffo's Marina to gain access to the fishing area. A $2 fee is collected by the Marina for passing through the marina establishment to gain access to the peninsula. The applicant proposes to build a recreational fishing terrace on the upstream end of the peninsula, a paved roadway to the site, and a parking area, thereby eliminating the existing fee for access. Approximately one acre of land will be removed from the upstream end of the peninsula to provide for a larger pool area below the dam and area for the tailrace (Figure F-4, Appendix F). The proposed recreation plan is adequate aside from the need to provide ancillary facilities such as restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

Allegheny L&D No. 2 has the fourth smallest amount of recreational land area per project/pool shoreline mile of the nineteen sites in the study area (Table 4.1.3-3). The proposed recreational fishing enhancements would improve access and use at a location where recreation opportunities are in high demand. The number of recreation days of fishing ranks the fourth highest of all of the proposed projects in the study area (Table 4.1.3-2).

Tygart (FERC No. 7307)

The applicant proposes the following recreation measures to accommodate a foreseeable future demand of 200 visitors per day: expansion of the existing parking areas, rehabilitation of the existing sanitary facilities, construction of a fishing pier parallel to the river, a fish-cleaning facility, and an interpretative display. The recreation plan is adequate aside from the need to provide for ancillary features, such as solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreational plan would need to be filed with the Commission for approval prior to project construction.(Figure F-5, Appendix F).

The Tygart River reservoir and the lands which comprise Tygart Lake State Park and the Pleasant Creek Public Hunting and Fishing Area receive the largest number of recreation days of use of all the proposed project areas in the study area (Table 4.1.3-2). Surveys by the WVDNR indicate the tailwaters at Tygart Dam receive a similar number of angler trips as the Pike Island tailwaters (WVDNR, 1983; WVDNR, 1982b). Preserving the recreational fishing success at the Tygart tailwater is particularly important due to its affiliation with a state park facility. The WVDNR is concerned that the proposed recreational fishing enhancements would create development problems as the land needed to develop the recreational fishing access is off federal land (letter to FERC from WVDNR, December 4, 1987).

In the event that sufficient lands are not available for the construction of a standard level of recreational development, a recreational compensation plan would need to be filed with the Commission. Recreational compensation measures could include the provision of off-site recreational facilities and the upgrading of existing access facilities. The compensation plan would be developed in consultation with the appropriate state and federal resource agencies.

Tygart (FERC No. 7399)

The competing applicant proposes to provide the following recreational enhancement features at the project site: a hand-launch ramp below the dam, a stairway upstream of the dam for access by anglers and sightseers, an interpretative display explaining the hydropower project, a fishing pier, scour holes or other fish attractants, a parking lot, a fish-cleaning shelter, and lighting to permit night fishing (Figure F-6, Appendix F). The overall recreation plan is adequate. Ancillary features such as solid waste disposal and drinking water, would also need to be provided. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The discussion in the second and third paragraphs under Tygart (FERC No. 7307) also applies to Tygart (FERC No. 7399).

Opekiska (FERC No. 8990)

The applicant estimates that existing recreational use approximates no more than 15 vehicles and 30 anglers at the project site simultaneously (letter to K. Plumb, FERC, from Noah Corp, November 4, 1987). The applicant proposes the following recreation features as recreational enhancements at the project site: a parking lot, a launching ramp for boats approximately 1,400 feet downstream of the powerhouse, a fishing pier, restrooms, potable water, a fish-cleaning shelter, fish attractants, and lighting for night fishing (Figure F-7, Appendix F). The overall recreation plan is adequate aside from the need to provide solid waste disposal. More detailed design drawings are needed which better illustrate the proposed enhancements in the context of the project site. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The number of recreational fishing days of use in the Opekiska project/pool ranks as the fifth highest of all the proposed projects in the study area (Table 4.1.3-2). The amount of recreational land acreage per shoreline mile at the Opekiska project area is the highest of all the project areas on the Monongahela River and is the seventh highest of all of the proposed projects in the study area (Table 4.1.3-3). The proposed recreational developments at the site would increase recreational access and use in an area that has a high recreation demand.

Hildebrand (FERC No. 8654)

The Hildebrand and Point Marion project/pool areas receive the lowest number of fishing days of use of all the proposed projects in the study area (Table 4.1.3-3). Nevertheless, bass tournaments are popular at the Hildebrand project site as is fishing at the tailwaters. The applicant proposes the following recreational enhancements at the project site: scour holes and rock reefs to improve fishing success, a fishing pier, a fish-cleaning shelter, parking, improvement of the Uffington launch ramp, fishing access at the riverward side of the power plant via a footbridge over the intake, and a flow bypass in the power plant to allow water in the tailrace when the plant is inoperative (Figure F-8, Appendix F). Currently used footpaths would provide access to fishing areas and the fish-cleaning shelter. Other ancillary features proposed include restrooms and lighting to allow night fishing. The recreation plan is adequate aside from the need to provide solid waste disposal. More detailed design drawings are needed, however, which better illustrate the proposed enhancements in the context of the project site. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The proposed enhancements would greatly increase the existing recreational fishing access and use at Hildebrand. The close proximity of the site to railroad tracks would, however, create considerable development and safety constraints for the developer. The WVDNR is concerned about land acquisition at the Hildebrand site, as some of the land needed to develop the recreational fishing access is off of federal land (letter to FERC from WVDNR, December 4, 1987).

In the event that sufficient lands are not available for the construction of a standard level of recreational development, a recreational compensation plan would need to be filed with the Commission. Recreational compensation measures could include the provision of off-site recreational facilities and the upgrading of existing access facilities. The compensation plan would be developed in consultation with the appropriate state and federal resource agencies.

Point Marion L&D (FERC No. 7660)

Existing recreational fishing occurs below the dam near the Cheat River and at the dam to a lesser extent (Borough of Pt. Marion, and Noah Corp., 1983). The applicant proposes to preserve and enhance the recreational opportunities at the site by providing a public access road to the tailwater area and connecting the site to Point Marion. A public parking lot and an access path beside the tailrace would also be provided. Lights would be installed to allow night fishing and fishing access would be provided during construction (Figure F-9, Appendix F). The proposed recreation plan lacks many of the standard provisions that staff recommends, such as a fishing pier, restrooms, a fish cleaning shelter, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The project site is located in Fayette County, Pennsylvania, which is the fifth most populated county in the study area with a proposed hydroelectric project. The applicant would increase recreational fishing access and use by connecting the site to Point Marion. The Point Marion abutment is very limited in terms of the amount of land available for project development. The steep, undeveloped terrain and the close proximity of the site to railroad tracks would pose serious development constraints.

Maxwell L&D (FERC No. 8908)

Existing recreational access to the Maxwell development is severely limited due to the steep, rocky topography and the close proximity of railroad tracks to the project. The applicant is proposing an improved access road which would connect the project site to Brownsville (Figure F-10, Appendix F). A railroad crossing would be constructed by the applicant 1,200 feet downstream from the dam, and the road would continue parallel to railroad tracks to the powerhouse area. The access road would be widened 500 feet to provide for a construction laydown area. After construction is completed, the applicant would provide for bank fishing by converting this laydown area into a public parking area. Another parking area would be constructed in the area of the powerhouse and switchyard to provide access to the tailrace retaining wall for handicapped individuals. A display describing the project features and their relationship to the Maxwell development would be located on the right side of the dam near the Corps office (Pennsylvania Renewable Resources, license application). The proposed recreation plan lacks many of the standard provisions that staff recommends, such as a fishing pier, restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The project area is in Washington County, Pennsylvania, which has the third highest county population of all the counties in the study area with proposed hydroelectric development. The project/pool area has the eighth largest amount of recreational land acreage per shoreline mile of all the proposed projects in the study area (Table 4.1.3-3). The proposed recreational development would increase recreational fishing use in an area where there is a demand for river access. The steep, rocky topography and the close proximity of the railroad tracks, however, would pose considerable development constraints at the site.

Monongahela River L&D No. 4 (FERC No. 4675)

The project is located approximately two city blocks from downtown Charleroi, Pennsylvania. Although a locked gate prevents vehicle access by the public, anglers frequently access the project area on foot. The applicant proposes to construct a parking lot and a paved pathway from the parking lot to the tailrace wall (Figure F-11, Appendix F). An extension of the path would be provided to the bank below the tailrace for fishing along the river bank. Access to the project would be along existing railroad tracks which would be upgraded to provide for vehicle access. A display describing the project features and their relationship to the L&D No. 4 development would be located on the right side of the dam near the Corps office (Pennsylvania Renewable Resources, 1984). The proposed recreation plan lacks many of the standard provisions that staff recommends, such as a fishing pier, restrooms, a fish cleaning shelter, solid waste disposal, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The amount of public recreational land acreage per shoreline mile is not as limited on the Monongahela River as it is on the Allegheny River. The Monongahela L&D No. 4 project/pool area has the ninth highest amount of recreational land acreage per shoreline mile of all the proposed projects in the study area (Table 4.1.3-3). There is a limited amount of land available, however, in the project vicinity due to the close proximity of existing industrial development to the abutment site. The provision of vehicle access and parking at the site should increase recreational fishing use at an area which currently has access restrictions and is near a downtown area with a demand for river access.

Emsworth (FERC No. 7041)

At the present time, recreational access to the project site is via an unmarked and unimproved road. Anglers access the tailwaters by climbing down a very steep embankment holding on to a poorly conditioned chain link fence. The applicant proposes to construct a new access road to a gravel parking lot. A stairway would connect the parking lot to a wooden fishing platform downstream of the diversion dike (Figure F-12, Appendix F). In addition to the proposed recreational fishing enhancements, the applicant would relocate and enhance an abandoned picnic area located at the site that was formerly used by Shenango Steel employees. The proposed picnic area would include a basketball court, jungle gym equipment, game tables, and landscaping (Figure F-13, Appendix F). Staff recommends the additional provisions of ancillary facilities such as restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The Emsworth project site is located in the most populated county in the study area. Although the amount of recreational land area per shoreline mile in the Emsworth pool is small relative to other project areas (Table 4.1.3-3), the amount of recreational days of use is high. The number of recreational of days of use and the number of boats locked at Emsworth in 1986 both rank as the third highest in the study area. The proposed enhancements should greatly improve the recreational use of the project area.

Dashields (FERC No. 7568)

There are no formal recreation facilities at the project site, although the dam abutment provides desireable shoreline conditions for fishing. There is a limited amount of space at the project site due to the close proximity of the Conrail tracks. In order to enhance the use of the site for sport fishing and increase recreational safety, the applicant proposes that access to the site occur across Little Sewickley Creek. A paved public parking area adjacent to the powerhouse would provide parking for sport fishing and general public use (Figure F-14, Appendix F). A paved foot path is proposed to descend down the riprap slope to the fishing platform area. Two paved fishing platforms are proposed, one about 10 feet above the minimum downstream pool, and the other about 4 feet above the downstream pool. Both the footpath and fishing platforms would be separated from the river by a low open-type handrail with a kick board attached. A high chain link fence will separate the powerhouse facilities from the fishermen access features. The recreation plan is adequate aside from the need to provide ancillary facilities, such as restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The Dashields project site is located in the most populated county in the study area. Nevertheless, the amount of recreational land area per shoreline mile in the Dashields pool is one of the smallest in the entire study area (Table 4.1.3-3). The Dashields project/pool area ranks the seventh highest when compared with the number of recreational days of use at the 19 proposed project locations. Recreational fishing at Dashields ranks the seventh highest and recreational boating ranks the fourth highest among the proposed project areas (Table 4.1.3-2). The provision of recreational fishing access facilities should enhance the fishing access and use opportunities at the site.

Montgomery (FERC No. 2971)

Presently there is no formal recreational fishing access in the project area. Anglers park their cars along the public streets of Ohioview near the dam abutment and walk down to the river's edge along the existing Corps' access road and undeveloped paths. No vehicular access is allowed due to steep grades and limited parking. Access also crosses dual Conrail railroad tracks which creates further restrictions on vehicular access and public safety. The applicant proposes to upgrade the existing steep, rutted access road that connects the site to existing public roads, thereby, providing safer pedestrian access to the site. An access trail to the shoreline below the dam is proposed as an enhancement to the existing shoreline paths (Figure F-15, Appendix F). The proposed recreation plan lacks many of the standard provisions that staff recommends, such as a fishing pier, restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The Montgomery project area is unique among projects in the study area in that there is no developed public recreational land acreage (excluding the PA Fish Commission ramps and the sites on the Beaver River) along the 37 miles comprising the Montgomery Pool (Table 4.1.3-3). The number of recreational days of use in the project area is the lowest of all proposed projects on the Ohio mainstem and ranks thirteenth when compared with all the proposed project sites in the study area (Table 4.1.3-2). Nevertheless, the project location is in Beaver

County, which is the fourth most populated county with a proposed hydroelectric project. Although recreational developments could enhance recreational fishing access and use at a project area with extremely limited existing access opportunities, adverse impacts to game fish from turbine-induced mortality at this site would create unmitigable impacts to recreational fishing.

Montgomery (FERC No. 3490)

Proposed recreational features include a gravel area for vehicle parking between the dam abutment and the powerhouse and a trail to the tailrace area along the river bank (Figure F-16, Appendix F). The proposed recreation plan lacks many of the standard provisions that staff recommends, such as restrooms, a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction. Comments in the second paragraph under Montgomery (FERC No. 2971) also apply to Montgomery (FERC No. 3490).

New Cumberland (FERC No. 6901)

Current public recreational access to the dam abutment is poor. Pedestrian access is possible by hiking approximately one mile from either upstream or downstream of the dam. Pedestrian access also occurs along a steep path from the top of the hillside immediately adjacent to the dam. The applicant proposes to acquire the necessary land rights to the access right-of-way in order to permit full-time automobile access to two proposed parking areas. Public parking spaces would be constructed along the tailrace channel to allow handicapped access to a fishing groin. In addition, parking would be provided on property at the existing brickyard facilities, involving the removal and replacement of three structures ancillary to the brickyard. A fishing groin and a proposed fishing cell are proposed for the tailrace area (Figure F-17, Appendix F). The recreation plan is adequate aside from the need to provide ancillary facilities such as restrooms, a fish cleaning shelter, solid waste disposal, lighting and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The New Cumberland project site is located in a relatively sparsely populated county in West Virginia. However, the population concentration along the opposite shore in Jefferson County, Ohio, is much higher. The amount of recreational land area per shoreline mile in the New Cumberland project/pool area ranks the sixth highest of all the proposed projects in the study area (Table 4.1.3-3). The number of recreational days of use ranks ninth highest of all the proposed projects in the study area, equal to the use in the Willow Island pool (Table 4.1.3-2). The New Cumberland tailwaters received the smallest number of angler trips of all those surveyed by the WVDNR (WVDNR, 1983). Nevertheless, the tailwater had the highest average of fish caught per angler trip, the highest average harvest per angler trip, and the highest average hours per angler trip of all dam tailwaters surveyed. Improved recreational access to the project tailwater could greatly increase the potential fishing use of the area. The recreation development plans are dependent on acquisitions of land currently owned by the Crescent Brick Company.

In the event that sufficient lands are not available for the construction of a standard level of recreational development, a recreational compensation plan would need to be filed with the Commission. Recreational compensation measures could include the provision of off-site recreational facilities and the upgrading of existing access facilities. The compensation plan would be developed in consultation with the appropriate state and federal resource agencies.

New Cumberland (FERC No. 10332)

Recreation enhancements measures proposed by the competing applicant include a fishing pier, parking lot, path from the parking lot to the fishing pier, and scour holes or other fish attractants beside the fishing pier. An existing building owned by the Cresent Brick Co. would be relocated across the railroad tracks in order to provide for parking. The applicant estimates that at the present time no more than 5 vehicles and 15 fishermen use the site (WV Hydro, Inc., 1987). Ancillary facilities include a fish-cleaning shelter, restrooms, and lighting (Figure F-18, Appendix F). The recreation plan is adequate aside from the need to provide solid waste disposal. More detailed design drawings are needed, however, which better illustrate the proposed enhancements in the context of the project site. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

Comments in the second and third paragraphs under New Cumberland (FERC No. 6901) also apply to New Cumberland (FERC No. 10032).

Pike Island (FERC No. 3218)

Existing facilities at the Pike Island L&D include a parking area and fishing pier adjacent to the west abutment in Yorkville and a parking area and observation deck overlooking the lock facilities in the Town of Richland, West Virginia (Figure F-19, Appendix F). The existing recreational fishing area is approximately 1.5 acres in area and includes a project identification sign, parking, walk-ways, a small open area, a ramp for handicapped persons, and a fishing pier along the west shore of the river immediately below the dam spillway. The applicant proposes to replace existing fishing facilities and add a picnicking area, restrooms, and area lighting (Figure F-20, Appendix F). The new fishing pier would extend along the tailrace wall and down the bank. This would replace the existing pier and would allow more anglers to use areas where the water is moving and the fish are more likely to be feeding (City of Orrville, 1982). The current pier can be fished from both sides only during high water which can create crowded conditions. The new pier would be integrated with the bank and fishing would occur from only one side. The proposed recreation plan is adequate aside from the need to provide ancillary facilities, such as a fish cleaning shelter and solid waste disposal. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The project area is in a heavily used recreational fishing area. The Pike Island L&D tailwater received the highest fishing pressure (no. of hours fished) of all the tailwaters surveyed by the WVDNR (WVDNR, 1983). The Pike Island Pool received more angler trips than any other pool in the WVDNR survey. The Pike Island project/pool area ranks the fifth highest of all of the proposed project areas in the amount of recreational land area per shoreline mile (Table 4.1.3-3). Therefore, it is important that the proposed development would not detract from the existing fishing opportunities at the site. The proposed development would not greatly alter the basic design of the existing recreation area. The vehicle capacity would be slightly increased. The proposed integration of the fishing area with the undulations of the shoreline should improve the existing fishing success at the site and the quality of recreational fishing.

Willow Island (FERC No. 6902)

Current facilities at the Willow Island L&D are restricted to two unpaved parking areas, three picnic tables, and a porta-toilet on the abutment side of the dam. Proposed enhancement features include an asphalt parking area, an asphalt ramp connecting the parking lot to a fishing groin, grouted walkways along the shoreline, two gravel parking areas, capped cofferdam cells for fishing along grouted walkway, a catwalk over the powerhouse to two concrete capped riverward cofferdam cells or to a fishing platform with railing. Ancillary facilities include a picnic shelter, restrooms, and an open space area with landscaping (Figure F-20, Appendix F). The proposed recreation plan is adequate aside from the need to provide a fish cleaning facility and solid waste disposal. A revised recreation plan would need to be filed for approval prior to project construction.

The Ohio River Access Study (ODNR, 1986) recommends improved fishing access at the Willow Island Dam tailwaters. The Willow Island tailwaters received the most angler trips, angler trips per acre, and hours of use per acre of all the navigational dam tailwaters surveyed by the WVDNR in 1981. In addition, the tailwater had the highest catch and harvest of sauger, northern pike, flathead catfish, and freshwater drum of all tailwaters. The Willow Island project area ranks the fourth highest in terms of the amount of recreational land acreage per shoreline mile of all the proposed project sites in the study area (Table 4.1.3-3). The number of recreational days of use is similar to the New Cumberland project area, although the number of recreational fishing days is 10 percent greater in the Willow Island project/pool (Table 4.1.3-2). The proposed recreational enhancements should greatly increase the recreational potential and use of the site. Unlike other project sites, the Willow Island site has a spacious land area for project development.

Willow Island (FERC No. 9999)

Recreational enhancement measures proposed by the competing applicant include a fishing pier, scour holes or other fish attractants to be place beside the pier, parking, and a launch ramp downstream from the pier (Figure F-22, Appendix F). Proposed ancillary recreational facilities include a fish-cleaning shelter, restrooms, and lighting. The proposed recreation plan is adequate aside from the need to provide solid waste disposal. More detailed design drawings are needed, however, which better illustrate the proposed enhancements in the context of the project site. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The boat launch facility proposed by the applicant at Willow Island (FERC No. 9999) would provide additional boating access and use in the Belleville Pool, which receives the second highest number of boating days of use of all the pools in the study area. By improving access to an area with a high demand for recreational boating, the proposed additional access facility would be beneficial to the region.

Comments in the second paragraph under Willow Island (FERC No. 6902) also apply to Willow Island (FERC No. 9999).

Belleville (FERC No. 6939)

There are two unpaved parking areas for use by anglers at the Belleville abutment . The applicant proposes to provide the following additional recreational facilities in the project area: 5 spur dikes, a gravel road extending downstream to the end of the Corps existing fill area, parking in the field along the gravel road and in a paved parking area in the powerhouse area, a fishermen's walkway across the power plant to public fishing piers on the riverward side of the powerhouse, and a fishing pier proximate to the paved parking area (Figure F-23, Appendix F). The proposed recreation plan is adequate aside from the need to provide ancillary facilities, such as a fish cleaning shelter, solid waste disposal, lighting to permit night fishing, and drinking water. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The Belleville project area is located in the fifth most populated county with proposed hydroelectric development in the study area, Wood County in West Virginia. The Belleville project/pool area has the most recreational land acreage per shoreline mile of all the nineteen proposed project sites (Table 4.1.3-3). In addition, the Belleville project/pool area has the highest number of fishing days of use in the study area, the second highest total recreation days of use, and the second highest number of boating days of all of the proposed project areas (Table 4.1.3-2). Recreation use at the Belleville lock and abutment accounts for 10 percent of the total recreation use in the project/pool area, with the abutment comprising 2 percent of the total use (Corps, Natural Resource Management System). The tailwater received the third highest number of angler trips of all the tailwaters surveyed by the WVDNR (WVDNR, 1981). The applicant's proposed recreation enhancements should increase the recreational fishing access and use opportunities at a location where there is a relatively large demand for recreation opportunities. In addition, there is a large amount of land available at the site for project development, relative to other project areas.

Gallipolis (FERC No. 9042)

At the present time, anglers fish from the riprap along the shore just below the dam. There is an existing gravel parking lot and a stairway that descends to the riprap. The applicant estimates that during a 7-month period, an average of approximately 25 persons are on the site daily, with 15-20 persons occupying the site at any one time (Gallia Hydro Partners, November 13, 1987). The applicant proposes the following recreational facilities at the project site to preserve and enhance the existing recreation opportunities: a fishing platform, a fish-cleaning shelter, public restrooms, lighting, drinking water, and an additional parking lot (Figure F-24, Appendix F). The proposed recreation plan is adequate aside from the need to provide access to riverward coffers and solid waste disposal. A revised recreation plan would need to be filed with the Commission prior to project construction.

The Gallipolis tailwaters have the second highest number of angler trips per acre of all the tailwaters surveyed by the WVDNR (WVDNR 1983). The tailwaters also have the second highest number of fish caught and kept per acre of all the tailwaters surveyed. The abutment has a slightly larger number of recreation days of use than at the Belleville abutment (Corps, Natural Resource Management System). The proposed recreational enhancements at the Gallipolis site should increase the recreational fishing access opportunities and the potential fishing use of the area. The WVDNR is concerned, however, that the land needed to develop the recreational fishing enhancements is off federal land (letter to FERC from WVDNR, December 4, 1987).

In the event that sufficient lands are not available for the construction of a standard level of recreational development, a recreational compensation plan would need to be filed with the Commission. Recreational compensation measures could include the provision of off-site recreational facilities and the upgrading of existing access facilities. The compensation plan would be developed in consultation with the appropriate state and federal resource agencies.

Gallipolis (FERC No. 10098)

The recreation enhancements proposed by the competing applicant include a parking lot, a fishing pier with three levels to allow fishing at varying river elevations, scour holes or other fish attractants to be placed beside the pier, and a concrete launch ramp downstream of the powerhouse on the Ohio side of the river (Figure F-25, Appendix F). Ancillary facilities include a fish-cleaning shelter, restrooms, and lighting. A bypass passage would be constructed to allow up to 2000 cfs to flow into the tailrace when the power plant is inoperative. A steel footbridge across the intake would allow fishing from the dam and from the permanent cofferdam which forms the riverward side of the power plant. Fishing access during construction would be provided with temporary dikes. The proposed recreation plan is adequate aside from the need to provide solid waste disposal. More detailed design drawings are needed, however, which better illustrate the proposed enhancements in the context of the project site. A revised recreation plan would need to be filed with the Commission for approval prior to project construction.

The applicant proposes to locate another powerhouse in an abandoned lock during a second phase of construction. Although there exist some uncertainties as to whether the Corps would permit hydro development on the lock side of the dam, the applicant's Phase 2 development should not create adverse recreational impacts to existing or proposed recreational developments adjacent to the Gallipolis Locks (Corps 1986b). There is sufficient recreational land acreage at the lock side of the dam to minimize any adverse recreational impacts. In addition, tailrace flows could perhaps improve recreational fishing on the lock side of the dam (B. Borda, Huntington district Corps, personal communication with M. Swihart, Oak Ridge National Laboratory, September 2, 1988).

Comments in the second and third paragraphs under Gallipolis (FERC No. 9042) also apply to Gallipolis (FERC No. 10098).

Muskingum L&D No. 3 (FERC No. 6998)

The proposed project on the Muskingum River is unique among the projects in the study area, as it is part of a system of L&D structures that are solely managed for recreation purposes. Existing state park facilities at the site include a picnic/open space area, parking, and restroom facilities. The applicant proposes to construct a fishing pier downstream of the tailrace outlet. A gravel path would be built from the existing parking lot to the pier (Figure F-265, Appendix F).

Public riverfront access is limited along the Muskingum River Parkway. The project has the seventh smallest amount of recreational land acreage per shoreline mile of the proposed projects in the study area (Table 4.1.3-3). Nevertheless, the proposed recreational enhancements cannot compensate for the loss of important ecological habitat that could occur from the development of the proposed project (Sections 4.1.2.2.3 and 4.1.4.3). The project site is unique in comparison to the other project sites in the study area due to its natural setting and location on a river managed solely for recreation purposes. The existing state park facilities, the undisturbed setting, and the unique fish and wetland habitats all contribute to the site's high recreational quality. Adequate mitigation for project impacts to the existing recreational quality of the area is not known to staff at this time.

Summary

Table 4.1.3-4 summarizes the proposed parking and shoreline facilities at each of the project sites.

Table 4.1.3-4. Proposed parking and shoreline facilities at each of the proposed project sites.

Project	Parking spaces	Shoreline development
Allegheny L&D No. 7 (7914)	10	(3) 25 ft x 15 ft platforms
Allegheny L&D No. 4 (7909)	10	(2) 20 ft x 6 ft platforms
Allegheny L&D No. 3 (4474)	30 1/	125 ft shoreline access
Allegheny L&D No. 2 (4017)	75 2/	150-ft-long terrace
Tygart (7307)	80	500-ft pier (200 per day)
Tygart (7399)	100	200 ft x 5 ft pier Launch ramp
Opekiska (8990)	75	200 ft x 5 ft pier (100 person) Launch ramp
Hildebrand (8654)	75	200 ft x 5 ft pier (75 person) Launch ramp improvement
Point Marion (7660)	10	Access path to river
Maxwell (8909)	30	Bank fishing/tailrace wall
Monongahela L&D No. 4 (4675)	10	Acĉess trail to river
Emsworth (7041)	10	50 ft x 25 ft platform 120 ft x 200 ft play area
Dashields (7568)	10	(2) 20 ft x 6 ft platforms
Montgomery (2971)	none	Improved ramp/path to shoreline
Montgomery (3490)	unknown	Path to shoreline
New Cumberland (6901)	50	50 ft x 150 ft fishing groin
New Cumberland (10332)	30	100 ft x 10 ft pier (75 person)
Pike Island (3218)	30	Fishing pier
Willow Island (6902)	56 2/	50 ft x 100 ft fishing groin
Willow Island (9999)	80	200 ft x 10 ft (100 person)
Belleville (6939)	20+	5 spur dikes (20 ft x 12 ft) Fishing piers
Gallipolis (9042)	40 (existing) 40 (proposed)	300 ft x 4 ft platform (60-75 people)
Gallipolis (10098)	75	(2) 200 ft x 10 ft fishing pier Launch ramp
Muskingum L&D No. 3 (6998)	existing	100 ft x 10 ft fishing pier (10-12 people)

1/ Morrison-Knudson Engineers, Inc. Letter to FERC regarding comments on the DEIS. July 14, 1988
2/ Assuming 270 square feet per vehicle.

4.1.3.2 Impacts to Tailwater Fishing Success due to the Alteration of River Flow Patterns

The direction of tailrace flow patterns associated with hydroelectric generation would affect tailwater fishing success. Angler success could be adversely impacted if flow patterns and velocities associated with the proposed projects do not create a desirable concentration of sport fishes in the public fishing areas. A variety of shoreline fishing access features are proposed by the applicants including: T-shaped piers, fishing groins, gabions, spur dikes, fishing cells, bank platforms, and shoreline pathways. In order to realize the potential for increased fishing use associated with the development of recreational fishing facilities, hydraulic modeling, as required by the Corps, of powerhouse placement should also include modeling of fishing piers, submerged dikes, riverward and landward coffer cells, temporary fishing facilities (Section 4.1.3.3), and bypass facilities (Section 4.1.3.4) in order to determine the preferred and finalized alignments of these facilities.

4.1.3.3 Impacts to the Tailwater Sport Fishery during Construction

Construction of hydroelectric facilities is expected to continue through three fishing seasons (3-year period) (letter to FERC from WVDNR, December 8, 1987). Simultaneous issuances of many licenses and concurrent construction could have adverse cumulative impacts on recreational fishing in the basin. The number of recreational days of fishing could be greatly reduced unless properly mitigated. Mitigation suggestions by WVDNR include (1) allowing fishing in safe areas outside the construction limits, (2) providing parking and restrooms, (3) posting signs indicating safe fishing areas and project purpose, and (4) constructing temporary (or permanent) wing dikes or other fish attractant structures to maximize fishing below the construction area. In project areas with small areas available for construction (e.g., Maxwell), it may not be possible to provide access during construction because of the limited land area. Impacts to recreational fishing during construction would need to be compensated in some manner beneficial to recreational fishing in the region to be determined in consultation with the appropriate state and federal resource agencies. Compensation measures could include, for example, the provision of off-site recreational facilities or the upgrading of existing access facilities. Recreation plans should be amended accordingly.

4.1.3.4 Impacts to Tailwater Anglers during Powerhouse Shutdowns

Recreational fishing would be jeopardized during periods when the power plants are inoperative (e.g., during low flows, maintenance work, or emergency situations), because the turbine tailrace currents that normally would attract fish to areas accessible by shoreline anglers would be curtailed. In order to guarantee shoreline fishing opportunities during times when the power plants are inoperative, flow velocities would need to be maintained in the vicinity of the tailrace fishing areas (e.g., via selective gate openings and/or bypass flow tunnels within the powerhouse). Approximately 10 percent of the mean annual flow, up to 2000 cfs, would need to be maintained in the tailrace fishing areas during times when the power plants are not generating. Bypass flow systems should be designed so that the discharge is well aerated. Aeration to within 90 percent of saturation should be feasible using simple and reliable technologies such as deflectors to spray the flow through the air, combined with a deep plunge pool. Such aerating outlets for the bypass system should be designed to avoid injury to fish passing through it.

4.1.3.5 Impacts to Recreational Boating Access and Navigation Due to the Alteration of Reservoir Pool Elevations and River Flow Patterns Downstream of Proposed Projects

Flow modifications could impact boating access (ramp, dock, hoist, or mooring space available at a launching area) and navigation close to the shoreline or at islands and embayments. Areas with high concentrations of boating users and areas with islands immediately downstream of the proposed powerhouse would be the most vulnerable to adverse impacts from flow modifications.

A potential lowering of pool elevations by 3 feet (or less) above hydroelectric projects at fixed-crest dams could occur during the low-flow summer months (Section 4.1.4). Altered pool elevations could impact boat navigation and access in pools above proposed project sites on the Allegheny and Muskingum Rivers. Impacts to boaters on the Allegheny River would be the most significant at the Allegheny L&D No. 2 pool. This pool has the highest number of berths of all the pools in the study area, approximately 30 percent of the total number of berths in the entire study area. In addition, 18 percent of the total number of boats passing through locks in the study area were at Allegheny L&D No. 2 in 1986.The Ohio Department of Natural Resources is concerned about the effects of the proposed project on pleasure boating on the Muskingum River, because altered water velocities from the operation of hydroelectric projects could create hazards for small boaters (letter to FERC from ODNR, October 24, 1984).

Physical hydraulic modeling studies required by the Corps should ensure that projects do not cause significant shifts in flow and sedimentation patterns that could impact upstream or downstream recreational navigation and access.

4.1.3.6 Effects on the Existing Quality of the Recreational Fishing in the Basin from Potential Impacts to Fishery Resources

Cumulative impacts to the existing quality of recreational fishing in the basin would result from impacts to fish resources under the proposed alternative (Section 4.1.2). Decreases in DO levels from hydroelectric generation during periods of low summer flows would cause significant changes in annual fish growth in the Ohio River. The most severe losses in annual growth from hydroelectric generation would occur in the reach between the New Cumberland tailwater and the Pike Island tailwater, where up to a 20 percent loss in annual (catfish) growth would occur. A 20 percent loss in fish growth would have significant adverse impacts to recreational fishing, because this would correspond to a 20 percent reduction in the size of fish caught in this reach of the Ohio River. This loss would occur in the Pike Island Pool which received the largest number of angler trips of all the pools surveyed in the WVDNR recreational use survey (WVDNR, 1983).

Recreational impacts in tailwater areas would also be of concern at New Cumberland and Pike Island. The New Cumberland dam tailwater had the highest average number of fish caught and kept per angler trip of all the tailwaters surveyed by the WVDNR (WVDNR, 1983). The Pike Island tailwater received more fishing pressure (number of hours fished) than any other tailwater.

A 10 percent loss in annual catfish growth and in the size of harvestable fish below Belleville would occur under the proposed alternative. Impacts below Belleville would have less effect on recreational fishing because the Racine pool received the least amount of fishing activity of all the pools surveyed by the WVDNR (WVDNR, 1983). Impacts on fish growth and the size of fish caught along the other rivers in the study area would not cause significant changes to fish (catfish) growth and harvest size. Changes of 4 to 9 percent in annual catfish growth and harvest size on the Monongahela River would occur only in the Hildebrand pool and tailwater. A maximum loss of 2 percent would occur on the lower Allegheny. Analyses indicate more severe changes in fish growth for sauger and walleye along the lower Allegheny, below Hildebrand L&D on the Monongahela River, and all along the Ohio River (Section 4.1.2). Therefore, the reduction in the size of sauger and walleye caught by anglers would be more severe than the reduction in the size of catfish caught under the proposed alternative.

Notable changes in fish habitat quality under the proposed alternative would occur on all of the sites on the Allegheny River, at Emsworth, and at Muskingum L&D No. 3 (Section 4.1.2). The most significant adverse changes to fish habitat and recreational fishing would occur at the Muskingum River L&D No. 3 Project, and Allegheny River L&D No. 7 project because of the presence of islands immediately downstream of these proposed project sites.

At most project sites, turbine-induced mortality is not expected to cause unmitigable entrainment problems for game fish (Section 4.1.2). Game species would be highly vulnerable to turbine impacts, however, at the Montgomery L&D Project, where an embayment is located immediately upstream of the proposed project.

4.1.4 Wetlands

Adverse impacts to wetlands, including riparian zones, will occur from both construction and operation of the proposed hydropower projects. Construction in riparian zones and dredging in emergent wetlands lead to losses of these important ecosystems. Dredging and excavation produce increases in turbidity of wetland waters and siltation of bottoms. Such increases in suspended solids or sedimentation can eliminate or damage aquatic vegetation (Darnell, 1976). Operational effects can result from decreases in pool elevations and erosion caused by tailrace discharges. Small changes in water levels may greatly influence the composition of shallow-water vegetation communities. Riparian communities may also be affected by lower soil moisture (decreases in pool level) or increased flooding (higher pool level or increased velocities) (Jahn, 1978). Loss of vegetation can lead secondarily to increased sedimentation and increases in the extent of bare areas (mudflats). Upstream operational impacts on wetland areas will be greatest at the fixed-crest dams, where pool elevations would change. Because wetland and riparian vegetation provides important, often critical, food, shelter, and nesting habitat for wildlife, changes in vegetation affect the numbers and diversity of wildlife using these areas (Adamus, 1983).

Freshwater wetlands are highly unstable ecosystems, changing in size, form, and structure through succession. Plant communities found in these wetlands are dependent upon moisture regimes for survival. As wetlands proceed from open water to mudflats, vegetated flats, persistent emergents, scrub-shrub, to forested wetland, any number of natural or human-induced impacts can accelerate, halt, or reverse the progression. Although it is difficult to predict the changes that may occur to wetlands impacted by the development of projects, changes in the areal extent and species composition of affected wetlands are likely to occur.

Impacts from construction were assessed using estimates of destruction and disturbance on the basis of project characteristics (Section 2.2) and considering the value and regional extent of the wetland types present. Impacts of operation were evaluated from consideration of predicted changes in pool elevations and of probable erosion from tailrace discharges, again taking into account the nature and extent of wetlands involved. Impacts to wildlife resulting from loss of wetland habitat can properly be considered a part of wetland impacts but are discussed separately in sections on endangered species (Section 4.1.6.3) and wildlife (Section 4.1.6.7).

To identify wetland areas, staff obtained the USFWS National Wetlands Inventory maps (Scale=1:24000) for the study area. About 20 percent of the quadrangles covering the study area have not been mapped and were not available. Aerial photographs taken in August and September 1986 by the Corps Pittsburgh District were also used. Vegetation surveys of wetlands and riparian zones on the Allegheny, Monongahela, and Ohio rivers were conducted by the Corps Pittsburgh District as a part of water quality surveys taken during the summers over the past 8 years. These data were mapped onto Navigation Charts by the Corps staff and includes information regarding the vegetation composition of the riparian zones (Reilly, 1988; Corps 1986, 1987a, b). A biological survey of the upper Ohio River from the Gallipolis L&D to the Hannibal L&D was conducted by Tolin and Schettig (1983a, b) and contains vegetation survey data and wetland areal estimates for all islands in this portion of the study area. Information on wetlands at Muskingum L&D No. 3 and Allegheny L&D No. 3 were provided in the environmental reports included by the applicants in their license applications. In the discussion that follows, the three projects that have the greatest potential for causing significant adverse impacts on wetlands are discussed first, followed by a general discussion of adverse impacts associated with the remaining projects.

4.1.4.1 Allegheny L&D No. 7

Construction and dredging activities would seriously affect wetlands associated with the Isle of White, a 2 acre recreational refuge directly in the path of the proposed tailrace channel. Channel maintenance and other necessary dredging in the vicinity of the island would increase sedimentation, turbidity, and erosion on and around the island. Staff expects all or a major portion of the island vegetation to sustain serious damage.

Operation of the project would entail further adverse impacts to the vegetation associated with the Isle of White at Allegheny L&D No. 7. The tailrace channel will discharge water just below the upper tip of the island, causing additional losses through erosion of the island. Over time, the entire island would seriously erode away. Changes in operation of the power plant and tailrace flows would change the species composition of species on and around the island (Section 4.1.5). Such changes would change the composition of the perimeter species from water willow [_Justicia_ _americana_ (L.) (Vahl)] and Japanese knotweed (_Polygonum_ _cuspidatum_ Sieb. & Zucc.) to a more wooded floodplain area or affect the reseeding capability and survivability of existing species in the shallow areas around the island. Staff estimates a net potential loss of 2 acres of wetland communities would occur as a result of constructing and operating the proposed project. No riparian vegetation would be destroyed by construction because the shoreline near the tailrace channel is classified as a disturbed area with little vegetation. Riparian vegetation upstream will not be adversely affected by construction because the facility will be built in a weir section of the dam. Upstream riparian vegetation, mostly floodplain forest and littoral zone vegetation, will be affected by pool elevation changes (see Section 4.1.5.2 for discussion of pool elevation impacts). Predicted decreases in pool elevation of 3.5 feet would cause changes in species composition of the riparian areas. An increase in mudflat area and increased erosion would be expected. Loss of the Isle of White would represent a 7.4 percent decrease in the wetlands area in the Allegheny L&D No. 6 pool. This pool contains about 36% of the total wetlands area in the Allegheny River portion of the study area (Table 3.3.5-2). Staff considers such loss of the island, shoals, and associated aquatic resources to be a significant adverse impact on wetland resources of the Allegheny River.

4.1.4.2 Muskingum L&D No. 3

The Muskingum L&D No. 3 has four islands close to the proposed construction site (Section 3.6.5; Figure C-18, Appendix C). Construction of facilities at Muskingum L&D No. 3 would not remove wetlands associated with the islands. However, as much as 1 acre of riparian vegetation along the main shore between the largest island and the shore would potentially be destroyed by construction of the tailrace channel. The increase in turbidity and sedimentation during excavation of the tailrace would also entail short-term impacts. Dredging would cause sedimentation and turbidity at this site both upstream and downstream of the project site, resulting in continued erosion and loss of wetland/riparian vegetation. The applicant has proposed protection measures for the island during construction, using hay bales. However, there would be some adverse disturbance to the island from excavation and dredging activities, even with these protective measures.

Project operation would contribute to additional adverse effects. The large island is located downstream of the tailrace channel and discharge point. When operating at full capacity, the plant would produce flow velocities on the order of 5 feet/second in the area between the island and the tailrace, compared to current 0.5 to 1.5 feet/second (Upper Mississippi Water Company, 1987). Thus, the island would be subject to erosion and the effects of turbidity and sedimentation resulting from project operation. Diversion of water through the powerhouse would also change flow patterns around the upper end of the island (Section 4.1.5.2). The use of riprap to stabilize the banks would lead to loss of riparian vegetation. These activities would also lead to instability of the island vegetation. Hence, operation of the project potentially would damage or threaten about 1 additional acre of wetlands and riparian communities.

4.1.4.3 Montgomery L&D

The Montgomery Embayment (approximately 17 acres) is a unique area on the Ohio River and lies in the proposed area of the intake channel with porous dikes proposed by one of the competing applicants (FERC 3490) as protection devices during the construction and operation of the project. Although the porous dike is expected to afford some protection, staff considers that construction of the dike itself would be likely to have adverse effects on the embayment (Section 4.1.2.3.3). Changes in flow patterns and increased velocities (Sections 4.1.5.1 and 4.1.5.2) would damage emergent vegetation and/or riparian communities. The close proximity of the embayment area (approximately 500 feet upstream) to the Montgomery L&D would subject the resource to disturbance by construction of any type. Because the Montgomery L&D is a gated structure, changes in pool elevation would not occur. The Montgomery Embayment and associated wetlands are the only significant wetlands in the Montgomery L&D pool. Loss of at least 1 acre would be expected during construction. Diversion of flows from the embayment by protection devices would result in species composition changes and area of the wetlands. Further disturbance and increased velocities from dredging during construction and operation could cause increased erosion, with increased tubidity and sedimentation. In the context of the value and regional rarity of wetlands and riparian zones, and in particular the designated importance of the embayment by the USFWS and the Pennsylvania Western Conservancy (Section 3.5.5.9), staff considers these adverse impacts to be unacceptable.

4.1.4.4 Other Projects

For the remaining projects, effects on wetlands would be minor. Either wetlands are not present in the vicinity of the projects, or they are unlikely to be adversely affected by construction or operation of a project.

Monongahela River System

No significant impacts on the riparian vegetation in the Monongahela River system within the project boundaries are predicted. All proposed project sites are located at gated structure dams, with no changes in pool elevation expected. Applicants at the Maxwell L&D and Opekiska L&D proposed project sites would construct facilities on the shore. All other project applicants propose to construct their facilities in the river. Assuming disturbance at each site of a strip of riparian vegetation 500 feet long and 15 feet wide, staff calculated that less than 0.2 acre per site would be disturbed by construction and operation of these projects. The 15-foot width was derived from an average of reported widths of riparian vegetation along the Monongahela River ranging between 5 and 35 feet.

Allegheny River Projects

No significant impacts on the riparian vegetation within the project boundaries are predicted. Six Mile Island, in the Emsworth L&D Pool, is located close to the Allegheny L&D No. 2. Increased flow velocities and patterns due to construction of Allegheny L&D No. 2 could lead to increased erosion and turbidity around the island. The applicant at Allegheny L&D No. 4 proposed construction of facilities in the river, removing a section of the dam. Minimal impacts to the riparian vegetation due to construction would be expected. Pool elevation changes would lead to changes in species composition of riparian edges and increased mudflats.

Construction of facilities at Allegheny L&D No. 3 would disturb or remove approximately 0.5 acres of wetlands associated with the island and shoreline riparian community if the use of crest gates is approved. This estimate is based on the size of the aquatic vascular plant/water willow area, length of the intake channel and tailrace, and an estimated riparian strip width of 15 feet. A small island downstream of Allegheny L&D No. 3 would be disturbed during construction of the tailrace channel. Staff estimates that approximately 0.2 acre of riparian vegetation would be destroyed by construction of the tailrace and about 0.3 acre in and around the island would be disturbed. Loss of this acreage would result in a 10 percent decrease in wetlands area in the Allegheny L&D No. 3 pool.

The islands between Allegheny L&D Nos. 4 and 6 are likely to be affected by pool elevation changes associated with hydropower plant operation at the Allegheny L&D Nos. 5 and 6. However, analysis of impacts as a result of hydropower operation at L&D No. 6 was outside the scope of this study. Similar adverse impacts on wetlands described in this analysis for proposed projects at Allegheny L&D Nos. 3 and 7 would be expected to occur from construction and operation of a hydropower plant at the L&D Nos. 5 and 6 sites.

Ohio River System

The Dashields L&D is the only fixed-crest dam in the Ohio River portion of the study area with a proposed hydropower plant. Damage to riparian vegetation during construction is expected to be minimal because the facility is proposed to be constructed in the river, removing about 250 feet of the dam. Pool elevation changes in the Dashields L&D pool will cause species composition changes and increased mudflats. These changes are expected to be minimal. The Emsworth L&D, New Cumberland L&D, and Willow Island L&D shorelines are classified as disturbed areas in the project vicinity. Therefore, no adverse impacts due to construction are expected. The Pike Island L&D site is classified as floodplain forest and exposed shoreline below ordinary high water mark.

4.1.5 <u>River Navigation and Hydraulics</u>

4.1.5.1 Flow Patterns

At fixed-crest dams without hydropower, the river flows evenly across the crest. At gated dams, the river is constricted to pass through the one or more gates that are open (Figure 4.1.5-1), and then spreads out across the navigation channel again. These flow patterns provide generally uniform flows near the entrances and exits to locks, which facilitate quick and safe lockage of barges. Hydropower plants constrict all or some of the river flow through the powerhouse on the far end of the dam from the locks and then discharge in a direction pointing downstream and offshore. A hydropower plant with a well-designed intake and discharge can provide fairly uniform flows above and below the dam (Figure 4.1.5-2) that would not affect barge lockage. A hydropower plant with a poorly designed intake and discharge can cause highly nonuniform flows and large eddies above and below the dam (Figure 4.1.5-3).

The nonuniform flows and eddies could make lockage slow and unsafe because the currents can push barges in directions the pilot is not expecting. Also, obstacles with which the barges might collide can increase the hazard from nonuniform flows. According to the Corps navigation charts, there are potential navigation obstacles (such as islands, moorings, and bridge piers) in the immediate vicinity of the locks at all four of the proposed project sites on the Allegheny, at two of the five proposed project sites on the Monongahela, and at five of the eight proposed sites on the Ohio. Project-induced navigation hazards at several dams, or at even one dam with a high volume of barge traffic, could slow river traffic through much of the system and increase the probability of accidents. Recreational boaters would also be affected by slowed lockage.

Changes in flow patterns are not expected to affect water intakes significantly but could change the debris loads and susceptibility to boat collisions. According to Corps navigation charts, the following proposed sites have intakes within about 4000 feet of the dam, which could be affected: at Allegheny L&D 4 there are intakes about 1000 and 2000 feet upstream of the dam on the lock side of the river; at Allegheny L&D 2 there are intakes about 2000 feet upstream and downstream of the dam on the hydro side (the side opposite the locks); at Point Marion L&D there is an intake about 2000 feet downstream of the dam on the hydro side; at Dashields L&D there is an intake about 3000 feet upstream of the dam on the hydro side; at New Cumberland L&D there is an intake about 2500 feet upstream of the dam on the lock side; at Pike Island there are intakes about 3000 and 4000 feet upstream of the dam on the hydro side; and at Belleville L&D there is an intake about 2500 feet upstream of the dam on the hydro side.

The best way to determine whether each project would cause undesirable flow patterns is the use of physical models of the dam, locks, powerhouse, and adjacent river (Berry and Schmitt, 1988). Physical models can also be used to design projects to avoid undesirable flow patterns. Physical modeling of the proposed projects has not been done in preparation of this EIS, but at projects previously licensed in the Ohio River basin, the Corps has required licensees to perform physical modeling studies prior to construction. It is expected that this requirement would also be applied to any new licensees resulting from this EIS (personnal communication, R. W. Schmitt, Pittsburgh District, Corps, September 16, 1987). This modeling requirement should ensure that projects do not cause significant impacts to barge lockage.

4.1.5.2 Pool Elevation Changes

Hydropower projects at fixed-crest dams would lower the water surface elevation of the pool above the dam, when operating. Without hydropower, the pool elevation is controlled by the depth of the water passing over the dam crest, which increases with increasing river flows. With hydropower, some of the flow passes through the turbines so the flow over the dam crest is reduced, and the depth of the flow over the dam crest is reduced. This effect, illustrated in Figure 4.1.5-4, reduces water surface elevations in the pool above the dam. Reductions in pool elevations can affect wetlands (Section 4.1.4), recreation (Section 4.1.3), and river navigation.

At river flows less than the maximum flow capacity of the hydropower project, it can be assumed that pool elevations for projects as proposed would be slightly higher than the dam crest elevation. The pool elevations without hydropower were estimated using rating curves (graphs of water surface elevation as a function of flow rate) for the dams provided by the Corps. Pool elevation changes at low river flows, when the projects just have sufficient flow to operate, would be less than about 0.5 foot. The maximum pool elevation changes, which occur when river flows are at or above the maximum flow capacity of the proposed projects, are approximately 2 feet at Allegheny L&D Nos. 2 and 3, and 3.5 feet at Allegheny River L&D Nos. 4 and 7 and at Dashields Dam on the Ohio River. Because pool elevations would approach their preproject levels at high river flows, or when plants are not operating, a wider range of pool elevations would occur with hydropower.

The reduced pool elevations caused by the proposed hydropower projects would increase river velocities by reducing the cross-sectional area of the channel through which the river flows (the average velocity of a river is equal to the flow rate divided by the cross-sectional area, so reductions in cross-sectional area cause increases in velocity). For example, in the Allegheny L&D No. 4 pool, at flows at which the proposed projects would cause a change in pool

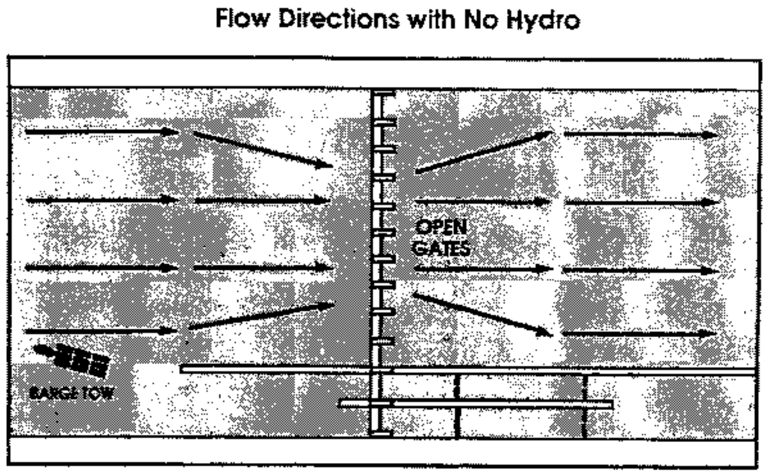

Figure 4.1.5-1. Flow patterns with no hydropower project.

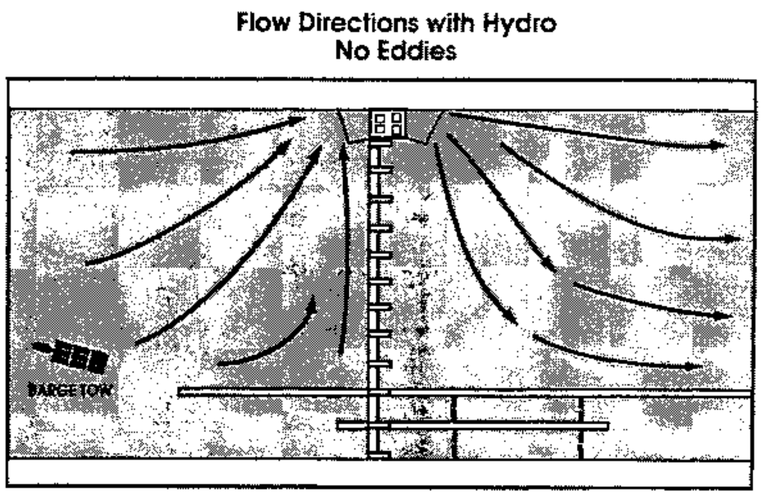

Figure 4.1.5-2. Flow patterns with a hydropower project and no eddies.

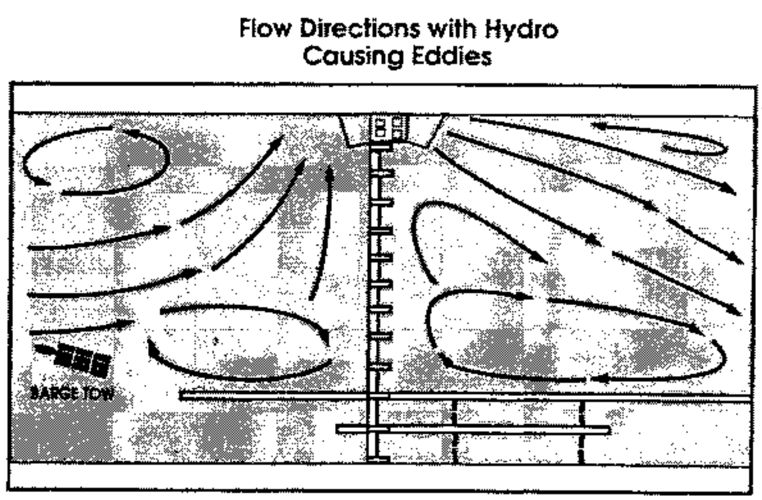

Figure 4.1.5-3. Flow patterns with a hydropower project causing eddies.

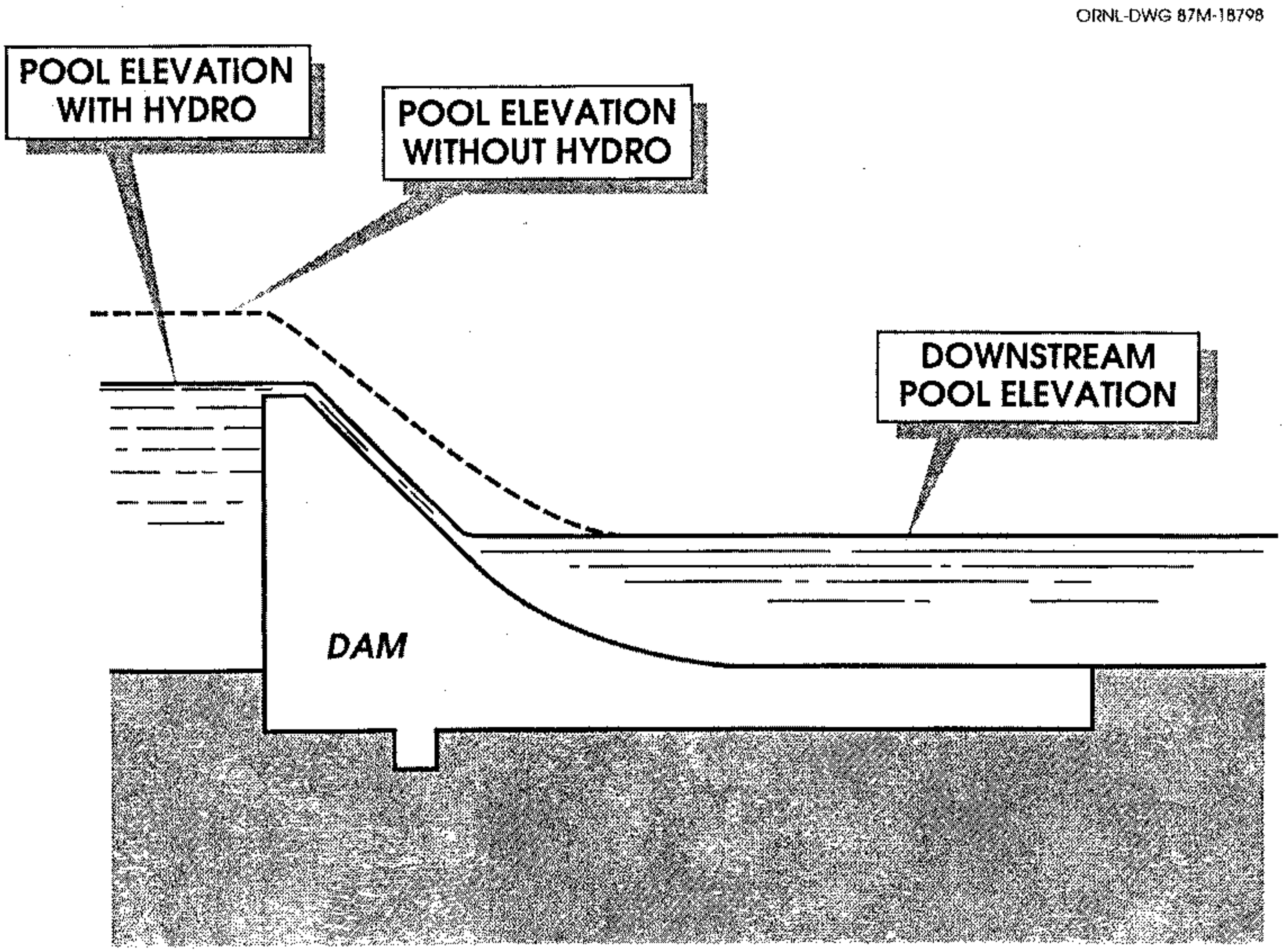

Figure 4.1.5-4. Pool elevation changes from a hydropower project at a fixed-crest dam.

elevation of about 3.5 feet, the resulting change in velocity was determined using 18 cross sections measured by the Corps. The proposed project would cause increases in velocity of 20 percent to over 50 percent through the pool, with an average velocity increase of 37 percent. Similarly, using 27 cross sections in the Allegheny 7 pool, the predicted increases in velocity would range from 25 percent to over 60 percent, with an average velocity increase of 40 percent. Velocities in the Allegheny at the river flows where maximum pool elevations occur are estimated to average between 1.5 and 2.5 feet per second.

The velocity increases caused by the proposed projects would have several effects, such as increases in sediment transport and erosion and disruption of transportation. Significant changes to river sediments and channel shape are not expected because the river bed of the Allegheny is made of mostly coarse materials; the proposed projects are not expected to affect velocities at flows high enough to cause the river bed to move. However, if a project should start up and cause a rapid increase in velocities, a pulse of fine sediments may be resuspended from the river bed and transported downstream.

The applicant at Allegheny L&D No. 3 proposed the installation of flashboards on the dam crest to mitigate the effects the project would have on pool elevations. Flashboards are removable boards mounted vertically along the crest to raise the effective height of the dam. Flashboards can be designed to collapse during flood flows to reduce flood elevations. Properly designed flashboards could maintain upstream pool elevations at approximately what they are without hydropower. In addition, they could increase the head available for power generation, but by increasing the upstream pool elevation, they would reduce the head available for generation at the next dam upstream.

During the application review process, the Corps provided comments stating that they do not favor the use of flashboards at these dams because of their questionable reliability and undesirable effects on the existing structure. A minimum of six inches of depth is generally recommended over the crest of the dam at all times for structural reasons. Use of flashboards could cause drying of the downstream face of the dam, wet-dry cycles and freeze-thaw damage. The installation of flashboards could, in some cases, damage the crest of the dam. The added damming height would create stresses affecting lockwall and/or dam stabilities, and unbalanced discharges could cause or aggravate scouring at the toes of dams. Flashboards increase the operational complexity in that they must be removed prior to flood events and their removal must be accomplished in a manner so as not to generate adverse waves that could affect navigation.

In response to recent discussions between the Corps and the Allegheny L&D No. 3 applicant, a letter from the Corps (July 26, 1988) was provided stating that the Corps would consider installation of facilities to control elevations during periods of low flow. Among other items, the Corps indicated that any device installed on the dam (e.g., crest gates) must be fully controllable. The applicant's plans have been revised to include crest gates in lieu of flashboards.

4.I.5.3 Backwater Effects and Flooding

Navigation dams increase the water level of floods by blocking the flow. The elevation of floodwaters above a dam depends on how much the dam blocks the flow; other structures that block flow, such as piers, gates, and locks, cause more flooding. Flooding is also determined by the structures' hydraulic resistance to flow. Hydropower projects that add structures that block flow, or replace existing structures with ones that have more hydraulic resistance to flow, can be expected to increase the elevation of flood flows. Therefore, hydropower projects that decrease a dam's ability to pass flood flows can be expected to increase the water level of floods, increasing the damage caused by floods and causing damaging floods to occur more often. These changes in flooding would have economic impacts to flood-prone areas along the rivers and would also affect barge traffic by increasing the amount of time that navigation would be unsafe during floods.

The effects of the proposed projects on flood elevations are best determined by using physical models. Whether or not a project is likely to increase flooding depends on whether it would remove any parts of the dam that pass water during high flows, such as crests of fixed-crest dams, weirs, or spillways; and if so, whether hydropower structures present obstructions to flow greater than the existing dam.

Table 2.1.1-I lists the part of the dam, if any, that would be replaced during the proposed projects. The proposed projects at Muskingum L&D No. 3, Willow Island (competing project No. 6902), Pike Island, New Cumberland (competing project No. 6901), Emsworth, Allegheny L&D No. 2, Monongahela L&D No. 4, Maxwell, and Opekiska all include powerhouses that are built into the shore and do not replace any part of the existing dam. These projects present the least probability of additional flooding. However, the porous dike intake structure proposed by the applicant at Emsworth would be an obstruction to flow across much of channel (Figure 2.1-14), so this project would have some probability of causing flood impacts.

The proposed projects at Gallipolis (both competing applicants), Belleville, Willow Island (competing applicant No. 9999), New Cumberland (competing applicant No. 10332), Montgomery (both competing applicants), Point Marion, and Hildebrand each would replace part or all of an existing gate, weir, or spillway at a gated dam. Therefore, all of these projects would have a high probability of causing additional flooding. The magnitude of additional flooding partly depends on the height of the powerhouse above the upstream pool elevation. For the project proposed at Belleville, the powerhouse is only 2 feet above the upstream pool elevation, so the magnitude of flood impacts is expected to be low at this project. At the other projects listed in this paragraph, the proposed powerhouse is at least about 8 feet above the upstream pool elevation, presenting a significant obstacle to flow and increasing the expected magnitude of flood impacts.

The proposed projects at Dashields, Allegheny L&D No. 3, Allegheny L&D No. 4, and Allegheny L&D No. 7 (all fixed-crest dams) would replace part of the dam crest with a powerhouse. At Allegheny L&D No. 3, the powerhouse would be about 10 feet higher than the dam crest, presenting an obstacle to flood flows. However, the applicant has proposed replacing some of the removed dam crest with a new spillway perpendicular to the existing dam, reducing the flood potential to some extent. All the other projects listed in this paragraph propose submergeable powerhouses with roof elevations that would be the same as the elevation of the existing dam crest. These powerhouses would not protrude above the dam crest, but the powerhouses are expected to have more hydraulic resistance to flow than the curved shape of the existing dam. The physical modeling studies done for the licensed projects at Allegheny L&D Nos. 5 and 6, which also have submerged powerhouses (but only at high flows) built into the existing dam, indicate that these projects may cause increased flood elevations of up to 2 feet at L&D No. 5 (at flows between 130,000 and 185,000 cfs) and up to 1 foot at L&D No. 6 [at flows between 185,000 and 220,000 cfs (see Figure 3.3.6-1)]. Similar increases in flood elevation can be expected at the proposed projects at fixed-crest dams if they are not sufficiently submerged.

An additional impact of the proposed projects is the expected increase in flooding during construction. All the proposed projects except Tygart Dam will require the installation of temporary cofferdams in the river during construction. These dams can block a significant portion of the channel cross section, so any floods that occur while cofferdams are in place could be more intense than they would be when the projects are completed.

Corps' policy is that (1) the financial responsibility for additional flooding caused by hydropower projects rests with the hydropower developer and (2) the developers should be required to obtain any additional flood easements that may be required to mitigate project effects (personnal communication, R. Yates, Ohio River Division, Corps, August 20, 1987). Although the magnitude of changes in flood elevations caused by the projects has not been completely quantified, significant increases are expected at some projects.

4.1.5.4 Flow Control

Rapid changes in river flow sometimes are created and propagated through the upper Ohio River system (Section 3.2.6). Pulses of high flows can be started with releases from existing hydropower projects in the basin and are changed (either damped or exaggerated) by how releases from gated navigation dams are made. The proposed projects would assume at least partial control over flow release rates from gated and fixed-crest dams and would affect how sudden changes in river flow would be propagated. The projects generally propose to use computers to monitor the pool elevation above the dam: (1) to increase flow through the plant if the pool starts to rise or (2) to decrease flow through the plant if the pool starts to fall. If hydropower projects would overcompensate for changes in pool elevation, fluctuations in river flow would be exaggerated by the projects and larger pulses of unsteady flow would propagate downstream. If, however, hydropower projects were designed to respond slowly to changes in pool elevation, fluctuations in river flow would be damped by the projects. The design of the automatic flow controllers would determine whether the projects would have a beneficial or negative effect on control of river flows.

Control of river flows requires the ability to measure river flow rates. River flow rates are generally measured by monitoring the water surface elevation and determining a relation between water surface elevation and flow rate. This method works well above fixed-crest dams that do not have hydropower but does not work at gated dams or at dams with hydropower because how such dams are operated (gate openings, generating rates, etc.) controls the water surface elevation more than the river flow does. At gated dams without hydropower, the river flow rate is estimated from how far open each of the gates is. The installation of hydropower at navigation dams may seriously decrease the accuracy of flow measurements made there. Accurate and continuous monitoring of the flow rate through the turbines would be required to maintain accurate gaging of river flows.

4.1.6 Other Issues

4.1.6.1 Land Use

Direct Impacts

The ownership and amount of land that would be occupied by power generation and transmission lines for each project are listed in Table 4.1.6-1. Most of the proposed generation facilities (powerhouse, switchyard, parking area, etc.) are located on vacant land in rural or industrial areas used primarily to provide access to the river for fishermen. Impacts on recreational use of the lands is described in Section 4.1.3. Other land use impacts would be negligible for most projects; however, some adverse impacts would occur for the following projects:

Allegheny L&D No. 7. This project would abut a residential area in the city of Kittanning, Pennsylvania, and the proposed access route to the site would be constructed between existing houses. Construction activities would produce noise, dust, and traffic, which would be incompatible with the adjacent residential land use. The addition of an access road would introduce a visual division within an established neighborhood. There would be an overall moderate adverse impact on the residential area that could be mitigated by restricting construction activities to weekdays between the hours of 8:00 a.m. and 6:00 p.m. A city-owned park upstream of the project should not be affected, provided the transmission line is routed along existing utility poles along Water Street, as proposed in the application. Any encroachment on the park would constitute a severe impact.

Allegheny L&D No. 2. Approximately 3.8 acres of industrial land owned by Dietch Company and Wholesale Lumber and Flooring would be used by the proposed project, and two rail lines (sidings that serve an industrial area) would be relocated. According to maps provided by the applicant, there are no existing structures on the industrial land proposed to be used for the project, but the project could reduce the land available to the current owners for storage of materials. The relocation of the rail lines would interfere with the service provided by these lines while the lines were being relocated; however, because both ends of the sidings connect to a main line, no interruption of service is expected. Overall, there would be a minor adverse impact on land use.

Tygart (both competing applications). The projects proposed at this site would be located adjacent to a tent camping area and trailer park owned by the city of Grafton. In addition, an overlook and picnic area of Tygart Lake State Park is located nearby. Construction activities would generate noise, dust, and traffic which would constitute a moderate adverse impact on these uses of adjacent lands. The impact would be mitigated by restricting construction activities during the months of May through August to between the hours of 8:00 a.m. and 6:00 p.m. on weekdays (see Section 5.3.2). No impact on land use is anticipated during project operations.

Hildebrand. An individual commenting on the DEIS objected to any project at this site because of its effects on a "high tech residential area" under development in the vicinity. While the project's power generation and transmission facilities on the east bank of the river would be located entirely on federally owned lands, the project access route and possible recreation mitigation facilities could be located on privately owned lands and might encroach on the proposed residential development. In addition, if the residential area is completed and occupied before construction of the hydropower project, it could be exposed to noise, dust, and traffic associated with construction activities.

Emsworth. The proposed project would use approximately 45 acres of land owned by Shenango, Inc., and Gulf Oil Company. The Shenango portion of the site is currently used for storage of pig iron and as a picnic area for company employees. The Gulf Oil Company portion of the site is currently used for fuel tanks. The applicant's proposal shows that three spur rail lines would be shortened as a result of the project. While the applicant proposes to relocate the picnic area at a nearby location, the project could interfere with the current industrial use of the area by the two affected companies. This would be a moderate adverse impact.

Montgomery (both competing applications). The project boundary at this site would be approximately 200 feet from a residential neighborhood, and a residential street would be used as part of the project access route. Construction activities at the site would have a moderate adverse impact on the residential area by generating noise, dust, and traffic that would be incompatible with the nearby residential use. This impact could be mitigated by restricting construction activities to between the hours of 8:00 a.m. and 6:00 p.m. on weekdays. No significant impact on the residential area would be expected during project operations.

New Cumberland (6901). This project proposes to relocate approximately 1400 feet of a rail line owned by Conrail to a parallel location approximately 75 feet inland. This action would constitute a moderate adverse impact, because rail operations would be interrupted for an undetermined period during construction of the relocation and could reduce the efficiency of rail movement in the area by introducing additional slight curvatures into the rail alignment. The rail relocation is necessitated by the proposed design and cannot be mitigated.

New Cumberland (10332). This project may require the rail line relocation as described in the preceding paragraph for the competing project (6901) proposed at this site.

Materials submitted by some project applicants indicate that additional lands (not listed in Table 4.1.6-1) would be required off-site for construction activities at Muskingum L&D No. 3 (3 acres), Dashields (acreage not specified), Allegheny L&D No. 4 (3 acres), and Allegheny No. 7 (4.6 acres). The locations of these off-site areas have not been determined. Because of restrictions imposed by terrain and the size of the area included in the project boundaries, additional off-site lands may also be required during construction of projects at Gallipolis (10098), Pike Island, New Cumberland (both competing applications), Montgomery (both competing applications), Allegheny L&D No. 3, Maxwell, Point Marion, Hildebrand, Opekiska, and Tygart (both competing applications). Construction activities at off-site locations could have significant adverse impacts on surrounding land uses if located near those that are sensitive to noise, dust, and heavy traffic. To mitigate these potential impacts the selection of off-site lands should be coordinated with local planning agencies (see Section 5.4.2).

New transmission lines for the proposed projects would have a minor adverse impact on land use in sensitive areas. The amount on new transmission line right-of-way required for each project is listed in Table 4.1.6-1, and the land uses crossed by the lines are shown in Table 4.1.6-2. Projects at Gallipolis (9042), Muskingum L&D No. 3, Pike Island, Montgomery (2971), Allegheny L&D No. 7, Monongahela L&D No. 4, Maxwell, and Tygart (both competing applications) propose the construction of new transmission lines through residential areas. These same projects (with the exception of Pike Island and Monongahela No. 4) in addition to Hildebrand and Opekiska would clear new right-of-way through wooded land. A water storage tank owned by a local water district is within the transmission line routes shown in the applications for both Tygart projects.

The amount (where known), ownership, and current use of proposed spoil disposal areas are shown in Table 4.1.6-3. Seven of the projects propose to use existing commercial disposal sites where there would be no impact on land use. Six projects propose to dispose of spoil material at abandoned strip mines. If these sites are properly graded and revegetated, the impact on these sites should be a moderate benefit. The proposal by applicants at Willow Island (6902) and New Cumberland (6901) to use agricultural fields for spoil disposal may remove the affected areas from production because the spoil material may not be able to support crops. Spoil material from the project at Belleville is proposed to be placed in an area of second-growth forest owned by the U.S. Government and would likely change the wooded nature of this site. Spoil material from the Emsworth project is proposed to be disposed of on

Table 4.1.6-1. Summary of land use requirements for power generation and transmission facilities. 1/

Project	Estimated land required in acres by type of owner							
	Power generation facilities				Transmission line 2/			
	Federal	Other public	Private	Total	Federal	Other public	Private	Total
Allegheny L&D No. 7	0	4.0	0	4.0	0	4.3	2.2	6.5
Allegheny L&D No. 4	0.9	2.4	0.4	3.7	0.7	0	0.2	0.9
Allegheny L&D No. 3	N.A.	N.A.	N.A.		0	0	12.1 3/	12.1
Allegheny L&D No. 2	2.9	11.6	3.8	18.3	0	0	0	0
Tygart Lake (7399)	4.6	0	0	4.6	5.6	0	10.0	15.6
Tygart Lake (7307)	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.	
Opekiska (8990)	3.7	0	0	3.7	0	0	10.0	15.6
Hildebrand	2.8	0	0	2.8	2.6	0	3.0	5.6
Point Marion	1.0	0	0.5	1.5	0	0	0.2 3/	0.2
Maxwell	2.8	0	0	2.8	0	0	18.2 3/	18.2
Monongahela L&D No. 4	5.0	0	0	5.0	0	0	6.9	6.9
Emsworth (7041)	0	0	45.0	45.0	0	0	1.0	1.0
Dashields (7568)	0	4.8	1.4	6.2	0	0	26.7 3/	26.7
Montgomery (2971)	3.7	N.A.	N.A.		0	0	27.0	27.0
Montgomery (3490)	4.0	4.0	1.5	9.5	0	0	43.3 3/	43.2
New Cumberland (6901)	4.0	N.A.	N.A.		0	0.9	2.3	3.2
New Cumberland (10332)	8.0	0	0	8.0	1.5	0	0.9	2.4
Pike Island (3218)	4.3	0.2	2.0	6.5	0.2	7.7 3/	11.9 3/	19.8
Willow Island (6902)	N.A.	N.A.	14.0		0	6.4 3/	13.2 3/	
Willow Island (9999)	12.6	0	0	12.6	2.3	0	15.2	17.5
Belleville (6939)	27.3	0	0.2	27.5	0.7	0	9.3	10.0
Gallipolis (9042)	9.5	0	0	9.5	0	0	29.5 3/	29.5
Gallipolis (10098)	7.9	0	0	7.9	12.6	0	8.0	20.6
Muskingum L&D No. 3	0	3.6	3.7	7.2	0.2	12.9 3/	0	12.9

1/ Sources: Project applications and additional information submitted by project applicants. N.A. = Not available.

2/ Does not include land currently used for transmission line right-of-way.

3/ Assumes right-of-way width of 100 feet.

Table 4.1.6-2. Land use along transmission line corridors. 1/

Project	Land use 2/
Allegheny L&D No. 7	Range of urban uses, wooded
Allegheny L&D No. 4	Over river; industrial
Allegheny L&D No. 3	Along rail ROW; vacant, commercial
Allegheny L&D No. 2	None (delivered to grid on-site)
Tygart (7307)	Grassy fields, forest, residential
Tygart (7399)	Along rail ROW; industrial, wooded, residential
Opekiska (8990)	Alongside existing transmission line; forest
Hildebrand	Alongside existing transmission line; forest
Point Marion	Overbuilt on existing transmission line except for 75 feet
Maxwell	Wooded, residential
Monongahela L&D No. 4	Industrial, residential, rural
Emsworth (7041)	Along existing access road; industrial
Dashields (7568)	Along rail ROW; industrial
Montgomery (2971)	Wooded, residential
Montgomery (3490)	Along rail ROW; vacant, industrial
New Cumberland (6901)	Vacant brushland, agricultural
New Cumberland (10332)	Vacant brushland
Pike Island (3218)	Industrial, urban residential
Willow Island (6902)	Industrial, vacant
Willow Island (9999)	Industrial, agricultural
Belleville (6939)	Mostly along an existing transmission line; remainder over cleared land
Gallipolis (9042)	Residential, woodland
Gallipolis (10098)	Agricultural, industrial, vacant
Muskingum L&D No. 3	Over river and along public streets and highways; agricultural residential, commercial, wooded

1/ Source: Project applications and additional information submitted by project applicants.

2/ ROW = right-of-way.

Table 4.I.6-3. Summary of land requirements for spoil disposal. 1/, 2/

Project	Size of disposal site (acres)	Current ownership of disposal site	Current use of disposal site
Allegheny L&D No. 7		Private	Sand and gravel company
Allegheny L&D No. 4		Private	Pond/unused portion of cemetery/golf club/ recreational club
Allegheny L&D No. 3		Private	Permitted disposal sites
Allegheny L&D No. 2	18/100/200	Private	Approved landfills
Tygart (7307)		Private	Commercial disposal sites
Tygart (7399)	N.A.	N.A.	N.A.
Opekiska (8990)		Private	Abandoned coal refuse dump
Hildebrand		Private	Strip mines
Point Marion		Private	Strip mines
Maxwell		Private	Commercial disposal sites
Monongahela L&D No. 4		Private	Commercial disposal sites
Emsworth (7041)	12 (on-site)	Private	Industrial
Dashields (7568)	20/20	Private	Vacant/vacant
Montgomery (2971)		Private	Commercial disposal site
Montgomery (3490)	2 (on-site)	Private	Vacant
New Cumberland (6901)		Private	Vacant/abandoned gravel pits/agricultural
New Cumberland (10332)	5	Private	Strip mine
Pike Island (3218)	N.A.	N.A.	N.A.
Willow Island (6902)	24/17	Private	Agricultural/vacant
Willow Island (9999)	10	Private	Strip mine
Belleville (6939)		Federal	Forested
Gallipolis (9042)	26	Private	Abandoned strip mine
Gallipolis (10098)		Private	Commercial disposal sites, borrow pits
Muskingum L&D No. 3		Private	Abandoned strip mine

1/ Source: Project applications and additional information submitted by project applicants. N.A. = Not available.

2/ Where more than one possible site is proposed, information for separate sites is separated by a "/" (e.g., site a/site b/site c).

industrial land within the project boundary. Because no additional land is required for spoil disposal, the impacts would be the same as described earlier in this section for the power generation facilities.

Indirect Impacts

As discussed in Section 4.1.5-3, all of the proposed projects except Tygart are likely to increase the risk of upstream flooding during construction. During the project operations period, there is a high probability of some increase in upstream flood elevations for projects at Gallipolis (both competing applications), Belleville, Willow Island (9999), New Cumberland (10332), Montgomery (both competing applications), Dashields, Emsworth, Allegheny L&D No. 3, Allegheny L&D No. 4, Allegheny L&D No. 7, Point Marion, and Hildebrand. At Gallipolis, project 10098, which includes a proposed Phase 2 development within an existing lock, would likely have a more severe long-term impact on upstream flood elevations than would competing project 9042. Any increase in the depth and extent of flooding would reduce the suitability of affected lands to support most uses. To mitigate this impact, staff recommends that the results of physical hydraulic modeling (expected to be performed in the project design phase) be provided to appropriate emergency management agencies and that project developers be required to purchase flood easements from affected property owners (see Section 5.3.2).

4.1.6.2 Endangered/Threatened Species

Any disturbance to habitat suitable for the pink mucket pearly mussel beds or reduction of DO there to intolerable levels for mussels would be unacceptable (Section 4.1.2.5 and Appendix I). Disturbance to habitat suitable for freshwater mussels listed by the state of Ohio as endangered or threatened should be avoided. The presence of habitat for the pink mucket pearly mussel below Willow Island L&D, Belleville L&D, Gallipolis L&D Muskingum L&D No. 3 (Section 3.1.6) requires additional consultation with the USFWS to avoid any impacts to this species.

Fish entrained at the Montgomery site (Section 4.1.2.3) could serve as an attractant to the bald eagle (Haliaeetus leucocephalus) to an urban area. The increased exposure of this endangered species to the hazards of such populated areas could have adverse impacts on species populations. The USFWS considers this added attractant to the bald eagle to be an undesirable impact to be avoided if possible. The osprey (Pandion haliaeteus) and the great blue heron (Arde herodias) were used as evaluation species by the USFWS in designating the resource category 1 rating for the Montgomery Embayment. These species are listed by the state of Pennsylvania as species of special concern (Table 3.1.6-1).

Construction activities would cause minimal adverse effects on the transient raptors visiting the project areas, with no overall cumulative effect. During construction phases, the noise and movement would cause the species to avoid the area. Minimal habitat would be destroyed as a result of construction. There would be minimal impacts during operation of these plants. Transmission lines, especially those crossing rivers, would be a hazard to raptors and migratory waterfowl that may use the area. To prevent or minimize electrocution hazards, devices for protecting raptors and migratory waterfowl should be installed on all transmission lines crossing or paralleling the rivers. No other federally listed endangered or threatened species are known to inhabit the project areas.

4.1.6.3 Socioeconomics

The proposed projects would have socioeconomic impacts during construction and operation. Potentially significant construction impacts include moderate benefits associated with the employment of construction workers and adverse impacts associated with general construction traffic and spoil disposal traffic. Impacts during operation of the projects include the benefits of employment of operating personnel and increased revenues for local governments. Adverse social and economic effects due to increased flood elevations would occur during both the construction and operations periods, and municipalities and industries could incur increased costs for improved wastewater treatment to meet water quality standards.

Construction Period Impacts

Workers for construction activities are expected to be hired from the area surrounding each project; no significant in-migration of workers is anticipated. Even if all projects were constructed concurrently, there would be a sufficient number of unemployed construction workers living within commuting distance of each project to meet the anticipated project work force requirements (see Appendix G). Construction employees would be drawn largely from the labor force living within 40 miles of each project. Because few workers are expected to relocate their residences, construction employment would not significantly increase the demand for housing or for local government services in any portion of the study area.

Construction employment would, on the other hand, temporarily increase economic activity in the affected counties. As shown in Table 4.1.6-4, construction employment would range from approximately 22 to 37 employees for the smallest project to about 153 to 255 employees for the largest project. The mean employment per project would be approximately 101 workers and would last for an average of 26 months. Construction wages and salaries would range from approximately $1.5 to $2.6 million for the least costly project to approximately $14.1 million to $23.5 million for the most expensive, with a mean of about $8.6 million per project. The largest and most costly projects, of course, would have the greatest economic benefits to the surrounding areas. In general, these projects are located on the downstream reach of the Ohio River main stem in the study area. Projects located on the upper reach of the Ohio and along the Allegheny and Monongahela Rivers would generally have smaller payrolls because the projects are smaller and would require fewer construction workers.

The temporary benefit of the additional employment and wages would be especially important in light of the economic decline the study area has experienced in recent years. While the benefit would fall directly on workers in the construction industry, other sectors of the economy would benefit indirectly because the workers spend their earnings for goods and services.

Adverse socioeconomic impacts during the construction period would be associated with traffic transporting workers, equipment, and spoil material. While all types of traffic can disturb affected residents, interfere with normal traffic flow, and cause accelerated deterioration of public roadways, the impacts are especially severe with regard to vehicles hauling spoil material to disposal sites. Table 4.1.6-5 lists pertinent characteristics of the spoil disposal programs which the applicants have proposed for the projects. Construction traffic at the following sites is likely to cause adverse socioeconomic effects.

Allegheny L&D No. 7. The project proposed at this site calls for the construction of a new access route within a residential area and would route construction traffic along a local street (which includes residential uses) for a distance of approximately 2 miles. The additional traffic would constitute a moderate adverse impact by interfering with the residential use of the area, increasing the risk of accidents, and accelerating the deterioration of the affected public streets. These impacts could be mitigated by restricting construction activities to weekdays between the hours of 8:00 a.m. and 6:00 p.m. and requiring the project applicant to develop a plan for appropriate restrictions on construction-related traffic.

Tygart Dam. Construction traffic from both of the competing projects proposed at this site would travel about 2.25 miles along a public road lined with mixed urban uses before reaching a highway. This public road is also used by recreational traffic bound for the nearby state park. The construction traffic would have a minor adverse impact by interfering with sensitive uses along the route, inconveniencing other motorists, increasing the risk of accidents, and speeding the deterioration of the roadway. The impact could be mitigated by (1) prohibiting construction activities at night and on weekends during the summer recreation season and (2) requiring the development to compensate the local government for roadway damage (see Section 5.3.2).

Opekiska L&D. The project proposed at this site would use several miles of public secondary roads as a connection to a major highway. Several small communities, as well as scattered residences, are located along these roads. There would be a minor adverse impact due to project construction traffic which would accelerate the deterioration of these minor roads and, by introducing an amount and type of traffic not common in the vicinity, disturb residents along the routes and increase the risk of accidents. To reduce the impact, staff recommends (1) that heavy vehicles (including spoil-hauling trucks) be prohibited from traveling to and from the project site between the hours of 6:00 p.m. and 8:00 a.m. and (2) that the project developer compensate the local government for additional deterioration caused to locally maintained secondary roads.

Table 4.1.6-4. Estimated construction employment and wages. 1/

Project	Estimated wages/ salaries ($1000)		Estimated number of employees		Counties most likely to provide construction workers
	Low	High	Low	High	
Allegheny L&D No. 7 (7914)	4,211	7,019	57	96	Armstrong, Pa.
Allegheny L&D No. 4 (7909)	4,306	7,176	56	94	Allegheny, Westmoreland, Armstrong, Pa.
Allegheny L&D No. 3 (4474)	4,554	7,590	41	69	Allegheny, Westmoreland, Pa.
Allegheny L&D No. 2 (4017)	3,821	6,369	38	64	Allegheny, Pa.
Tygart (7307) 2/	3,576	5,961	37	62	Taylor, Barbour, Harrison, W. Va.
Tygart (7399) 2/	8,723	14,539	87	145	Taylor, Barbour, Harrison, W. Va.
Opekiska (8990)	1,616	2,694	24	40	Monongalia, Marion, W. Va.
Hildebrand (8654)	1,546	2,576	22	37	Monongalia, Marion, W. Va.
Point Marion (7660)	N.A.	N.A.	160 3/	180 3/	Fayette, Greene, Washington, Pa.
Maxwell (8908)	2,196	3,660	29	48	Washington, Fayette, Greene, Pa.
Monongahela L&D No. 4 (4675)	1,852	3,087	23	39	Washington, Westmoreland, Fayette, Allegheny, Pa.
Emsworth (7041)	4,225	7,042	53	88	Allegheny, Pa.
Dashields (7568)	6,745	11,241	81	135	Allegheny, Pa.
Montgomery (3490) 2/	5,062	8,436	58	97	Beaver, Pa.
Montgomery (2971) 2/	8,211	13,684	137	228	Beaver, Pa.
New Cumberland (10332) 2/	11,427	19,045	88	147	Hancock, Brooke, W. Va.; Jefferson, Ohio; Beaver, Pa.
New Cumberland (6901) 2/	14,086	23,476	132	220	Hancock, Brooke, W. Va.; Jefferson, Ohio; Beaver, Pa.
Pike Island (3218)	6,965	11,608	84	139	Belmont, Ohio
Willow Island (9999) 2/	11,221	18,701	153	255	Pleasants, Wood, Tyler, Ritchie, W. Va.; Washington, Ohio
Willow Island (6902) 2/	N.A.	N.A.	N.A.	N.A.	Pleasants, Wood, Tyler, Ritchie, W. Va.; Washington, Ohio
Belleville (6939)	12,383	20,639	133	221	Wood, W. Va.
Gallipolis (10098) 2/	11,221	18,701	140	234	Gallia, Meigs, Ohio; Mason, W. Va.
Gallipolis (9042) 2/	10,755	17,925	98	163	Gallia, Meigs, Ohio; Mason, W. Va.
Muskingum No. 3	2,886	4,810	39	66	Washington, Ohio
Mean	6,436	10,726	77	125	

N.A. = Not available.
1/ Source: Staff (see Appendix B).
2/ Competing applications.
3/ Source: FERC, 1984. Environmental Assessment, Point Marion Lock and Dam Project, FERC No. 7660, Pennsylvania.

Table 4.1.6-5. Applicants' proposed spoil disposal programs.

Project	Amount of spoil material: Truck loads	Amount of spoil material: Barge loads	Road distance to disposal site (miles)	Land use enroute
Allegheny L&D No. 7	14,600		1-5	Mixed urban
Allegheny L&D No. 4	24,500		0-3.5	Agriculture, mixed urban
Allegheny L&D No. 3	11,860		7-52	Mixed urban
Allegheny L&D No. 2	10,250		9-22	Mixed urban
Tygart (7307)	21,400		1-6	N.A.
Tygart (7399)	10,000	N.A.	N.A.	N.A.
Opekiska	N.A.	N.A.	N.A.	N.A.
Hildebrand	1,100		N.A.	N.A.
Point Marion	N.A.		1.5	Rural, scattered residential
Maxwell	8,800		1-10	N.A.
Monongahela L&D No. 4	21,200		1-10	N.A.
Emsworth	200,000		0 (on-site)	
Dashields	37,000	90-100	0.5-5.4	Mixed urban
Montgomery (3490)	0			
Montgomery (2971)		60-70		
New Cumberland (10332)	20,000		4.5	Agriculture, forest, scattered residential
New Cumberland (6901)	77,000		3.6-6.0	Rural, residential
Pike Island	N.A.	N.A.	N.A.	N.A.
Willow Island (9999)	22,000		3	Industrial, agriculture, woodland
Willow Island (6902)	132,000		N.A.	N.A.
Belleville	116,000		N.A.	N.A.
Gallipolis (10098)	N.A.	N.A.	N.A.	N.A.
Gallipolis (9042)	60,000		3-5	Rural, scattered residential
Muskingum L&D No. 3	21,620		15-70	Various rural and urban

N.A. = Not available.

Sources: Project information filed by applicants.

Hildebrand L&D. The current access route to this site includes about 2 miles of dirt road and 0.5 mile of paved secondary road before reaching a highway. While the area is largely undeveloped, a small residential area is located at the intersection with the highway. A comment received on the DEIS reported that a more extensive residential development is underway between the project and the highway. This development would include upgrading the road system in the vicinity. The project would have minor adverse impacts on existing development in the area by accelerating the deterioration of roads and causing some inconvenience for the nearby residents. Construction of the hydropower project could have adverse impacts on the new residential development being constructed in the area by introducing noise, dust, and traffic. In addition, if the construction traffic uses roads constructed or improved as a part of the new residential development, the deterioration of these roadways will be accelerated. Staff recommends that the project impacts be mitigated by requiring the project developer to compensate local governments or private parties for additional deterioration caused to locally or privately maintained secondary roads.

Point Marion L&D. Construction traffic from this site would travel along a public road for about 0.5 mile to reach a highway. Several residences are scattered along this minor road. The construction traffic would have a minor adverse impact by inconveniencing the affected residents. Accelerated deterioration of the affected roadway is not a factor, because the applicant is the municipality that owns the road.

Maxwell L&D. Approximately 0.25 mile of a public road would be used by construction traffic between the construction site and the nearest major highway. While the area is rural and no sensitive land uses are nearby, the construction traffic would contribute to the deterioration of the affected road, thus having a minor adverse impact. To reduce the impact, staff recommends that the project developer be required to compensate the local government for the additional road deterioration.

Emsworth L&D. Approximately 4 miles of public street would be used as a connection between the proposed project at this site and the nearest major highway. A small residential area is located near the intersection of the street and the highway. However, impacts are expected to be minor because the area is heavily industrialized, with manufacturing plants lining the affected street and surrounding the residential area. The amount and type of traffic associated with project construction would not be out of character with current use of the area.

Montgomery L&D. Both of the competing projects proposed at this site would use a local residential street in the town of Ohioview, Pennsylvania, for access between the construction area and the nearest highway. One applicant (2971) proposes to alleviate the impact of traffic on the neighborhood by using vanpools to transport construction personnel and an off-site marshalling area to reduce the hauling of construction materials and equipment. The other applicant (3490) that proposes the use of barges to deliver as much construction and project equipment as possible. While these measures would reduce the impact, the use of this local street by construction traffic would interfere with the residents' use of their neighborhood, present an increased risk of accidents, and accelerate the deterioration of a roadway not designed for concentrated use by heavy vehicles. There would be an overall moderate adverse impact, which could be mitigated by requiring the developer to (1) restrict construction activities to weekdays between 8:00 a.m. and 6:00 p.m. and (2) develop a plan for enforcing appropriate restrictions on construction traffic in the residential area.

Belleville L&D. The applicant at this site proposes to upgrade and use approximately 0.5 mile of privately owned, single-laned, unpaved road for access to the project from State Route 68. Construction traffic would be routed through the edge of the Belleville community, passing by several residences and a church. Because of the nature of the existing road, the construction traffic would generate considerable dust in the community and would significantly deteriorate the roadway. It is recommended that the applicant avoid these impacts by constructing a new road segment approximately 450 feet long from State Route 68 to the portion of the existing road which follows the axis of the dam. This would reduce the road distance between the highway and the powerhouse site to about 0.2 mile and would avoid all sensitive land uses. It would also avoid potential long-term impacts on the community caused by traffic associated with project operations and users of the recreation facilities proposed at the project site.

Muskingum L&D No. 3. This site is adjacent to a highway, but a trailer park and a developed recreation area are located in close proximity. Construction traffic and activities are likely to disturb residents and park users and to reduce the convenience and safety of access to these areas, and thus constitute a minor adverse impact. The impact could be reduced by restricting construction activities to weekdays between the hours of 8:00 a.m. and 6:00 p.m.

The possibility of increased flooding would also constitute a significant socioeconomic impact during the construction period. As discussed in Section 4.1.5.3, all of the proposed projects except those at Tygart Dam would increase flood elevations during the construction period. Increased flood elevations would increase personal risks as well as the economic and social costs of flooding. Increased flood elevations would be likely to have significant socioeconomic implications at any location in the study area because development throughout the region has concentrated in the relatively flat land along the rivers. The impact would be most severe, however, in areas where there is extensive development at an elevation near the existing floodplain. In particular, the socioeconomic effects of flooding could affect a large number of people and developed land for projects at Montgomery (both competing applications), Dashields, Emsworth, Allegheny L&D No. 2, and Monongahela L&D No. 4.

Operations Period Impacts

The proposed projects will have a minor beneficial effect by employing persons during the operating period. Most of the projects are to be designed for automatic or remote control, thus limiting the number of persons necessary for operations. In some cases (such as projects owned by the City of Pittsburgh, Allegheny County, or utility companies), the duties associated with project operations would likely be assigned to current employees. However, the total workload would be increased, and some additional employment would result. Information included in the project applications indicates that each project would be likely to require one person at all times for monitoring operations and performing routine checks and maintenance. This requirement is equivalent to 4.2 full-time employees who would be used throughout the life of the project. This employment would constitute a minor benefit to the areas where the projects are located.

The proposed projects would also increase the revenues of local governments. Twelve of the proposed projects are privately owned and would pay property taxes to the jurisdictions in which they are located. According to information in the project license applications, these property tax payments would average about $40,000 per year and would constitute a minor beneficial effect. The remaining 12 proposed projects would be owned by local governments. While these projects would not pay property taxes, their profits would directly add to municipal revenues. Table 4.1.6-6 lists the publicly owned projects and the expected annual revenue associated with each project for each of the alternative actions being considered. Under Alternative 1, the annual revenues from the publicly owned projects would range from $367,000 to $9,453,000, constituting moderate to significant benefits. These increases in revenues would not require any significant increases in government expenditures because project operations would not require any discernable increase in public services.

The principal adverse socioeconomic impact of project operations would be an increase in flood elevations in some areas along the affected rivers. As discussed in Section 4.1.5.3, there is a high probability that upstream flood elevations would be increased by projects at Gallipolis (both applications), Belleville, Willow Island (competing application 9999), New Cumberland (competing application 10332), Montgomery (both applications), Dashields, Emsworth, Allegheny L&D Nos. 3, 4, and 7, Point Marion, and Hildebrand. At Gallipolis (No. 10098), because of its proposed second phase of development, would likely have a more severe long-term impact on flood elevations than would competing project 9042. Increased flooding would increase personal risks as well as the economic and social damage caused by floods. With urban-type development throughout the study area concentrated in the relatively flat land adjacent to the rivers, increased flooding in any area would be likely to have significant socioeconomic impacts. The severity of impact would be greatest in those areas that are most intensely developed and where the elevation of the development is near that of the river. In particular, extensive development is present upstream of the projects proposed at Montgomery (both competing applications), Dashields, Emsworth, and Allegheny L&D No. 3. To mitigate this impact, staff recommends that the results of physical hydraulic modeling (expected to be performed in the project design phase) be provided to appropriate emergency management agencies and that project developers be required to purchase flood easements from affected property owners.

Table 4.1.6-6. Estimated net annual revenues of publicly owned projects. 1/

Project	Estimated net annual revenue (in thousands of dollars)			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Allegheny L&D No. 4	1,136	1,136	328	328
Allegheny L&D No. 3	712	712	583	583
Allegheny L&D No. 2	1,231	1,143	539	539
Tygart (7307	3,421	3,421	3,421	3,421
Point Marion	422	422	264	264
Emsworth	3,070	3,070	2,611	2,611
Dashields	1,617	1,245	70	70
Montgomery (3490)	367	367	2/	3/
New Cumberland (6901)	4,311	4,135	1,114	1,114
Pike Island	7,825	7,356	4,538	4,538
Willow Island (6902)	2,368	2,368	2,368	2,368
Belleville	9,453	9,453	9,453	9,453

1/ Source: Staff.

2/ Project revenue negative under this alternative.

3/ Project eliminated under this alternative.

Another major adverse socioeconomic impact of the projects as proposed would occur if industrial and municipal wastewater dischargers were required to improve their wastewater treatment to compensate for the lower DO concentrations that would be caused by the projects (Section 4.1.1.1). Dischargers are permitted by the states to discharge wastewaters in quantities and concentrations that do not cause the DO in the river to go below the legal water quality standard of 5 milligrams per liter (mg/L); if a discharge would cause a violation of this standard, the state would require additional wastewater treatment to prevent further violation. The proposed hydropower projects would cause DO concentrations to be much closer to 5 mg/L than they are without hydropower, especially near Pittsburgh (Section 4.1.1.1). It is possible that existing or proposed new wastewater dischargers would be required to spend thousands or millions of dollars on additional wastewater treatment to maintain state DO standards because of reductions in water quality in the river caused by the hydropower projects. Only large wastewater dischargers, such as a few of the industries near Pittsburgh and a number of municipalities on the Allegheny, Monongahela, and Ohio rivers (such as Allegheny County), release sufficient waste loads for additional treatment costs to be a potential concern. However, additional treatment costs at even one major municipal treatment plant could offset the economic benefits of the hydropower development that caused significantly reduced DO concentrations.

4.1.6.4 Archaeological and historical resources

A majority of the proposed projects in the study area have no National Register of Historic Places eligible or listed historic or archaeological properties within their project boundaries. Table 4.1.6-7 lists the project areas that the state historic preservation officers have determined should have no effect upon known historic or archaeological resources.

Archaeologic surveys of several project areas are required, are under way, or have been completed (Table 4.1.6-7). The Pennsylvania Historical and Museum Commission (PHMC) has identified a high probability that archaeological sites may be affected by projects at Allegheny L&D No. 7 and Montgomery L&D in Pennsylvania (PHMC, 1984e; 1985e; 1987). Archaeological surveys of these project areas still need to be performed. Archaeological surveys of the project areas at Tygart (7307 and 7399), Opekiska, New Cumberland (10332), Willow Island (6902), and Gallipolis (10098) have been completed and the West Virginia Department of Culture and History (WVDCH) has determined that the proposed projects will have

Table 4.1.6-7. Status of project coordination with the state historic preservation officers.

Project	No historic or archaeological properties in project area 1/	Archaeological survey of project area required 1/
Allegheny L&D No. 7		PHMC, 1984e
Allegheny L&D No. 4	PHMC, 1985c	
Allegheny L&D No. 3	PHMC, 1985a	
Allegheny L&D No. 2	PHMC, 1985d	
Tygart (7307)		WVDCH, 1984c (report complete/no effect)
Tygart (7399)		WVDCH, 1984d (report complete/no effect)
Opekiska		WVDCH, 1986b (report complete/no effect)
Hildebrand	WVDCH, 1985a	
Point Marion	PHMC, 1983	
Maxwell	PHMC, 1984d	
Monongahela L&D No. 4	PHMC, 1988	
Emsworth	PHMC, 1985b	
Dashields	PHMC, 1984c	
Montgomery (2971)		PHMC, 1985e
Montgomery (3490)		PHMC, 1987
New Cumberland (6901)	WVDCH, 1983c	
New Cumberland (10332)		WVDCH, 1987a (report complete/no effect)
Pike Island	OHPO, 1982	
Willow Island (6902)		WVDCH, 1987b (report complete/no effect 2/)
Willow Island (9999)		WVDCH, 1987c (survey incomplete)
Belleville	WVDCH, 1983a	
Gallipolis (9042)		OHPO, 1988 (report complete/conditional no adverse effect) 3/
Gallipolis (10098)		WVDCH, 1988 (report complete/no effect)
Muskingum L&D No. 3	OHPO, 1983b	

1/ Ohio Historic Preservation Office (OHPO).
Pennsylvania Historical and Museum Commission (PHMC).
West Virginia Department of Culture and History (WVDCH).

2/ Stipulations regarding an archaeological site (46 PL 43) located 130 feet east of the proposed transmission line corridor include additional survey work if the proposed corridor is relocated to the east.

3/ A Phase II cultural resource survey would need to be performed prior to project construction.

no effect on known cultural resources (WVDCH, 1984c, 1984d, 1986b, 1987a, 1987b, 1988). Stipulations at the Willow Island (6902) site include additional evaluation of an archaeological site (46 PL 43), located about 130 feet east of the proposed transmission line, should the proposed transmission line be relocated. The Phase I cultural resource survey has been completed and reviewed by the Ohio Historic Preservation Office for the Gallipolis (9042) project. A conditional finding of no adverse effect was given for the project (OHPO 1988). A Phase II cultural resource survey of the transmission line route would need to be completed before project construction. Archaeological surveys at Willow Island (9999) are still incomplete because of difficulties in obtaining permission to access private property to conduct the surveys (WVDCH, 1987c).

Survey work at the above-identified sites would need to be completed and the findings evaluated. A cultural resources management plan would be prepared to avoid or mitigate any impacts to archaeological or historic sites identified as eligible for inclusion in the National Register of Historic Places. The Advisory Council on Historic Preservation would be consulted on any such plan.

Should previously unknown cultural resource sites be uncovered during project construction, construction would be halted and a qualified archaeologist would be consulted.

4.1.6.5 Aesthetic Resources

Impacts to aesthetic resources from the development of the proposed projects would be the most serious in those areas that: (1) are relatively steep and undeveloped with a small amount of on-site land available for development (e.g., Hildebrand, Point Marion, Maxwell, New Cumberland); (2) have islands potentially subject to severe impacts because of their location immediately downstream of a proposed powerhouse (Allegheny L&D No. 7 and Muskingum L&D No. 3); (3) are close to residential neighborhoods (Allegheny L&D No. 7, Allegheny L&D No. 4, Montgomery L&D, and Muskingum L&D No. 3); or (4) are proximate to developed recreation areas that are aesthetically unique within the study area (Tygart Dam and Muskingum L&D No. 3).

Potential aesthetic impacts from the development of the proposed hydroelectric facilities would result from both project construction and the long-term changes associated with project operation. Project construction would have short-term adverse aesthetic impacts because of: (1) the visual impact associated with construction activities, such as clearing, grading, the installation of cofferdams, the presence of construction equipment and materials; (2) the noise associated with construction; (3) the hauling of spoil disposal; and (4) the clearing of vegetation for transmission line and new access road construction. The construction period at each project would span approximately three years. Aesthetic impacts from individual project construction would be aggravated further by the concurrent construction of multiple hydroelectric projects in the study area. Long-term aesthetic impacts associated with project operation would result from the potential degradation of water quality, changes in wetland habitats, and changes in the recreational users' aesthetic enjoyment (Sections 4.1.1, 4.1.4, and 4.1.3).

Project facilities would add to the degree of man-made development in the area. The scale of the powerhouse facilities, particularly at the gated-dam structures, would appear small, however, in comparison with the existing L&D structures. The roof of the powerhouse would typically be at ground level at the dam. Above-grade facilities in the powerhouse area would include the control house and substation. For the proposed structures to blend in with the existing facilities at the site, the applicants would need to consult with local agencies regarding the final design (building materials, colors, grading, vegetative selection and maintenance, and rehabilitation of construction areas).

The construction of transmission lines would require the clearing of roughly 2 to 43 acres for new rights-of-way at each project, an average of 14 acres per site (Section 4.1.6.2). The Montgomery project area would require the largest amount of clearing for new transmission line construction, which could create aesthetic impacts for the residential areas in the project vicinity. To minimize aesthetic impacts from transmission line construction, all cleared areas would need to be replanted with native plant materials. Selective clearing at road crossings would also serve to minimize visual impacts.

The excavation of the powerhouse facilities and the dredging of intake channels at the project sites would create a necessity for spoil disposal. A majority of the applicants plan to use existing landfills and strip mines as locations for spoil disposal (Section 4.1.6.2). To minimize the aesthetic impacts associated with spoil disposal, the applicants would need to grade and revegetate the areas with native trees, shrubs, and groundcover.

4.1.6.6 Wildlife Resources

Construction of projects would cause temporary adverse effects on wildlife because of the close proximity of the project sites and the high proportion of urbanization/industrialization along the rivers. Construction of the projects would quickly result in population losses in species that have a small limited local habitat and do not move to alternative habitats (e.g., frogs, salamanders, lizards). Small mammals, deer, and songbirds using project areas would be disturbed by loss of habitat, noise, and movement during construction. Migratory waterfowl would probably avoid the area during construction activities. The patchiness of suitable habitat would limit the alternatives and possible movement corridors. Losses of habitat for wildlife due to powerhouse facilities and access road construction would be permanent. The loss of habitat due to clearing of transmission line rights-of-way would be temporary, with revegetation in native species creating perhaps a more diverse habitat.

Construction activities at Tygart Dam would temporarily disturb wildlife populations inhabiting the state wildlife management area bordering the project site adversely, causing movement to other parts of the management area and avoidance of the area. Disturbance during operation of the plant would be minimal.

The osprey (*Pandion haliaetus*), a state-listed endangered species in West Virginia, would also be disturbed by construction activities at the Tygart Dam site, especially during the breeding and nesting/fledgling season.

Development of recreation areas and access roads would have potential impacts on wildlife, especially in areas that are remote and do not have recreation access facilities. The additional noise, movement, and crowding would cause wildlife to avoid the area. Overall, operation of the projects would have minimal impacts on wildlife resources. Cumulative effects would be minimal, because movement corridors between sites are already limited by patchiness of suitable habitat.

4.1.6.8 Spoil Disposal

Excavation for power plant facilities and dredging for intake and tailrace channels during construction and maintenance operations at the proposed sites require planning for disposal of all or portions of the resulting material. Table 4.1.6-8 summarizes the estimated amounts of spoil from construction and maintenance at all the proposed project sites. The area required for disposal was calculated for a rectangular prism configuration for the waste, assuming a depth of 10 feet unless otherwise specified by the applicant. Table 4.1.6-9 summarizes the estimated area requirements for the volume of spoil and the distance and mode of transport from the project site to the disposal site.

Sediment contamination would limit the amount of spoil that could be reused either as backfill at the construction site or purchased by a sand and gravel company for aggregate or road-paving materials. The Gallipolis L&D and Pike Island L&D sites on the Ohio River and the Muskingum L&D No. 3 site on the Muskingum River recently have tested positive for heavy metals and other contaminants. These three sites probably would have contaminated spoil material. Significant contamination would not expected at other sites.

Disposal of spoil material into existing commercial landfills, abandoned gravel pits, and abandoned strip mines using appropriate measures to control erosion and to prevent release of contaminants would not have significant adverse impacts. The use of clean rock spoil to construct fish habitat structures could offset project impacts to recreational use.

4.1.6.9 Transmission Lines

The most adverse impact of transmission lines would be the loss or change in habitat due to clearing of the right-of-way. Replanting with native species of low shrubs and trees and native grasses is recommended to minimize the maintenance of the right-of-way and provide cover and food for wildlife. Table 4.1.6-10 presents a summary of the proposed transmission lines for each project and the area that would comprise the right-of-way, with a 100-foot-wide right-of-way. Use of existing poles and right-of-way decreases the actual amount of land that would be used for transmission line construction The potential adverse impacts of transmission line construction and maintenance are minimal.

Table 4.1.6-8. Estimates of spoil disposal requirements.

Lock & dam	Estimated amounts of spoil (yd^3)			
	Construction		Maintenance	
	Excavation	Dredging	Dredging	Trash racks
Allegheny L&D No. 7	20,000	53,000	400 2/	
Allegheny L&D No. 4	122,500			
Allegheny L&D No. 3	55,400	3,900	200	
Allegheny L&D No. 2	260,265 1/			175-200
Tygart (7399)	50,000	0	1-5 tons	
Tygart (7307)	120,000	7,000		
Opekiska			5-10 tons	
Hildebrand	5,500			
Point Marion	6,000		1-5 tons	
Monongahela L&D No. 7	80,000			
Maxwell	64,000			
Monongahela L&D No. 4	116,000	4,000		
Emsworth		1,200,000		
Dashields	102,000	33,000		
Montgomery (2971)	158,000			
Montgomery (3490)	52,000			
New Cumberland (6901)	385,000			
New Cumberland (10332)	100,000			
Pike Island				
Willow Island (6903)	664,900			
Willow Island (9999)	110,000			
Belleville	220,000	460,000		
Gallipolis (9042)	300,000	53,000	5,000	
Gallipolis (10098)				
Muskingum L&D No. 3	103,100	5,000	0	

1/ Dredge material estimate not separated out.

2/ Estimate for 5-year interval.

Table 4.1.6-9. Estimated area required for spoil disposal. 1/

Lock & Dam	Area (acres)	Type of disposal site(s)	Distance (miles)
Allegheny L&D No. 7	4.5	Reuse-sand & gravel	
Allegheny L&D No. 4	7.6	Industrial; recreation	< 4
Allegheny L&D No. 3	5.73	Landfill	7-50
Allegheny L&D No. 2	0	Sand & Gravel Company	< 5
	2.02	Gorge 80' deep	< 5
Tygart (7399)	5.2 2/	Strip mine	4.5
Tygart (7307)	7.9	Strip mine	< 6
Opekiska		Landfill	
Hildebrand	0.3	Strip mine	1
Point Marion	0.3		
L&D No. 7	5.	Strip mine	
Maxwell		Corps landfill	
Monongahela L&D No. 4		Glass Company landfill	Adjacent
Emsworth	103.45	Landfill	Onsite
Dashields	13.97 3/	Reuse, quarry pit	< 5
Montgomery (2971)	8.13	Landfill	1
Montgomery (3490)	5.37	Backfill at site	Onsite
New Cumberland (6901)	39.83	Agricultural, gravel pits	3.6-6
New Cumberland (10332)	20.23	Strip mine	
Pike Island	0	Backfill	Onsite
Willow Island (6902)	68.78	Agricultural/open field	1
Willow Island (9999)	22.76 4/	Strip mine	< 1
Belleville	35.1 5/	Reuse, landfill	
Gallipolis (9042)	72.16	Strip mine	
Gallipolis (10098)			
Muskingum L&D No. 3	6.7	Strip mine	

1/ Assumes disposal of all spoil material.

2/ Depth of 6 feet assumed.

3/ Estimates of 5 acres at 50 percent reclamation, 1 acre at 90 percent.

4/ Depth of 3 feet assumed.

5/ Assumes 50 percent rock to be used as riprap.

Table 4.1.6-10. Estimated area of habitat changed or lost from construction and maintenance of proposed transmission line corridors. 1/

Lock/dam	Length of line (miles)	Width of ROW (feet)	Area (acres)	New ROW (acres) 2/
Allegheny L&D No. 7	2.1	100	6.5	5.0
Allegheny L&D No. 4	0.3	100	0.9	0.9
Allegheny L&D No. 3	1.0	100	12.1	
Allegheny L&D No. 2	0.01	0	0	0
Tygart (7399)	1.4	100	17.0	15.6
Tygart (7307)	0.83	100	10.1	10.1
Opekiska	0.83	100	10.1	3.6
Hildebrand	0.46	100	5.6	2.8
Point Marion	1.0	50	6.1	0.1
Maxwell	1.5	100	18.2	0
Monongahela L&D No. 4	0.57	100	6.9	6.9
Emsworth	0.34	100	4.1	0
Dashields	2.2	100	26.70	0
Montgomery (2971)	2.8	100	34.0	0
Montgomery (3490)	3.57	100	33.3 3/	0
New Cumberland (6901)	0.19	100	2.3	2.3
New Cumberland (10332)	0.19	100	2.3	2.3
Pike Island	1.63	100	19.8	0
Willow Island (6902)	1.6	100	19.4 4/	5.0
Willow Island (9999)	0.95	100	11.5	0
Belleville	11.89	50	71.8	10
Gallipolis (9042)	3.0	100	36.4	36.4
Gallipolis (10098)	1.7	100	20.6	18.3
Muskingum L&D No. 3	0.85	100	10.4	0

1/ ROW = Right-of-way.

2/ New ROW includes only the area where new disturbance would occur. Existing ROW along roads, railroads, and transmission lines was excluded from the estimate.

3/ Parallel to river on existing railroad ROW. New poles to be installed.

4/ About 5 acres of forest to be cleared; remainder is on existing access road ROW.

4.1.6.10 Access Roads

The Allegheny L&D No. 2 project proposes a new 1700-foot-long and 20-foot-wide road, resulting in a permanent loss of 0.78 acres of land area. The Allegheny L&D No. 3 project proposes building a road across the railroad tracks to provide access. There would be no loss of land area, because the railroad tracks already represent a highly disturbed area. The Allegheny L&D No. 7 project proposes building an access road that is 200 feet long from a residential street (Water Street). The land area permanently lost because of construction of the access road would be 0.09 acres. The Gallipolis L&D project (9042) proposes a 130-foot-long and 20-foot-wide access road, resulting in a permanent loss of 0.06 acres. Similarly, the Gallipolis L&D project (10098) would require construction of an access road, as does Project No. 9042. The impacts of Project No. 10098 would be the same as those stated for Project No. 9042. The Willow Island L&D project (6902) proposes to relocate a 1150-foot-long and 20-foot-wide gravel road, with no significant change in area. All remaining projects propose to use existing roads. These roads would be upgraded and maintained for heavy construction usage during the construction phase.

4.2 PROJECT OPERATION TO MEET DISSOLVED OXYGEN STANDARDS (ALTERNATIVE 2)

4.2.1 Water Quality

ORSANCO and the states of Pennsylvania, Ohio, and West Virginia maintain an ambient DO standard of 5 mg/L, meaning that proposed new developments such as hydropower are legally prohibited from causing daily or weekly average DO concentrations in the rivers to fall below 5 g/L. The water quality modeling analysis of the projects as proposed indicates that they could cause DO concentrations to fall below 5 mg/L under conditions when concentrations would not otherwise fall below the standard (the model also indicates that the standard can be violated even without hydropower under extremely low flows). Therefore, the model was used to determine what changes should be made to the proposed hydropower operations to prevent violations of the standard from occurring more frequently, or over more miles of river, than they would occur without hydropower.

Additional violations of the standard are not caused by the projects as proposed under any of the design conditions in the Allegheny and Monongahela rivers. Although DO concentrations below 5 mg/L occur above and below Opekiska Dam, Opekiska does not provide aeration, so spillage would be ineffective for increasing DO concentrations. The applicant at Hildebrand has proposed to spill all flow when river flows are below 1800 cfs; the model predicts that violations of the standard do not occur at river flows above 1800 cfs. Hydropower on the Allegheny River will cause a reduction in DO in the Ohio River, which contributes to DO standards violations, but spillage at Allegheny L&D No. 2 is sufficient to make up for the other Allegheny River projects when needed to avoid violations on the Ohio River. The submerged outflow dams at Willow Island, Belleville, and Gallipolis are poor aerators and have little effect on DO, with or without hydropower.

At low flows (in the range of 7Q10 flows) and summer conditions, spillage at Ohio River dams cannot prevent a standards violation below Willow Island. The model indicates that this violation occurs even without hydropower.

The one area where the model indicates hydropower would cause DO violations where they would otherwise not occur is in the first 150 miles of the Ohio River below Pittsburgh. To provide aeration sufficient to meet state standards, approximately equal spill at the first five dams on the Ohio is preferable over increased spill at some dams and not at others, because equal spill adds a factor of safety in case the actual location of the lowest DO concentrations varies from where the model predicts it to be (which is between Dashields and Montgomery).

The model predicts that the projects as proposed, including competing projects with the lowest proposed spill flows, would protect the DO standard except when Ohio River flows fall below 9000 cfs. Below 9000 cfs, increasing spill flows at Allegheny L&D No. 2, Emsworth, Dashields, Montgomery, New Cumberland, and Pike Island are required as river flow decreases. To provide a factor of safety for DO concentrations, and because most of these projects are proposed to cease generation at flows less than 9000 cfs, the recommended spill is that each of these six projects cease generation when Ohio River flow falls below 9000 cfs, measured at the Sewickley gage, during the warmwater season of July through October. During other flows and times, the spill flows proposed by the applicants are sufficient to meet the 5-mg/L standard.

The DO concentrations with the spill flows to meet the 5-mg/L standard were modeled for the same two cases as for the first alternative (Section 4.1.1.1).

Case 1: Low summer flows (7Q10 flows). The DO-concentration profile for the Monongahela River for this second alternative is the same as for the first alternative (Section 4.1.1.1) under 7Q10 flows (Figure 4.1.1-2). On the Allegheny River (Figure 4.2.1-1), the DO profile under 7Q10 flows under this second alternative is higher than with projects as proposed below L&D No. 2 because of the required spill flow. On the Ohio River, the DO profile at 7Q10 flows essentially matches the profile with no hydropower (Figure 4.1.1-4) because (1) spill flow at Allegheny L&D No. 2 raises the DO at Pittsburgh to where it would be without hydropower, and (2) the only projects that would be allowed to generate are at dams (Willow Island, Belleville, and Gallipolis) that are poor aerators.

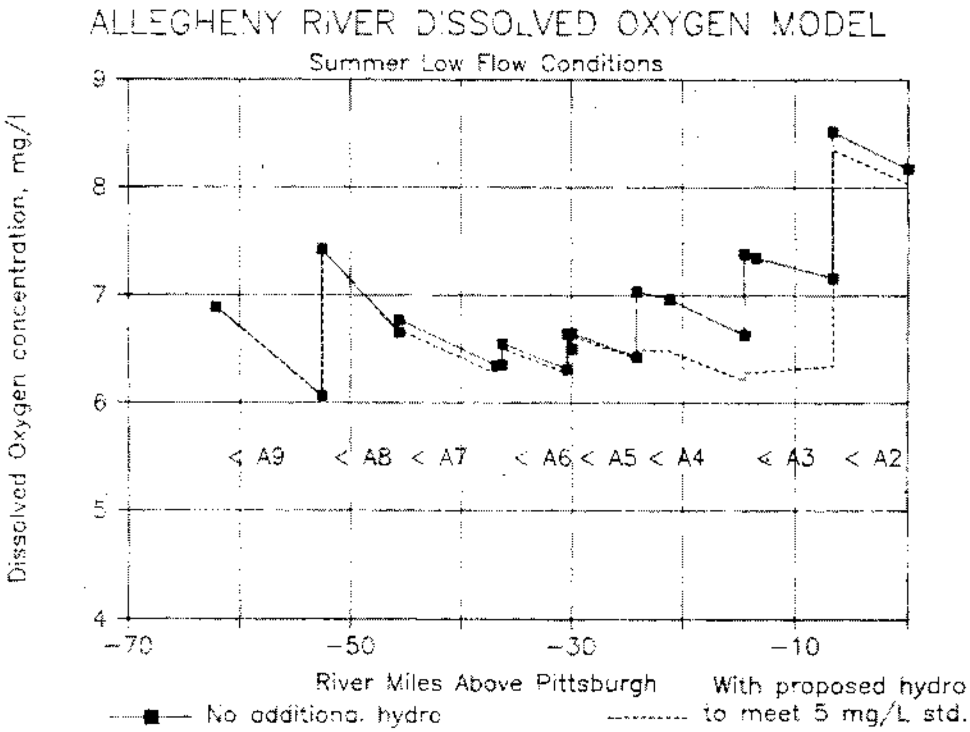

Figure 4.2.1-1. Allegheny River DO model results for summer low flow conditions, with spill flows to maintain 5 mg/L.

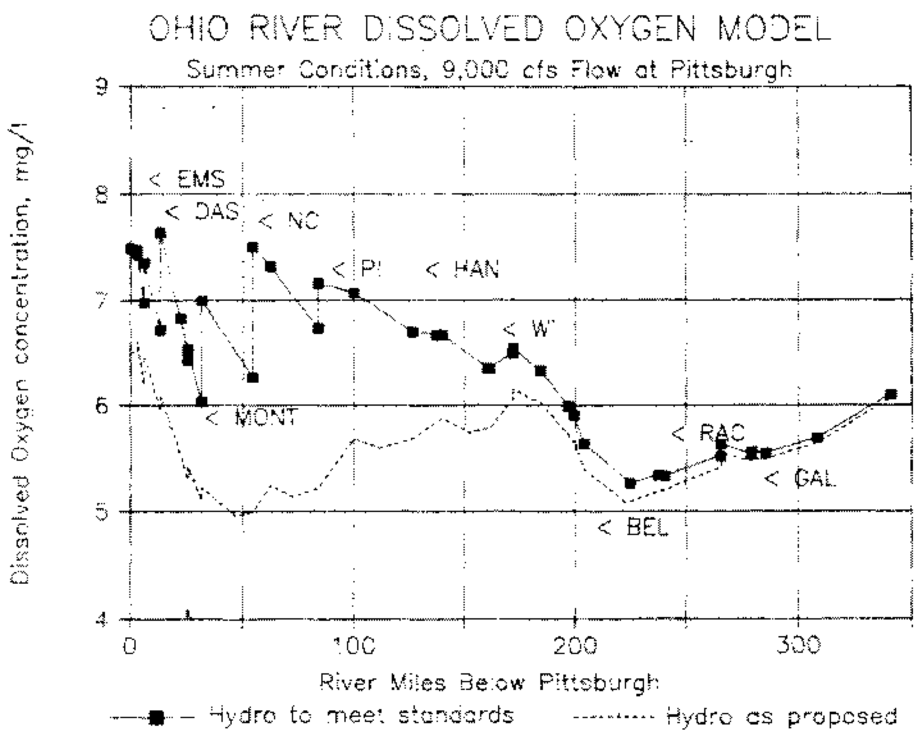

Figure 4.2.1-2. Ohio River DO model results for summer flow conditions, 9,000 cfs at Pittsburgh, with spill flows to maintain 5 mg/L.

For Case 1, with spill flows to meet state standards, there are approximately 80 miles of river with DO concentrations below 5 mg/L (these violations occur even without any hydropower), and 370 miles with DO concentrations below 6.5 mg/L. The proposed projects would reduce DO concentrations by about 0.5 mg/L or more for approximately 17 miles of river.

Case 2: Moderate summer flows. The moderate summer flows analyzed for the first alternative (2.6 times the 7Q10 flows, when all proposed projects would operate; Section 4.1.1.1) showed no violations of the 5 mg/L standard. No additional spill is required at these river flows, so the impacts of the proposed projects on DO concentrations at moderate flow are the same as for the projects as proposed.

The additional spill flows to meet the DO standard are needed below 9000 cfs on the Ohio River at Pittsburgh. To illustrate the effects of the spill flow, DO concentrations in the Ohio, with temperatures and BOD loads equal to those used for the moderate flow analysis for the first alternative but with flows of 9000 cfs at Pittsburgh, are shown in Figure 4.2.1-2.

The hydropower plants, operating as proposed by the applicants, would cause violations of the 5-mg/L standard more frequently than without hydropower during only relatively low flows in summer. Cessation of generation at six of the dams is sufficient to prevent such additional violations. However, the projects would still cause significant reductions in DO concentrations throughout the study area throughout the year, and overall impacts of the projects would be very similar to the impacts of the projects as proposed.

4.2.1.2 Toxic compounds

Under Alternative 2, the projects would operate the same as under the first alternative, except at low summer flows. Therefore, the impacts of the projects on the concentrations of toxic compounds are expected to be essentially the same under the second alternative as under the first (Section 4.1.1.2).

4.2.1.3 Sediments

Under Alternative 2, the projects would operate the same as under the first alternative, except at low summer flows. Therefore, the impacts of the projects on the sediments are expected to be essentially the same under the second alternative as under the first (Section 4.1.1.3).

4.2.2 Fisheries

Alternative 2 (spills to meet state DO standards of 5.0 mg/L) will not alter the "as proposed" effects of lowered DO on fisheries. Cessation of generation during the summer low-flow conditions will divert the rapid-flow, tailwater habitat to the dam gates, which could affect fish abundance and fishing success in the turbine tailwater unless a compensatory flow augmentation is implemented (Section 4.2.3). Mortalities of fish due to turbine entrainment will be stopped at these times, thus protecting primarily young-of-the-year gizzard shad and freshwater drum. With more of these fish remaining in the pelagic zone, there may be additional fish kills in turbines (above those expected in the "as proposed" case) as operation resumes. There will be less dewatering of shallow-water habitat in the pool of Allegheny L&D No. 2 during these low-flow periods, but the rise and fall of water around the few days of very low flows may be more detrimental to fish habitat than would a more stable drop.

The moderate summer flows showed no violation of state standards, so no additional spill would be required and the estimated dissolved oxygen concentrations and impacts on mussels would be the same. Additional spill flows would be needed to meet the standard at flows below about 9000 cfs at Pittsburgh. When summer spill flows are regulated to maintain the state standard at these flows, there are only small improvements in dissolved oxygen between operating the projects as proposed and those estimated to maintain state standards at the lowest point in the sag curve. That point is near mussel beds below Belleville L&D. The greatest estimated improvement would be in the mussel beds below Willow Island L&D, where the difference (which is minor compared to natural variation) would approximate 0.5 mg/L. This largest change would be in a range just above 6.0 mg/L, whereas the changes in estimated concentrations at the other two sites are in the range of 5 to 6 mg/L. Spilling to maintain 5.0-mg/L at flows below 9000 cfs will not prevent dissolved oxygen concentrations in the mussel beds from dropping below 6.0 mg/L, where growth might be inhibited. For summer low flows (7Q10), the DO profile under this alternative essentially matches the profile with no hydropower.

There would be little change in the impacts on physical habitat for mussels at Muskingum L&D No. 3 with this alternative. Increased spillage requirements would slightly reduce the time when the mussels' large host fish would be entrained.

4.2.3 Recreation

Impacts to recreational fishing under Alternative 2 would be similar to those described under the first alternative (Section 4.1.3). In addition, impacts to recreational fishing under Alternative 2 would occur at those six sites where the hydroelectric plants would be occasionally inoperative during July through October (Table 2.1.2-1). The potentially increased number of recreational users could experience reduced fishing success at the proposed fishing facilities at these sites because flows would be diverted away from the public fishing areas and spilled over the gates (or fixed crests, in the case of Allegheny L&D No. 2 and Dashields). This impact is significant because it would occur during a high-use recreation period. The maintenance of flow velocities in the developed tailrace areas would be an important mitigative measure for preserving fish abundance and fishing success during times when the power plants are not generating (Section 4.1.3.4).

4.2.4 Wetlands

The environmental impacts to wetlands occurring from implementation of Alternative 2 would be similar to those described for Alternative 1 (Section 4.1.4). The same sites would be affected, and operational impacts, including those resulting from changes in pool level, would not be significantly different.

4.2.5 River Navigation and Hydraulics

4.2.5.1 Flow Patterns

Under Alternative 2, the projects would operate the same as under the first alternative, except at low summer flows. Therefore, the impacts of the projects on flow patterns are expected to be essentially the same under the second alternative as under the first (Section 4.1.5.1).

4.2.5.2 Pool Elevation Changes

Under Alternative 2, the projects would operate the same as under the first alternative, except at low summer flows. Pool elevation changes caused by cessation of generation at low flows to meet water quality standards (Section 4.2.1.1) would be small because they would occur during low flows. Therefore, the impacts of the projects on the pool elevation changes are expected to be essentially the same under the second alternative as under the first (Section 4.2.5.2).

4.2.5.3 Backwater Effects and Flooding

Under Alternative 2, the projects would operate the same as under the first alternative, except at low summer flows. Therefore, the impacts of the projects on flooding are expected to be the same under the second alternative as under the first (Section 4.1.5.3).

4.2.5.4 Flow Control

Under Alternative 2, the projects would operate the same as under the first alternative, except at low summer flows. Therefore, the impacts of the projects on flow control expected to be essentially the same under the second alternative as under the first (Section 4.1.5.4).

4.2.6 Other Resources

Impacts to land use, endangered and threatened species, archeological and historic resources, and wildlife from Alternative 2 would be similar to those described for

Alternative 1 (Section 4.1.6). The same sites would be affected, and operational impacts, including those resulting from changes in pool elevation would not be significantly different.

The socioeconomic impacts of this alternative would be substantially the same as for Alternative 1 (Section 4.1.6.4). However, the requirement that greater flows be released over the dams during specific conditions would reduce the local government revenues generated by the operation of some publicly owned projects (Table 4.1.6-6). For the following projects, the benefit of increased local government revenues during operation of the projects would be less than under Alternative 1: Pike Island, New Cumberland (6901), Dashields, and Allegheny L&D No. 2. There would be no change in the proposed operations of the remaining publicly owned projects, and the property taxes paid to local governments by privately owned projects would not be affected. Reductions in DO sufficient to require more treatment by wastewater dischargers would occur during some conditions, and over the same river miles as for Alternative 1.

4.3 PROJECT OPERATION TO MEET ANTIDEGRADATION CRITERION (ALTERNATIVE 3)

4.3.1 <u>Water Quality</u>

This alternative allows hydroelectric generation (with sufficient spill flows) and prevents DO concentrations that harm aquatic organisms from occurring more frequently than they do without hydropower. The literature suggests that DO concentrations above 6.5 mg/L do not cause detectable effects on fish survival or growth (Section 4.3.2). DO concentrations below 6.5 mg/L occur frequently in the upper Ohio River basin even without hydropower development, but there are also many conditions under which hydropower generation can take place without causing DO concentrations below 6.5 mg/L. Therefore, this alternative is defined by finding the spill flows that provide the most hydropower generation without causing DO concentrations to fall below 6.5 mg/L, except when they would occur even without hydropower. The spill flows were determined by using an optimization model that finds the combination of spill flows at the dams in the system that provides the most generation while maintaining the DO requirement. (See Appendix B for a description of the optimization model.)

In the optimization model, the spill required at any given dam is a function of (1) the DO and BOD concentrations above the dam, which determine how much aeration is required; (2) the amount of power that the proposed project can generate per unit of river flow, which is largely a function of the difference in pool elevations (or head) maintained by the dam; (3) the aeration efficiency of the dam; and (4) any other projects that are upstream and downstream of the dam and the aeration and power generation characteristics of such other projects. It was assumed that the proposed projects at Opekiska, Allegheny L&D No. 7, Willow Island, Belleville, and Gallipolis would provide as much aeration as the existing dams do, since these dams are poor aerators that do not contribute much DO to the rivers (Section 4.1.1.1).

The optimization model was run for the same sets of conditions under which the first two alternatives were evaluated (Sections 4.1.1.1 and 4.2.1.1). Spill flows that are believed to provide the required aeration were determined (Table 2.1.3-1). There are two spill flows for each project. One spill flow is to be maintained during the months of November through June, when DO concentrations are rarely critical (because of the higher saturation concentration of DO at lower temperatures, and because of the higher river flow rates that occur during these months). This noncritical-season flow is expected to provide sufficient aeration, as well as flow for other resources such as fish habitat and protection of concrete structures, when DO concentrations are normally high. The second spill flow is to be maintained during the months of July through October, when DO concentrations are typically low (because of the lower saturation concentration of DO at higher temperatures and because of lower river flows). Aeration requirements are higher during the critical season, so more spill flow is required. Some of the proposed projects would not operate during much of the critical season because the spill flow requirement is higher than the flow required for generation to occur, when lockage and leakage flows and the minimum flow sufficient for generation are taken into consideration.

Case 1: Low summer flows (7Q10 flows). During the very low 7Q10 flows (Section 4.1.1.1), the projects at dams that provide little aeration (Opekiska, Allegheny L&D No. 7, Willow Island, Belleville, and Gallipolis) would generate. Of the projects at dams that are good aerators, only the project at Allegheny L&D No. 3 would generate (with a spill flow of 500 cfs); at all other such projects the critical-season spill flow requirement is higher than the 7Q10 river flow. Therefore, the DO concentrations for this case are essentially the same as with no hydropower (Section 4.1.1.1).

Case 2: Moderate summer flows. The moderate summer flows analyzed for the first alternative (2.6 times the 7Q10 flows, when all proposed projects would operate; Section 4.1.1.1) were modeled with spill flows to maintain DO concentration at 6.5 mg/L. On the Monongahela (Figure 4.3.1-1), the DO concentrations essentially match those with no hydropower except below Maxwell and Monongahela L&D No. 4, where DO concentrations are high enough that generation can take place without causing concentrations less than 6.5 mg/L. Spill flows at Hildebrand and Morgantown are very important to provide recovery from the DO degradation that takes place above Opekiska. No spill flow is recommended for Opekiska because it is predicted that hydropower there will improve DO conditions by breaking up the stratification.

On the Allegheny River (Figure 4.3.1-2) generation would occur at L&D No. 7, where little aeration takes place without hydropower, and at L&D No. 3, where aeration at L&D Nos. 2 and 4 are adequate to maintain DO concentrations above 6.5 mg/L. Spill flow at L&D No. 4 is required to provide recovery from the reductions in DO caused by the licensed projects at L&D Nos. 9, 8, 6, and 5, which have relatively low spill flow requirements. Spill flow at L&D No. 2 is required to maintain DO concentrations on the Ohio River; Allegheny L&D No. 2 is such an efficient aerator that spill there is more cost effective for maintaining DO concentrations on the Ohio than spill at some of the Ohio River dams.

On the Ohio River (Figure 4.3.1-3), no generation would occur at Dashields, Montgomery, and New Cumberland under Case 2, and high spill flows are required at Emsworth and Pike Island because these projects prevent low DOs from occurring in approximately the first 200 RM below Pittsburgh. Below about RM 200, hydropower development has little effect on DO concentrations because (1) the effects of the efficient dam aeration at the first five dams on the Ohio have dissipated, and (2) the dams at Hannibal and below do not provide much aeration, so dam aeration does not control the DO concentrations.

Model results not presented here indicate that the spill flows determined for Alternative 3 would prevent DO concentrations from falling below 6.5 mg/L over a wide range of river flows, at water temperatures that are rarely exceeded. These spill flows would be effective in preventing degradation of water quality to levels harmful to aquatic life.

4.3.1.2 Toxic Compounds

Under this alternative, there would be considerably more spill flow between July and October at aerating dams than under the first or second alternative. Therefore, the expected impacts of the proposed projects on concentrations of toxic compounds (Section 4.1.1.2) would be reduced under this alternative, during the July through October critical season.

4.3.1.3 Sediments

Under this alternative, the potential sources of sediment resuspension and contaminated sediment found for the projects as proposed (Section 4.1.1.3) would also occur. The potential impacts caused by reductions in pool elevation above fixed-crest dams would be reduced between July and October by the higher spill flows required at fixed-crest dams (except for Allegheny L&D No. 7).

4.3.2 <u>Fisheries</u>

Staff selected a DO concentration of 6.5 mg/L as the level above which there should be no detectable effects of oxygen deficiency on aquatic life. Review of DO criteria documents and the scientific literature gave assurance that this level could legitimately be considered "antidegradation" in the sense of biological effects in the environment. DO criteria are discussed further in Sect. 4.1.2.1.2.

Enhanced spills at projects that provide aeration in the warmer months of July through October are proposed to maintain 6.5 mg/L of DO at all times to ensure no degradation of fish communities from lowered DO (Alternative 3). This alternative will enhance the summer tailwater habitat below the dams with both maintained DO and continued flow but will, thereby, shift fish away from the active fishery expected near the turbine discharge (Section 4.3.3). Mortalities of fish due to turbine entrainment will be stopped at these times, thus protecting

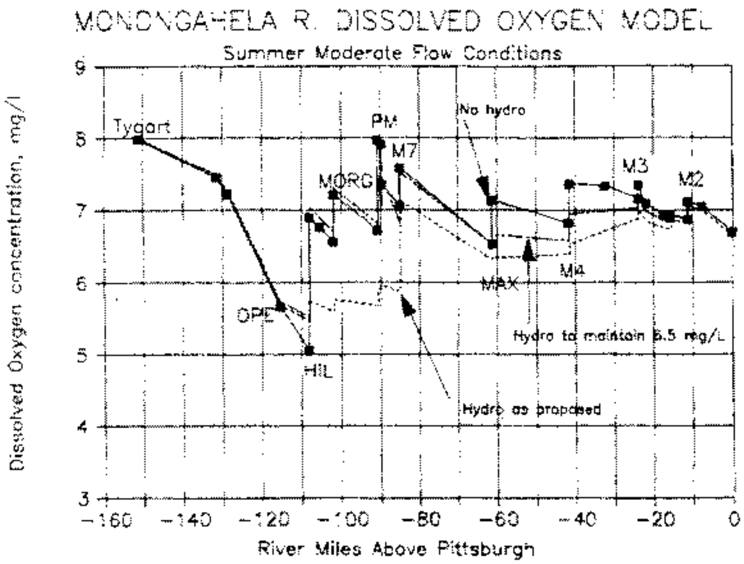

Figure 4.3.1-1. Monongahela River DO model results for summer moderate flow conditions, with spill flows to maintain 6.5 mg/L.

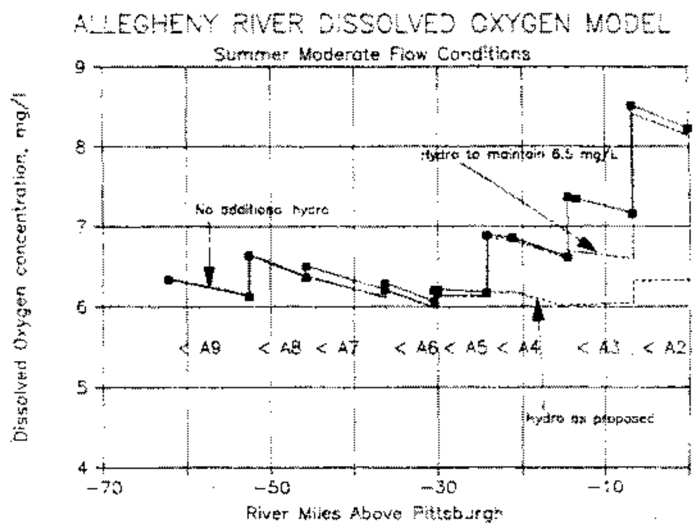

Figure 4.3.1-2. Allegheny River DO model results for summer moderate flow conditions, with spill flows to maintain 6.5 mg/L.

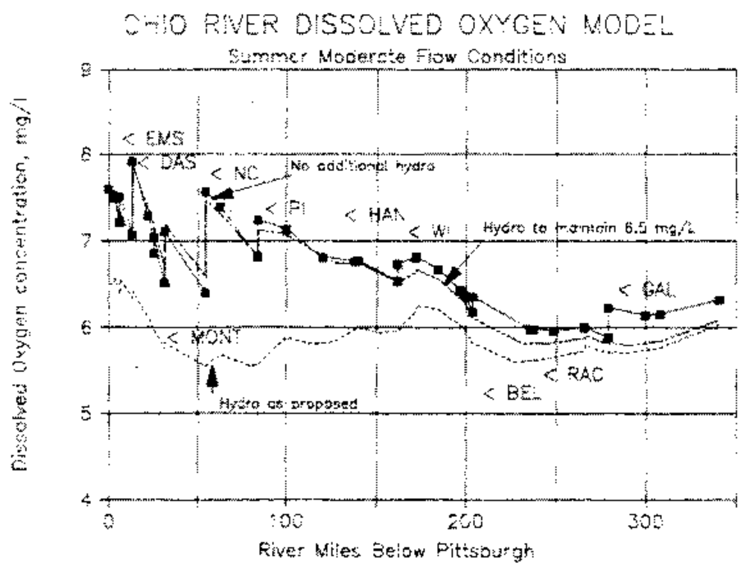

Figure 4.3.1-3. Ohio River DO model results for summer moderate flow conditions, with spill flows to maintain 6.5 mg/L.

primarily young-of-the-year gizzard shad and freshwater drum. With more of these fish remaining in the pelagic zone at the end of the summer, there may be additional fish kills in turbines (above those expected in the "as proposed" case) as operation resumes in autumn. There will be less dewatering of shallow-water habitat in the pools above fixed-crest dams; water elevations should be more stable than in Alternative 2 (cessation at only the 7Q10 flows), thus providing more protection for shallow-water fish habitats.

Under summer moderate flow conditions, efforts to maintain 6.5 mg/L where it now occurs would still cause a few tenths of a milligrams per liter drop in dissolved oxygen concentration in the Gllipolis pool at the important mussel beds there. This estimate is minor compared with natural variability, however. Concentrations could be depressed from slightly above 6.0 mg/L to just below that value. Below Belleville L&D, DO could be reduced slightly to near 6.0 mg/L. There would be little change in concentrations at mussel beds below Willow Island L&D, where concentrations are likely to be in the 6.5- to 7.0-mg/L range under these conditions. The biological effect on mussels from these changes could amount to a small decrease in long-term growth and production. At summer low flows (7Q10), few projects would operate. Thus, the DO concentrations for this case are essentially the same as with no hydropower. There would be little additional impact on mussels at any site beyond the naturally stressing conditions.

As with Alternative 2, there would be little change in the physical habitat at Muskingum L&D No. 3 with this alternative. Increased spillage requirements would further slightly reduce the time when large host fish for mussels would be entrained.

4.3.3 Recreation

Impacts to recreational fishing under Alternative 3 would occur at those sites where hydroelectric plants would be occasionally inoperative during July through October. Fishing success at the proposed fishing facilities at these sites would be reduced as flows would be diverted away from the public fishing areas and spilled over the gates or fixed crests. The provision of bypass flows at these sites would be an important mitigation measure for maintaining fish abundance and fishing success in the developed tailrace areas. The maintenance of flow velocities in the developed tailrace areas would be an important mitigative measure for preserving fish abundance and fishing success during times when the power plants are not generating (Section 4.1.3.4).

The new public fishing access facilities, coupled with the protection of water and fish habitat quality afforded under Alternative 3, could enhance recreational fishing at most sites in the basin.

4.3.4 Wetlands

The adverse impacts to wetlands during operation of the proposed projects would not be significantly reduced. Erosion, turbidity, and sedimentation would continue to exist with resultant changes in species composition, changes in area or the wetlands, and increased mudflat areas.

4.3.5 River Navigation and Hydraulics

The project features that cause potential navigation and hydraulic impacts (changes in flow patterns, changes in pool elevation above fixed-crest dams, backwater effects on flooding, and changes in flow control; Section 4.1.5) are not altered significantly by the spill flows under Alternative 3. However, because this alternative would reduce generation at some of the dams between July and October, some of these potential impacts would be reduced during these months. Pool elevation changes would occur less frequently between July and October at Allegheny L&D Nos. 2 and 4 and at Dashields because of the high spill flows required. Changes in flow patterns at Hildebrand, Morgantown, Allegheny L&D Nos. 2 and 4, Dashields, and New Cumberland would occur less frequently between July and October because the high spill flow requirements would prevent generation much of the time. The higher spill flows required at Point Marion, Monongahela L&D No. 4, Montgomery, and Pike Island would also reduce changes in flow patterns. Other than these changes, the impacts of the projects under Alternative 3 would be similar to those of the projects as proposed (Section 4.1.5).

4.3.6 Other Resources

Impacts to other resources (i.e., land use, endangered and threatened species, archeological, historic and aesthetic resources, and wildlife) from Alternative 3 would be essentially the same as those described for Alternative 1 (Section 4.1.6). The same sites would be affected, and operational impacts on these resources would not be significantly different.

The socioeconomic impacts of this alternative would be substantially the same as for Alternative 1 (Section 4.1.6.4). However, the requirement that greater flows be released over some dams would reduce the local government revenues generated by the operation of some of the publicly owned projects (see Table 4.1.6-6). For the following publicly owned projects, the benefit of increased local government revenues during operation of the projects would be less than under Alternatives 1 or 2: Pike Island, New Cumberland (6901), Dashields, Emsworth Allegheny L&D No. 2, Allegheny L&D No. 3, Allegheny L&D No. 4, and Point Marion. The proposed publicly owned project at Montgomery (3490) would not be profitable under this altrnative. There would be no change in the proposed operations of the remaining publicly owned projects, and the property taxes paid to local governments by privately owned projects would not be affected. Reductions in DO sufficient to potentially require more treatment by major wastewater dischargers are not expected to occur under Alternative 3. No industries or municipalities are expected to have to purchase new treatment facilities.

4.4 PROJECTS SELECTED TO MINIMIZE IMPACTS TO ALL TARGET RESOURCES (ALTERNATIVE 4)

4.4.1 Water Quality

4.4.1.1 Dissolved Oxygen

This alternative is defined by finding the spill flows that provide the most hydropower generation without causing DO concentrations to fall below 6.5 mg/L, except when DO would be less than 6.5 mg/L even without the hydroelectric projects, and assuming that no generation takes place at the sites where no development would occur under this alternative (i.e., Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3). The spill flows were determined by using an optimization model that finds the combination of spill flows at the dams in the system that provides the most generation while maintaining the DO requirement (see Appendix B for a description of the optimization model). The same modeling methods and assumptions were used for this alternative as for Alternative 3.

The optimization model was run for the same sets of conditions under which the first three alternatives were evaluated (Section 4.1.1.1). Spill flows that are believed to provide aeration sufficient to keep projects from causing DO concentrations less than 6.5 mg/L under all but very unusual conditions were determined (Table 2.1.3-7). There are two spill flows for each project. One spill flow is to be maintained during the months of November through June, when DO concentrations are rarely critical (because of the higher saturation concentration of DO at lower temperatures and because of the higher river flow rates that occur during these months). This noncritical season flow is expected to provide sufficient aeration, as well as flow for other resources such as fish habitat and protection of concrete structures, when DO concentrations are normally high. The second spill flow is to be maintained during the months of July through October, when DO concentrations are typically low (because of the lower saturation concentration of DO at higher temperatures and because of lower river flows). Aeration requirements are higher during the critical season, so more spill flow is required. Some of the proposed projects would not operate during much of the critical season because the spill flow requirement is higher than the flow required for generation to occur, when lockage and leakage flows and the minimum flow sufficient for generation are taken into consideration.

<u>Case 1: Low Summer Flows (7Q10 Flows)</u>

During the very low 7Q10 flows (Section 4.1.1.1), only the projects at dams that provide little aeration (Opekiska, Willow Island, Belleville, and Gallipolis) would generate; at all other such projects, the spill flow requirement is close to or higher than the 7Q10 river flow. Therefore the DO concentrations for this case are essentially the same as with no hydropower (Section 4.1.1.1).

Case 2: Moderate Summer Flows

The moderate summer flows analyzed for the first alternative (2.6 times the 7Q10 flows, when all proposed projects would operate; Section 4.1.1.1) were modeled with spill flows to maintain 6.5 mg/L. On the Monongahela River, project impacts on DO concentrations are the same as for Alternative 3 (Section 4.3.1.1 and Figure 4.3.1-1).

On the Allegheny River (Figure 4.4.1-1), the elimination of generation at L&D No. 7 has little effect on DO because little aeration takes place at this dam without hydropower. On the Ohio River (Figure 4.4.1-2), the elimination of generation at Montgomery would increase DO slightly at Pike Island compared with Alternative 3. The spill at Pike Island during the critical season would still be required to prevent low DOs from occurring in approximately the first 200 RM below Pittsburgh.

The spill flows designed to prevent hydropower from causing DO concentrations to fall below 6.5 mg/L for the fourth alternative are effective in preventing degradation of water quality to levels harmful to aquatic life. Not developing hydropower at Muskingum L&D No. 3 would eliminate any potential reductions in DO on that river.

4.4.1.2 Toxic Compounds

Under this alternative, there would be considerably more spill flow between July and October at aerating dams than under the first or second alternatives, and hydropower development would not occur at three of the dams. Therefore, the expected impacts of the proposed projects on concentrations of toxic compounds (Section 4.1.1.2) would be reduced under this alternative during the July through October critical season and year-round at the three sites where hydropower would not be developed.

4.4.1.3 Sediments

Under this alternative, the potential sources of sediment resuspension and contaminated sediment found for the projects as proposed (Section 4.1.1.3) would also occur, except at the three sites where no development would occur. Impacts caused by construction would be avoided at these three projects. The potential impacts caused by reductions in pool elevation above fixed-crest dams would be reduced between July and October by the higher spill flows required at fixed-crest dams (except at Allegheny L&D No. 7, where the project would not be built).

4.4.2 Fisheries

If the three projects were not developed (Alternative 4) on the basis of wetlands and fisheries degradation, the effects at these sites and the impacts at two other sites where flows change in compensation would be eliminated or altered. Projects that would not be developed in this alternative are Muskingum L&D No. 3 and Allegheny L&D No. 7 (primarily for significant degradation of tailwater aquatic habitat), and Montgomery (for proximity to the important upstream embayment and the likelihood of significant entrainment of the fish that populate the main stem Ohio river from this highly productive spawning and nursery area). Effects at other projects will be similar to Alternative 3.

Dissolved oxygen concentrations and their expected biological effects at mussel sites would be essentially identical under this alternative to those seen under the nondegradation alternative. The principal effect of this alternative would be elimination of potential damages to the mixed community of mussels and any surviving population of L. abrupta in the lower Muskingum River below the proposed Muskingum No. 3 project. This project would not be recommended for development under this alternative in order to protect the tailwater habitat from physical alteration. Host fish mortalities due to entrainment should be the same as in Alternative 3.

4.4.3 Recreation

Under Alternative 4, projects causing potential significant impacts to target resources (Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3) are removed from the suite of projects considered. By removing these projects, the potential significant adverse site-specific impacts to recreational resources at these sites would be eliminated. Impacts at other projects sites under Alternative 4 would be similar to those discussed under

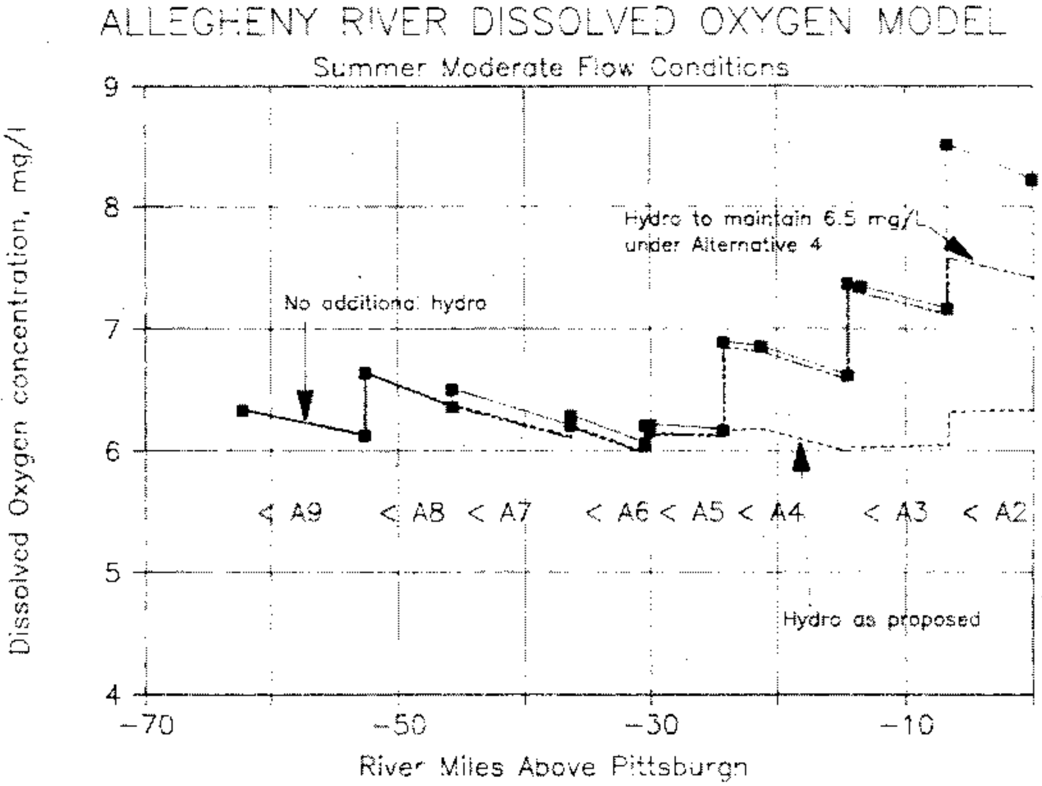

Figure 4.4.1-1. Allegheny River DO model results for summer moderate flow conditions, with spill flows to maintain 6.5 mg/L under Alternative 4.

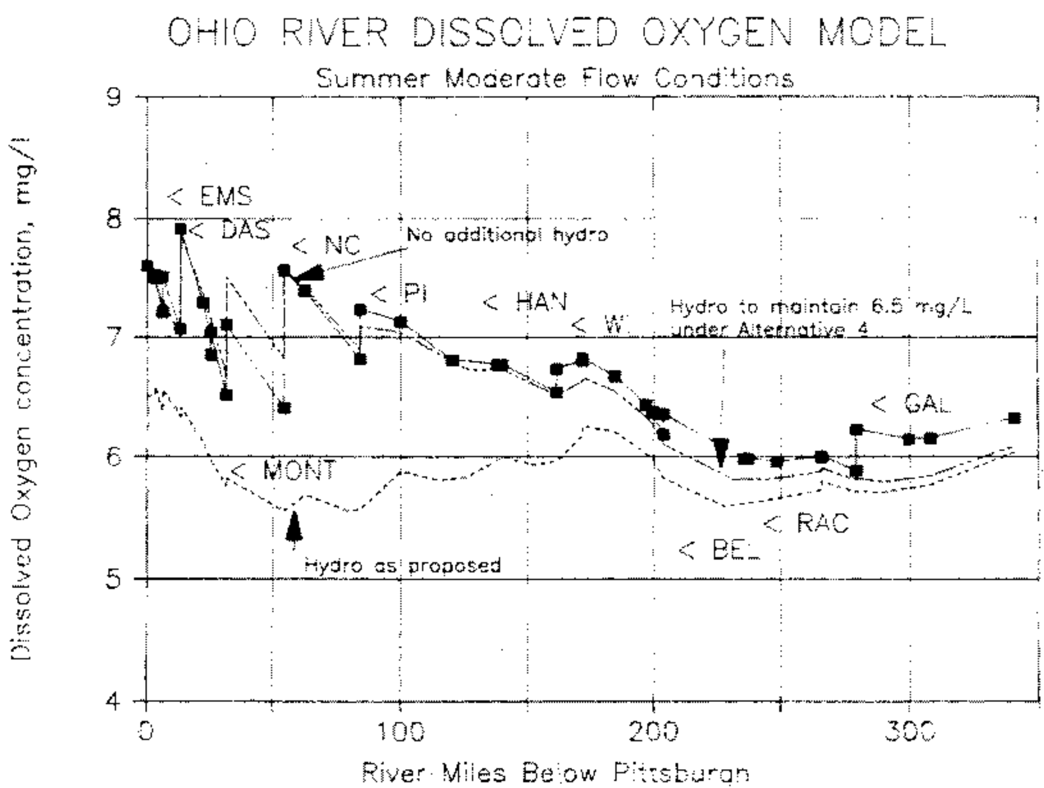

Figure 4.4.1-2. Ohio River DO model results for summer moderate flow conditions, with spill flows to maintain 6.5 mg/L under Alternative 4.

Alternative 3. Those projects with no generation during the months of July through October would require mitigation in order to preserve fishing success in the public fishing areas during these times (Section 4.1.3.4).

Alternative 4 would provide additional benefits to recreation compared to Alternatives 1, 2, and 3 because it would avoid significant adverse impacts to existing established recreational opportunities at three hydropower sites, while protecting and enhancing recreational fishing at 16 hydropower sites in the basin.

4.4.4 Wetlands

If the three projects were not developed for hydropower, the significant, adverse impacts on wetlands would be eliminated. Developing the remaining sites would not produce impacts significantly greater than those associated with current conditions.

4.4.5 River Navigation and Hydraulics

Impacts of Alternative 4 are essentially the same as those of Alternative 3 (Section 4.3.5), except none of the potential impacts caused by Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3 would occur because these projects would not be constructed.

Alternative 4 would allow accurate river flow gauging to continue at Allegheny L&D No. 7, because the gauging inaccuracies caused by hydropower facilities would not occur.

4.4.6 Other Resources

4.4.6.1 Land Use

The land use impacts of this alternative are the same as those described for Alternative 1 (Section 4.1.6.1), except that all impacts associated with projects at Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3 would be eliminated.

4.4.6.2 Endangered and Threatened Species

If hydropower projects are not developed at the Muskingum L&D No. 3 and Montgomery sites, pre-existing conditions would be maintained and impacts at these sites would be the same as no action. Potential environmental impacts to endangered and threatened species at other project sites would be the same as discussed for Alternative 1 (Section 4.1.6.2).

4.4.6.3 Socioeconomics

Construction Period Impacts

The construction-related socioeconomic impacts of this alternative would be the same as for Alternative 1 (see Section 4.1.6.4) except that beneficial and adverse effects would be eliminated for projects proposed at Muskingum L&D No. 3, Montgomery (both competing applications), and Allegheny L&D No. 7. For these projects, there would be no beneficial impact of increased employment and local area incomes during the construction period (see Table 4.1.6-4). On the other hand, there would be no adverse impacts due to construction traffic at these projects, where substantial traffic-related impacts were expected, and the risk of increased upstream flooding during the construction period would be eliminated at these sites. Traffic-related impacts, as described in Section 4.1.6.4, would still be anticipated at Emsworth, Allegheny L&D No. 4, Maxwell, Point Marion, Hildebrand, Opekiska, and Tygart. All projects except Tygart would still increase the risk of upstream flooding during the construction period.

Operations Period Impacts

With the exception of the following items, socioeconomic impacts during project operations would be the same as under Alternative 1 (see Section 4.1.6.4):

(1) The minor economic benefit of the additional employment of 4.2 full-time employees per project would not occur for projects at the three eliminated sites [Muskingum L&D No. 3, Montgomery (both competing applications), and Allegheny L&D No. 7].

(2) No additional local government revenues would be realized from projects at the three eliminated sites. For Muskingum L&D No. 3, Montgomery (2971), and Allegheny L&D No. 7, roughly $40,000 in property taxes per site would not be collected by local governments. For Montgomery (3490), which would be a publicly owned project, the amount of annual local government revenues foregone would amount to approximately $367,000. For other publicly owned projects, the change in local government revenues would be the same as under Alternative 3 (see Section 4.3.6.4).

(3) The socioeconomic risks associated with increased upstream flood elevations would not occur at the three eliminated sites. This reduced risk is especially significant for Montgomery (both competing projects), where there was found to be a high probability of increased flood elevations and where extensive development is located along the river. The reduced risk at Allegheny L&D No. 7, while not as important, is still significant because this project was found to have a high probability of raising flood elevations, but there is less development near the river. Significant socioeconomic impacts due to increased upstream flooding would still be anticipated at Gallipolis (both competing applications), Belleville, Willow Island (9999), New Cumberland (10332), Dashields, Emsworth, Allegheny L&D Nos. 3 and 4, Point Marion, and Hildebrand. Areas upstream of Dashields and Emsworth are especially sensitive in this regard because of extensive development near the river.

(4) Reductions in DO concentration sufficient to potentially require more treatment by major wastewater discharges would not occur. No industries are expected to have to purchase new treatment facilities.

4.4.6.4 Archaeological and Historical Resources

This alternative would eliminate potential site-specific impacts during construction to cultural resources at Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3. Because the PHMC has identified a high probability that archaeological sites are located in or close to the Allegheny L&D No. 7 and Montgomery project sites (Section 4.1.6.5), this alternative would result in fewer potential impacts to archeological resources than the other three alternatives.

4.4.6.5 Aesthetic Resources

Under Alternative 4, potential site-specific impacts at Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3 would be eliminated. The island habitats immediately downstream from the proposed powerhouses at Allegheny L&D No. 7 and Muskingum L&D No. 3 would be preserved. In addition, significant adverse aesthetic impacts to the residential areas close to Allegheny L&D No. 7, Montgomery L&D, and Muskingum L&D No. 3 would be eliminated under this alternative.

4.5 NONHYDROELECTRIC GENERATING ALTERNATIVES

A 400-MW unit (Section 2.2.1), operating at roughly 70 percent capacity, would consume an average of 1,900 tons of coal per day. The scrubber would consume about 170 tons of limestone per day. Additional resources would be consumed in mining and transporting the coal and limestone to the unit. The cooling towers would consume in excess of two million gallons of water per day, and an additional one-third million to one-half million gallons of water per day. The existing water intake would be used, but the additional water requirements would increase intake flows.

The unit would produce about 140 tons of ash per day, with about 0.5 ton of the ash emitted to the atmosphere each day and the remainder collected and disposed of as solid waste. Scrubber sludge of roughly 370 tons/day would be collected and require disposal. Roughly four acres per year of waste disposal area would be consumed by the unit.

The unit would release approximately 0.5 ton/day of ash, 13 tons/day of sulfur dioxide, and 25 tons/day of oxides of nitrogen. Cooling towers would release roughly two million gallons of water vapor each day.

The impacts of these releases would be site specific, depending upon the dispersive capability of the local atmosphere, other local sources of air pollutants, and regional concentrations of the pollutants released by the unit. Before a unit could be constructed, a detailed environmental review would be required under the Clean Air Act (PL 95-95). Compliance with these regulations would ensure that air quality impacts from unit operation would be analyzed and found to be acceptable. In addition, a 400-MW coal unit would cause a small increase in regional coal combustion. However, unit operation would degrade air quality, would increase regional pollution levels, and would contribute to air quality-related problems such as acid rain and regional ozone levels.

4.6 NO-ACTION ALTERNATIVE

The no-action alternative would constitute a denial of all the applications for license to construct, operate, and maintain the proposed projects. This alternative would result in the nonuse of potential energy that could be derived by developing the proposed sites and the consumption of fossil fuel that would be saved if the proposed projects were developed. In general, the no-action alternative would result in no change or a continuation of existing trends for the target and other resources discussed in this DEIS.

Not constructing the proposed projects would avoid the impacts on water quality discussed in Section 4.1.1. Not licensing the projects, however, would result in some negative impacts on water quality. Development of hydropower at Opekiska Dam on the Monongahela River is expected to improve DO conditions during the summer by eliminating one of the causes of thermal stratification in the Hildebrand pool (Section 4.1.1). This improvement would be lost if the project were not licensed. The potential for aerating rivers by using turbine aeration, if this technology proves feasible, would be lost if the projects were not licensed.

Generation of power at nonhydropower plants causes significant impacts on water quality, such as the discharge of cooling water which increases river temperatures and lowers DO concentrations. Generation at coal-fired plants may result in the deposition of acidic precipitation, which degrades water quality. Mining of coal also causes negative impacts on water quality.

The no-action alternative would prevent project-induced decreases in DO, decreases in the rate at which volatile pollutants are removed from the water, and increases in sedimentation. However, this alternative would also prevent beneficial changes some projects could provide, and would increase regional effects of power generation at nonhydropower plants.

If the proposed projects were not constructed, the benefits associated with the development of proposed recreational tailrace fishing facilities would not be realized. This loss would be greater at those sites in the study area with difficult access to the tailwaters of the L&Ds.

The no-action alternative would prevent potential project-induced impacts on flow patterns, pool elevations and velocities, and flood water elevations. A possible beneficial effect of the projects that would be lost if no projects were licensed is the possibility of the projects reducing the unsteadiness of river flows in the basin because of their automated flow control.

4.7 RELATIONSHIP TO LAWS AND POLICIES

The National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. §§ 4331 et seq., mandates the preparation of an environmental impact statement (EIS) for all major federal actions significantly affecting the quality of the human environment. The Commission has determined that issuance of licenses for Project Nos. 4017, 4474, 7909, 7914, 4675, 8908, 7660, 8654, 8990, 7307, 7399, 7041, 7568, 2971, 3490, 6901, 10332, 3218, 6902, 9999, 6939, 9042, 10098, and 6998 is an action that falls within this mandate of NEPA. Accordingly, this FEIS for 24 proposed hydroelectric projects at 19 sites has been prepared pursuant to the requirements of NEPA.

Section 10(a) of the Federal Power Act, 16 U.S.C. § 803(a), requires that each licensed project be best adapted to a comprehensive plan for improving or developing a waterway for, among others, beneficial public uses including recreational purposes. The Commission, therefore, requires that each license applicant consult with concerned federal, state, and local recreation agencies to determine an appropriate level of development to help meet the recreation needs of the project area.

Pursuant to the Fish and Wildlife Coordination Act (FWCA), 16 U. S. C. §§ 661 et seq., the Commission must consult with the USFWS and state resource management agencies on preventing loss or damage to wildlife and fishery resources and on developing water resources. Each

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applicant has submitted its FERC license application to these agencies for review and comment, and the responses have been part of the record reviewed by the FERC staff. These agencies were invited participants in the Commission's scoping process for this EIS. Workshops were organized by the FERC staff on turbine-induced mortality and recreation to involve these agencies directly in deliberations (Section 1.3). The Electric Consumers Protection Act of 1986 (Pub. L. 99-495) amended the FPA, requiring the Commission to consider including conditions in its licenses that incorporate recommendations derived from FWCA consultations. Comments and recommendations provided in the DEIS have been used by staff in developing and revising its recommendations as needed for the FEIS. The FEIS, including the responses to comments, indicates documentation of staff's position and evidence of disagreements between staff's position and appropriate fish and wildlife agencies' positions on resource protection.

Consistent with the requirements of the Endangered Species Act, 16 U.S.C. § 1531, as amended, the Commission requires each applicant for license to submit a list of any threatened or endangered species or critical habitat listed or designated by the Department of the Interior or the Department of Commerce and occurring in the vicinity of the proposed projects. Applicants have included correspondence with the USFWS in their license applications, as appropriate.. Consistent with Section 7(c)(1) of the Endangered Species Act, as amended, and 50 CFR § 402.06 (1987), staff's biological assessment on the pink mucket pearly mussel, a federally listed endangered species, was included in the DEIS transmitted to the USFWS in May 1988. In response to USFWS's request for additional information included in its DEIS comments, staff compiled additional information (Appendix I), and has requested that USFWS prepare its biological opinion regarding the mussel.

The Corps has been authorized by Congress to operate rivers of the upper Ohio River Basin for navigation, flood control, and water quality. The navigation dams, and Tygart Dam, have not been authorized for hydropower production, so power generation at these facilities must not interfere with the specific purposes for which Congress authorized them. Prior to beginning construction, licensees would be required to obtain permits from the Corps (404 permits) that would regulate the placing of dredge or fill materials in waters of the United States.

Under Section 401 of the Clean Water Act, 33 U.S.C. § 1341, a Commission license for a project may not be issued unless the applicant for license obtains either (1) state certification that any discharge from the proposed project will comply with applicable provisions of the Act or (2) waiver of such certification by the appropriate state agency. The Commission requires each license applicant to apply for such certification or waiver before they file with the Commission.

The states in which these projects are proposed have regulations to maintain DO concentrations above a standard (5 mg/L) in the rivers that the projects would affect. In addition, the federal Clean Water Act and each state have antidegradation policies, which are to prevent degradation of waters that meet or exceed the standards (these policies and their application to the proposed projects are discussed in Section 2.1). The mechanism by which the states enforce standards and the antidegradation policy for hydropower projects is water quality certification, in which the state specifies requirements for project operation that it feels are sufficient to maintain water quality adequately. The following summarizes water certification status of the projects:

Projects in Pennsylvania

The Pennsylvania Department of Environmental Resources has granted water quality certificates under Section 401 of the Clean Water Act for the following projects:

Project Name	FERC No.	Date granted
Allegheny River L&D No. 7	7914	January 30, 1984
Allegheny River L&D No. 4	7909	April 20, 1984
Point Marion	7660	July 7, 1983
Monongahela L&D No. 4	4675	October 10, 1985
Emsworth	7041	December 24, 1985
Dashields	7568	December 4, 1984
Montgomery	2971	June 25, 1985.

Pursuant to Commission Order 464, the Section 401 certification for the following projects have been waived because more than one year had elapsed since the date the 401 certification was requested, with no response by OEPA:

Project Name	FERC No.	Date Requested
New Cumberland	6901	August 2, 1983
Pike Island	3218	September 23, 1982
Willow Island	6902	August 2, 1983
Muskingum River L&D No. 3	6998	January 4, 1984.

Pursuant to Commission Order 464, the OEPA was notified that the 401 certification was waived for FERC project number 6998, and was invited to submit comments and recommendations regarding water quality. OEPA submitted comments or recommendations on the application for FERC project number 6998 in a letter dated April 21, 1987.

OEPA denied water quality certification for FERC project numbers 10332 and 9999 in letters dated November 9, 1987. Pursuant to the Commission's procedure issued in an order granting appeal for Project number 3986-003, the applicants for these projects have appealed the denials to OEPA. The Commission will therefore defer action on these license applications until the applicants have exhausted their remedies on administrative and judicial appeal, as long as the applicant continues to demonstrate due diligence in pursuing these remedies.

4.8 UNAVOIDABLE ADVERSE IMPACTS

Hydropower generation at the proposed projects, especially those that are efficient aerators, would cause some loss of DO to the rivers, though the effect of such losses on aquatic life depends on what the DO concentration is. Generation would reduce the amount of volatile pollutants that are assumed to leave the water at dams. Sediments would be disturbed by project construction and operation.

There would be unavoidable losses of some fish due to entrainment through turbines and mortality resulting from direct or latent injuries, primarily immature gizzard shad and freshwater drum but also including occasional game fish. There are insufficient data to quantify the extent of losses, and the technology is insufficiently developed for Ohio River basin applications to require installation of effective devices for excluding entrainment. Monitoring is recommended to quantify the extent of these losses and to develop mitigation.

There would be unavoidable changes in tailwater habitats for aquatic life requiring high water velocities. During certain site-specific ranges of flows, the largest percentage of river flow would be through turbines at one end of the dams rather than through gates or over fixed crests across the width of the dam. Water velocities would be decreased in much of the present tailwater seasonally. This change can be partially mitigated by habitat management at the turbine tailwater, including turbine bypass flows.

Head reduction at fixed-crest dams would cause an unavoidable increase in water velocity in the upstream pool and dewatering of shoreline fish habitat. These changes would have minor significance unless the elevations change often and erratically, in which case habitats would become unstable and would not be replaced by other suitable habitat at lower elevation or with different velocities.

Dredging for the powerhouses and turbine intake and discharge areas would cause an unavoidable loss of a small and insignificant amount of river bottom habitat.

There would be an unavoidable loss of riparian and wetland vegetation from construction activities and project facilities. Changes in pool elevation during construction and operation may disturb existing wetland or riparian vegetation. Unavoidable loss of wetland habitat would occur if Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3 were to be built.

Hydropower projects at fixed-crest dams would cause drops in the pool elevation above the dam that can be mitigated only with the addition of flashboards to effectively raise the crest of the dam. However, installation of flashboards may not be approved by the Corps, so this impact may be unavoidable. Many of the projects are constrained by factors such as space and

Pursuant to Commission Order 464, the Section 401 certification for the following projects have been waived because more than one year has elapsed since the 401 certification was requested, with no response from the state:

Project Name	FERC No.	Date requested
Allegheny River L&D No. 3	4474	September 20, 1984
Allegheny River L&D No. 2	4017	June 21, 1984
Maxwell	8908	January 15, 1984
Montgomery	3490	February 3, 1986.

Projects in West Virginia

The West Virginia Department of Natural Resources (WVDNR) has granted water quality certificates under Section 401 of the Clean Water Act for the following projects:

Project Name	FERC No.	Date granted
Tygart	7307	December 11, 1985
Tygart	7399	August 15, 1985
New Cumberland	10332	February 22, 1988.

Pursuant to Commission Order 464, the Section 401 certification for the following projects have been waived, since more than one year elapsed since the 401 certification was requested, with no response by WVDNR:

Project Name	FERC No.	Date Requested
Opekiska	8990	February 20, 1985
Hildebrand	8654	November 25, 1985
New Cumberland	6901	May 12, 1986
Willow Island	6902	March 20, 1985
Willow Island	9999	May 12, 1986
Belleville	6939	April 12, 1983
Gallipolis	9042	March 20, 1985.

In addition, water quality certification was requested for Gallipolis (FERC No. 10098) from WVDNR on September 24, 1986.

Pursuant to Commission Order 464, the WVDNR was notified that the 401 certification was waived for FERC project numbers 8990, 6901, 6902, 9999, 6939, and 9042, and was invited to submit comments and recommendations regarding water quality. DNR submitted comments or recommendations on the applications for FERC project numbers 6901, 6902, 9999, 6939, and 9042 in letters dated June 5 and 6, 1987.

Projects in Ohio

The Ohio Environmental Protection Agency (OEPA) granted a water quality certificate under Section 401 of the Clean Water Act for the following project:

Project Name	FERC No.	Date Granted
Gallipolis	9042	August 14, 1985.

Water quality certification was requested on October 21, 1987, from OEPA for Gallipolis FERC Project No. 10098.

the dam design so that they must include features that would increase water elevations during floods.

The proposed projects would remove land (amounts shown in Table 4.1.6-1) from its current uses and commit this land to energy generation.

The proposed projects would disrupt recreational fishing activities during construction. The construction period would span approximately three years. Even with adequate temporary fishing facilities at each project, the concurrent construction of multiple hydroelectric projects in the basin would likely create unavoidable cumulative adverse impacts to recreation.

Construction activities would generate noise, dust, and traffic that would interfere with current uses of nearby lands for projects located at Muskingum L&D No. 3, New Cumberland (6901), Montgomery (both competing applications), Emsworth, Allegheny L&D No. 2, Allegheny L&D No. 7, and Tygart.

Construction traffic at some projects would use local, secondary roads that were not designed to support the loads that would be involved in the delivery of construction equipment and the hauling of spoil material. Significant deterioration of the affected roadways could result. This impact is likely to occur for projects at Montgomery (both competing applications), Allegheny L&D No. 7, Maxwell, Point Marion, Hildebrand, Opekiska, and Tygart.

There is an increased risk of flooding during the construction period upstream of all projects except Tygart, and the probability of long-term increases in flood elevations upstream of Gallipolis (both competing applications), Belleville, Willow Island (9999), New Cumberland (10332), Montgomery (both competing applications), Dashields, Emsworth, Allegheny L&D No. 3, Allegheny L&D No. 4, Allegheny L&D No. 7, Point Marion, and Hildebrand. Increased flood elevations would increase the adverse social and economic impacts of flooding and would decrease the suitability of affected lands to support most uses.

4.9 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The finished powerhouses would have a permanent effect on flood elevations. Increased flood elevations caused by the proposed projects would make the land areas affected unsuitable for many developed uses. Lands occupied by project facilities would be irretrievably lost to their current uses and committed to the use of energy production. River bottom habitats for aquatic life that are covered by powerhouses would be lost irretrievably.

Development of the proposed projects would replace a section of shoreline at dam abutments often used by anglers with the powerhouse facilities and would therefore be permanently unavailable. Riparian habitat that would be replaced by project facilities would be irretrievably lost. Habitat lost during construction would be reversible with time, given application of proper reclamation techniques. Habitat lost or changes in species composition due to operational pool elevation changes would persist for the life of the projects. Should projects be built at Allegheny L&D No. 7, Montgomery L&D, and Muskingum L&D No. 3, irretrievable and significant loss of wetlands could occur.

4.10 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Power generation at the proposed projects is a long-term use of the rivers' resources, even though the projects would not operate every day of the year. The recommended alternative has been designed to avoid major long-term decreases in biological productivity of the system. The recommended mitigation measures should prevent major decreases in the system's productivity for navigation.

If projects were to operate solely to maximize hydroelectric generation, there would be a loss of long-term productivity of river fisheries due to decreases in river aeration and habitat loss. With the alternative recommended and appropriate mitigation at each site, there should be little, if any, long-term loss in productivity of aquatic life.

5. STAFF CONCLUSIONS

This section contains staff's conclusions regarding the impacts of developing hydropower projects proposed at 19 sites located at existing dams on the Ohio, Allegheny, Monongahela, Muskingum, and Tygart Rivers. Staff has determined that the proposed hydroelectric projects would be useful in displacing fossil-fueled generation, as discussed in Section 1.2. The projects would conserve nonrenewable fossil fuels and reduce the emission of noxious byproducts caused by the combustion of fossil fuels. Section 5 also summarizes the staff's evaluation of significant environmental impacts, identifies appropriate mitigative measures to avoid or minimize these impacts, and presents staff's recommendations. Four major alternatives that produce hydroelectricity have been evaluated (Section 2.1):

(1) Projects constructed and operated as proposed by developers in their license applications (Section 2.1.1). Mitigative measures, including spill flows and recreation facilities, are those proposed by applicants following consultation with resource agencies. Needs for additional mitigation are identified by staff.

(2) Projects constructed and operated to meet dissolved oxygen (DO) standards (5.0 mg/L) that have been established by the states (Section 2.1.2). This alternative considers impacts of the projects as proposed, except that spill flows sufficient to maintain state DO standards are included.

(3) Projects constructed and operated to avoid degradation of water quality (Section 2.1.3). This alternative considers impacts of the projects as proposed, except that spill flows sufficient to maintain DO concentrations of 6.5 mg/L, which would minimize water-quality-related impacts of hydropower on fish populations, are included. The required spill flows optimize power generation in the basin while maintaining DO concentrations of 6.5 mg/L wherever possible.

(4) Projects selected to minimize impacts to all target resources (Section 2.1.4). This alternative provides the same level of water quality protection as Alternative 3, but in addition, it protects other target resources by avoiding the significant adverse impacts to wetlands, fisheries, and recreation. This alternative considers the impacts of 16 of the proposed projects, which could be developed without causing significant adverse impacts. Spill flows that optimize power generation in the basin while maintaining DO concentrations of 6.5 mg/L are included in this alternative.

In addition to these hydropower generating alternatives, nonhydroelectric generation, nongeneration, and the no-action alternatives have been evaluated. Each of these alternatives is briefly defined in the following sections and the significant environmental impacts are summarized (Section 5.1). An economic evaluation of the alternatives is presented in Section 5.2. The major alternatives are compared in Section 5.3, followed by the staff's recommended action in Section 5.4. Additional details and the basis for the impact assessment summarized in this section are contained in Section 4 and the appendices.

5.1 SIGNIFICANT ENVIRONMENTAL IMPACTS

The summary and discussions in this section are limited primarily to the significant environmental impacts to target resources identified during the scoping process for this EIS. The target resources related to hydroelectric development in the upper Ohio River Basin are water quality, fisheries, recreation, wetlands, and river navigation. This analysis is based on the assumption that mechanical aeration is an unproven technology and therefore cannot be relied on at this time for project design and operation decisions. The Commission will reconsider the use of mechanical aeration techniques, when and if project developers can demonstrate their effectiveness. Impacts to other resources of lesser significance are discussed in detail in Section 4. Where appropriate, both positive and negative impacts are identified. Positive impacts are primarily related to enhancement of recreation resources and to socioeconomics during the construction period.

5.1.1 Alternative 1 - Projects as Proposed

The first hydroelectric alternative consists of projects developed at 19 of the sites with one or more pending license applications. The project design and operation would be as proposed by the applicants in the most recent revision to their license applications. Individual descriptions of the projects as proposed are presented in Section 2.1.1.

The spill flows analyzed in this alternative (Table 2.1.1-3) are the flows proposed in the license applications. Mechanical aeration is not included as mitigation in this alternative because it has not been proven feasible at low-head navigation dams retrofitted with bulb-type turbines (Section 4.1.1.1).

The project-specific environmental impacts of the first alternative are summarized in relative impact values for environmental resources, including the target resources (Table 5.1.1-1).

5.1.1.1 Water Quality

Under existing conditions in the upper Ohio River Basin, DO concentrations that would be low enough to harm aquatic life (Section 4.1.2) or violate state water quality standards occur generally during July through October when river flows are low and water temperatures are high. Low DO concentrations commonly occur in the Hildebrand and Opekiska pools of the Monongahela River, and below river mile (RM) 200 on the Ohio River. DO concentrations on the Allegheny River are expected to be lowered significantly by the hydropower projects already licensed on that river (i.e., Allegheny L&D Nos. 5, 6, 8, and 9) due to the interim spill flows required at the sites. In general, however, the upper Ohio River ecosystem is benefitting from higher DO concentrations than were present a decade ago, primarily because of the reduction of industrial discharges and the use of water pollution control measures (Section 3.1.4.1).

Cumulative impacts of the proposed projects on DO concentrations were predicted by using a water quality model of the study rivers. Field measurements of aeration at each navigation dam were used to make statistical models that predict how hydropower would change the amount of DO added to the river at the dams. These models of dam aeration were incorporated in a DO model that uses traditional equations to simulate DO consumption by biological respiration and aeration at the water surface (Section 4.1.1.1 and Appendix B). The model was calibrated to field measurements made by the Corps in 1983 when DO concentrations were low. The sensitivity and undertainty analyses (Appendix B) and the reviews of the models by the Corps and ORSANCO indicate that the models are appropriate for evaluating the impacts of changes in dam aeration caused by hydropower development.

The DO model indicates that, if licensed as proposed, many of the hydropower projects would contribute to significant cumulative decreases in DO concentrations, with decreases of 1 to 2 mg/L occurring in parts of each of the Allegheny, Monongahela, Muskingum, and Ohio rivers. These changes would occur in approximately 330 miles of river and over a wide range of river flow and water temperature conditions. The proposed projects would cause violations of state DO standards in the first 50 miles of the Ohio River below Pittsburgh when river flows are less than about 9,000 cubic feet per second (cfs) and water temperatures are high. These changes would be caused by the project-induced reductions in spill flow (flow through gates or over fixed crests) at dams that are currently efficient aerators and especially by projects at dams such as those below Pittsburgh where municipal and industrial wastewater loads (which depress DO concentrations) are high. Projects at dams that are not effective aerators would not be expected to cause significant changes in DO concentrations (Section 4.1.1.1). The major reductions in DO caused by Alternative 1 could affect wastewater dischargers in the basin by requiring them to provide additional waste treatment at higher cost to maintain existing water quality standards. The reductions in DO concentrations would also have significant adverse effects on fisheries and recreation.

Most of the applicants for the projects propose to include provisions for mechanical aeration systems, which would replace some of the aeration currently provided by the dams. Mechanical aeration, if proven technically and economically feasible, may offer the ability to generate under conditions when hydropower would otherwise cause unacceptable degradation of DO concentrations. However, because the feasibility of mechanical aeration has not been proven

Table 5.1.1-1. Relative adverse impact values for project-specific effects under Alternative 1.

	Resource affected 1/						
Project (FERC No.)	DO	FM	FH	WH	R	LU	SE
PROJECT-SPECIFIC IMPACTS				Relative impact value 2/			
Allegheny L&D No. 7	1	2	3	3	3	2	2
Allegheny L&D No. 4	3	2	2	0	1	1	1
Allegheny L&D No. 3	3	2	3	2	2	1	1
Allegheny L&D No. 2	3	2	2	1	1	1	0
Tygart Dam 3/	1	1	1	0	1	2	1
Opekiska	0	2	1	0	1	0	1
Hildebrand	3	2	1	0	1	1	2
Point Marion	3	2	1	0	1	1	2
Maxwell	2	2	1	0	1	0	1
Monongahela L&D No. 4	2	2	1	0	1	0	0
Emsworth	3	2	1	0	1	2	1
Dashields	3	2	1	0	1	1	1
Montgomery 3/	3	3	2	2	2	2	2
New Cumberland 3/	3	2	1	0	1	2	0
Pike Island	3	2	1	0	2	0	0
Willow Island 3/	1	2	1	0	1	1	0
Belleville	1	2	1	0	1	2	1
Gallipolis 3/	1	2	1	0	1	0	1
Muskingum L&D No. 3	2	2	3	3	3	1	1
RELATIVE ADVERSE IMPACT				Number of projects			
No impacts	1	0	0	14	0	5	5
Minor impacts	5	1	13	1	14	8	10
Moderate impacts	3	17	3	2	3	6	4
Major impacts	10	1	3	2	2	0	0

1/ Resource definitions are as follows:
DO = Dissolved oxygen, FM = Fish mortality in turbines,
FH = Fish habitat, WH = Wetland habitat
R = Recreation, LU = Land use
SE = Socioeconomics.

2/ Interpretation of relative impact values is as follows:
0 = No major concerns,
1 = Minor impacts,
2 = Moderate impacts, and
3 = Major, unavoidable impacts.
Recreational benefits associated with the development of applicants' proposed recreational facilities are not included in the impact values reported in this table.

3/ The staff has compared the competing projects at these sites and concludes there are no significant differences in relative impact values.

(Section 4.1.1.1), it cannot be assumed to be adequate to fully mitigate the loss of aeration provided by spill flows at the dams.

The proposed projects may reduce the rates at which some toxic compounds are removed from the rivers via volatilization, though the amounts of such reductions and their importance to overall concentrations of toxic compounds are uncertain (Section 4.1.1.2). The greatest reductions in the removal of volatile compounds would be expected at the dams where project impacts on DO concentrations would be the greatest. Although concentrations of volatile compounds are relatively low in the Ohio River Basin, any increase in concentration would be of concern because of the high toxicity of some of these compounds.

5.1.1.2 Aquatic Ecology and Fisheries

The existing environment of the upper Ohio, lower Monongahela, and lower Allegheny rivers is characteristically a stairstep of pools with low gradients and slow water velocity interspersed with short stretches of swift-water habitat immediately downstream of dams. The predominant habitat for fish is channelized deep water, where species such as gizzard shad, freshwater drum, and emerald shiner (important to the food chain) predominate, but also bottom-dwelling and open-water game species such as channel catfish, walleye, sauger, white bass, and striped bass are found.

Backwaters of islands and the small tributaries provide important habitats for quiet-water game fish species such as largemouth bass, sunfishes, spotted bass, northern pike, and muskellunge. The swift, rocky dam tailwaters are especially important for smallmouth bass, spawning of sauger and walleye, and maintenance of the life cycles of several nongame fish species; the most important sport fishing activity is in the tailwaters of dams. The fish and freshwater mussel (clam) community is improving in species and numbers following decades of pollution. Several rare and endangered mussels are found in the area, notably in the dam tailwaters.

Hydroelectric development as proposed at the series of navigation dams would have significant adverse effects of a cumulative nature on aquatic ecology and fisheries through (1) lowering concentrations of DO to levels that are detrimental to organisms (Sections 4.1.1.1 and 4.1.2.1), (2) reducing the area of the swift-water habitats below dams that supports smallmouth bass, nongame species, and spawning of sauger and walleye (Section 4.1.2.2), and (3) causing death or injury to fishes that pass through the turbines (Section 4.1.2.3). In addition, the federally endangered pink mucket pearly mussel and other rare mussels may be affected by hydropower construction and operation at certain dam tailwaters (Sections 3.1.6, 4.1.2.2, and Appendix I).

<u>Effects of Lowered Dissolved Oxygen</u>

Dissolved oxygen in water is necessary to sustain living aquatic resources (Section 4.1.2.1). DO concentrations would be reduced by the proposed hydropower developments to levels damaging to aquatic life (using biological effects criteria published by U.S.EPA, 1986), although at one project (Opekiska) on the Monongahela River DO concentrations would be more suitable for aquatic life. Acutely lethal DO concentrations for early life stages of fishes are estimated to be reached for about 10 miles below Dashields L&D and for a shorter distance below Belleville L&D when water temperatures and river flows match the 7Q10 low-flow condition in summer (using DO concentrations estimated in Section 4.1.1 for cumulative effects on riverine DO and staff conclusions regarding effectiveness of mechanical aeration). Under these low-flow conditions, the Allegheny River below L&D No. 4 would experience DO concentrations that would slightly impair growth of early life stages of fish. These low DO concentrations would result in significant, adverse effects on aquatic life.

Under more typical, moderate low flows of summer, the projects as proposed would cause less severe DO conditions for fish (slightly impair growth), but over at least 275 miles of the river system. These lengths amount to 50 miles in the Monongahela River in addition to those with low DO under current conditions, 25 additional miles in the Allegheny River, and the entire 200-mile stretch of the Ohio River from Pittsburgh to Belleville L&D. Below Belleville L&D there may be additional declines of already depressed growth as far downstream as this study extended into the Greenup L&D pool (320 miles). Using monthly average DO concentrations through the summer, staff determined that hydropower development would induce earlier suppression of growth (beginning in June) and would extend the period of growth reduction later in the year, compared with normal summer low DO concentrations. These results are also considered by staff to be significant and adverse.

Staff used a computer model of fish growth to estimate the amount of annual growth lost due to hydropower development as proposed. The model incorporated effects of seasonally changing temperature; fish size; ammonia concentration; and DO concentration, with and without hydropower, as predicted by the DO model for the April through November growing season. The model simulated growth of channel catfish and a representative coolwater fish (sauger or walleye), both sensitive to lowered DO, in the tailwater and pool sections at each dam (using

DO estimates for before and after hydropower development as discussed above and in Section 4.1.1). The model results were calibrated for channel catfish growth parameters in its original pool application but remain uncalibrated for the coolwater fish (growth parameters for this generic fish were estimated from values in the literature for several species). The model is most valuable as an indication of trends, rather than absolute values.

Under summer moderate low-flow conditions, when all projects would be operating, channel catfish annual growth is estimated to be reduced 4 to 9 percent in the low-oxygen zone of the upper Monongahela River, 2 percent in the lower Allegheny River, 15 to 20 percent in the 60-mile reach of the Ohio River between New Cumberland L&D and Pike Island L&D, and greater than 10 percent in much of the rest of the Ohio River.

For the coolwater fish, these estimated reductions in annual growth are more severe, amounting to 25 percent in the Monongahela River, 33 percent in the Allegheny River, and as much as 36 percent in the Ohio River, with fish in much of the Ohio River showing growth reduction of 15 to 20 percent. Staff considers these estimated annual growth reductions from lowered DO to represent impacts that are detrimental to the production of sport fishes in the study area.

Tailwater Habitat Losses

Aquatic habitat is one of the most important resource concerns for fisheries in the study area (Section 4.1.2.2). There would be a general reduction in valuable tailwater habitat in the river system with hydroelectric development as proposed. In general, about one-half of the normal low-flow, swift-water habitat below a dam would be lost at any one time when hydropower units are operating and there is little, if any, spill flow. The loss would be in the zone extending about one dam-width downstream from fixed-crest dams and somewhat less from dams with gated spillways (because of the way gates are now operated).

Shifting of flows between spillways and turbines because of seasonal changes in river flows and plant outages for repairs would make the tailwater environment a less consistent and stable habitat for fish and other aquatic life. There should be little (if any) loss of spawning habitat for game fish in tailwaters, because spawning occurs in spring when river flows are high and water would spill normally. Although there would be some negative changes to fish habitat at summer low flows, recreational developments proposed at most sites would generally improve access by fisherman to good fish habitat (Section 4.1.3). At most projects, impacts would be reduced by spill flows required for maintaining DO and additional habitat improvements for recreational fishing in turbine discharge areas (Section 4.1.3).

Staff has determined that construction and operation of three of the proposed projects would result in significant adverse impacts to the regional resource of shallow, tailwater, aquatic habitats and that at this time there are no adequate means for mitigating these impacts at two of them. At Allegheny L&D Nos. 3 and 7 and Muskingum L&D No. 3, habitats rich in islands and gravelly,.shallow water habitat (riffles and runs) would be severely impacted by diverting flows during hydropower operation at these sites to an extensively dredged turbine discharge (Section 4.1.2.2.3). This diversion would dewater portions of the habitat at summer low flows and reduce flow velocities in other parts of the riffles.

Directly in line with the powerhouse discharge at Allegheny L&D No. 7 is a small island and surrounding 14-acre shallow-water habitat. This habitat would be substantially removed during project construction and would be further eroded following dredging of a channel; no alternative orientation of the turbine discharge seems capable of avoiding significant, adverse habitat loss. At Allegheny L&D No. 3, a channel would be dredged through a 500-ft-wide, shallow riffle on the backchannel side of a 2-mile-long chain of downstream islands. The dredging and reorientation of most river flow to the narrow backchannel during a large part of the year is expected to significantly change the flow directions and velocities in much of the 2-mile-long river reach and erode the islands and surrounding shallow-water habitat. However, staff believes this impact could be mitigated with construction of new habitat downstream. The proposed project at Muskingum L&D No. 3 would divert tailwater river flows in much of a mile-long shallow rapids interspersed with several small islands in the river downstream from the dam. High-velocity turbine discharge would occur in a dredged channel on the river's right side. The existing shallow dam tailwater to be affected may provide habitat for the federally endangered pink mucket pearly mussel (*Lampsilis abrupta*) and 10 of the 17 mussels listed as endangered by the state of Ohio (Appendix I).

Turbine-Induced Fish Mortality

Losses of some fish can be expected because they would be entrained in the water that passes through the turbines (Section 4.1.2.3). Pressure changes, shear stresses, and direct impacts by the rotating blades cause injury, with greater damage to the larger fish. Damages would be primarily of local importance, although there could be cumulative impacts on fish that make long movements (e.g., striped bass and its hybrids, walleye, and American eel). Because all applicants propose nearly identical turbine-generator units except for size and minor details, site-specific differences relate mostly to local influences on susceptibility of species to being entrained.

Vulnerability to entrainment is greatest for early life stages (larvae and juveniles) of those species, principally gizzard shad and freshwater drum, which occupy the open-water habitat in the low-flow periods of summer, as determined by two years of monitoring at the licensed and operating Racine project (FERC No. 2570) in the lower study area. One-half to two-thirds of individuals of these species in the pool above the dam may pass through the turbines, on the basis of water volumes alone. Game species are not particularly vulnerable relative to shad and drum. Considering study difficulties at Racine, no reliable, quantitative estimate of passage rates for L&D sites on the upper Ohio River system is currently available. At Tygart Dam (a Corps storage reservoir), spill flows to purposely flush juvenile walleye from the lake to downriver locations are expected to continue based on existing agreements between the Corps and the WVDNR.

For young gizzard shad and freshwater drum entrained, the staff estimates an upper mortality rate of 0 to 10 percent provisionally from the Racine studies, including both immediate and latent effects. Mortalities of larger fishes, including the game fish of most direct interest, could be closer to 10 percent of those entrained (applying the higher estimate from Racine because of the higher expected mortalities to bigger fish). Demonstrable damages are not anticipated to planktonic early life stages of fish, including game species.

Currently, the impacts to the river ecosystem from these losses are unquantifiable. Both gizzard shad and freshwater drum are prolific spawners and serve the remainder of the fish community (especially game fishes) as food. Staff believes their high reproductive potential makes it unlikely that losses from turbine damages would impair their populations. Serious questions remain about population effects on larger game fishes and on harvestable numbers of species that are currently stocked (e.g., striped bass). Moderate numbers of killed or injured fish undoubtedly would contribute to predation by game fish in tailwaters and thus to sustaining the highly productive predator populations there.

Staff concurs with the federal and state fish and game agencies that unresolved questions of entrainment rates and fish damages would be moot if effective fish diversion devices were installed and operated at turbine intakes. Most applicants have proposed to study entrainment effects and to develop appropriate mitigative measures. However, staff review of recent analyses of the technology (Section 4.1.2.3) suggests that there is no device that has been well-enough designed, tested, and evaluated to ensure its effectiveness for large river conditions similar to the Ohio River Basin and the warmwater fish assemblage found there. Installation of unproven fish protection devices at the proposed projects at this time is not warranted, but a joint, basin-wide effort to design and test prototypes for fish guidance and protection is needed. This objective could be accomplished by designating a bioengineering test facility at one (or a few) of the projects.

Staff believes that the vulnerability of gamefishes to entrainment during hydropower operation at the Montgomery L&D site on the Ohio River is sufficiently high and would, therefore, result in adverse impacts on resident fish populations. A major embayment that is of special importance for fish spawning and rearing in the Montgomery pool lies immediately upstream of the proposed turbine intake. Fish entering and leaving the embayment would likely be swept into the turbine intake and would be injured or killed. With current understanding of the importance of the embayment for fish populations, of turbine-induced mortality in general, and of current mitigation options, staff believes that the significant adverse impacts are probable at this site.

Cumulative Effects on Fish

There would be positive impacts on recreational fishing opportunities from hydroelectric development (Section 5.1.1.3 below), but the cumulative impacts of all sources of fish losses would likely be negative for fish populations if the projects are built and operated as proposed. This evaluation assumes that staff conclusions about the ineffectiveness of mechanical aeration and residual impacts of entrainment are valid. Available data preclude quantitative modeling of cumulative impacts on fish populations; however, the results of several sources of fish loss are generally additive. These sources include (1) reducing fish growth rate (and thus reproductive potential) through lowering of DO concentrations, (2) reducing fish habitat in dam tailwaters, (3) killing some fish during entrainment, and (4) increasing fish mortality by additional harvesting by anglers through enhanced recreational access. Increased recreational fish catches at the projects could be sustained only if they were coupled with protection and enhancement of water and habitat quality and reduction in sources of fish mortality other than angling. Mitigation beyond that proposed by the applicants would be necessary to achieve such an objective.

5.1.1.3 Recreation

Recent improvements in the water quality of the Ohio River Basin have significantly increased the opportunities for water-based recreation in the region. Fish management and water quality improvement efforts have brought about the return of a popular sport fishery resource. Better recreational access is needed, however, at the tailwaters of the locks and dams where fishing pressure (per unit area) as well as the number of fish caught and kept is greatest in the basin.

Although the number of recreational fishing area users would be likely to increase greatly with the development of the applicants' proposed recreational enhancement facilities, cumulative adverse impacts to the existing quality of recreational fishing in the basin would result from impacts to fish resources under Alternative 1, projects as proposed (Section 4.1.2). Decreases in DO levels from hydroelectric generation during periods of low summer flows would cause significant changes in annual fish growth in the Ohio River. The most severe losses in annual growth from hydroelectric generation would occur in the reach between the New Cumberland L&D tailwater and the Pike Island L&D tailwater, where up to a 20 percent loss in annual (catfish) growth would occur. A 20 percent loss in fish growth would have significant impacts to recreational fishing, because this would correspond to a reduction in the size of fish caught in this reach of the Ohio River. This loss would occur in the Pike Island pool, which received the largest number of angler trips (73,802) of all the pools surveyed in the WVDNR recreational use survey (WVDNR, 1983).

Impacts to recreational fishing in tailwater areas would also be of concern at the New Cumberland L&D and Pike Island L&D sites. The New Cumberland L&D tailwater had the highest average number of fish caught (2.6) and kept (1.6) per angler trip of all the tailwaters surveyed by the WVDNR (WVDNR, 1983). The Pike Island L&D tailwater received more fishing pressure (24,690 hours during the survey period) than any other tailwater.

A reduction in annual (catfish) growth and in the size of fish caught downstream of Belleville L&D in the Racine pool would occur under this alternative. These changes downstream of the Belleville L&D would have less impact to recreational fishing because the Racine pool received the least amount of fishing activity of all the pools surveyed by the WVDNR (WVDNR, 1983). There would not be significant impacts to fish growth and the size of fish caught along the other rivers in the study area under Alternative 1. Changes of 4-9 percent in annual (catfish) growth and size of fish caught on the Monongahela River would occur only in the Hildebrand pool and tailwater. A maximum loss of 2 percent would occur on the lower Allegheny River. There would be more severe changes in fish growth for sauger and walleye along the lower Allegheny River, downstream of Hildebrand L&D, and along the Ohio River (Section 4.1.2). Therefore, the reduction in the size of sauger and walleye caught by anglers along these reaches would likely be more severe than the reduction in the size of catfish caught.

Moderate to major changes in fish habitat quality under this alternative would occur on all of the sites on the Allegheny River and at Muskingum L&D No. 3 (Section 4.1.2). The most significant adverse changes to fish habitat and recreational fishing due to hydropower construction and operation would occur at Muskingum River L&D No. 3 and Allegheny River L&D Nos. 3 and 7. Impacts are related to the presence of islands located immediately downstream of these proposed project sites. The impact on fish habitat at Allegheny L&D No. 3 could be mitigated, however, with construction of new habitat downstream.

Impacts to recreational fishing from turbine-induced mortality are not expected to be unmitigable, except where there is an embayment immediately upstream of the proposed powerhouse, such as at the Montgomery L&D site.

Because construction activities may continue through three fishing seasons, recreational days of fishing at hydropower project sites could be greatly reduced unless properly mitigated. In addition, concurrent construction could result in further cumulative adverse impacts on recreational fishing in the basin. Mitigation to provide fishing access during construction in safe areas outside of the construction limits would reduce this impact to acceptable levels. In project areas with little area available for construction (e.g., Maxwell L&D), it may not be possible to provide access during construction due to limited land area. Impacts to recreational fishing during construction at these sites would need to be compensated in some manner beneficial to recreational fishing in the region. Compensation measures could include, for example, the provision of off-site recreational facilities or the upgrading of existing access facilities. Recreation plans to address these concerns would need to be developed accordingly.

In addition, a minimum level of recreational development is needed at each site. Recreational plans need to include fishing piers, multi-level grouted/paved walkways parallel to the shoreline, access to riverward coffers, fish attractant structures, parking, access paths, restrooms, a fish cleaning shelter, provisions for handicapped use, solid waste disposal, lighting to permit night fishing, drinking water, and informational signs. The new public fishing access facilities proposed by the applicants could increase the potential recreational fishing use in the basin. However, to realize the potential for increased fishing use associated with the development of recreational fishing facilities, hydraulic modeling studies, as normally required by the Corps prior to project construction, would be important in determining the appropriate alignment of the shoreline fishing access features in relation to the tailrace flows.

Recreational fishing would be jeopardized during periods when the powerplants are inoperative (e.g., during low river flows, maintenance work, or emergency situations), because the turbine tailrace currents which normally would attract fish to areas accessible by shoreline anglers would be curtailed. In order to protect shoreline fishing opportunities at developed recreation facilities during times when powerplants are inoperative, flow velocities would need to be maintained in the vicinity of the tailrace fishing areas.

Flow modifications during hydropower operation could impact boating access (ramp, dock, hoist, or mooring space available at a launching area) and recreational boating navigation close to the shoreline or at islands and embayments. A potential lowering of pool elevations by three feet (or less) upstream of hydroelectric projects at fixed-crest dams could occur during the low flow summer months (Section 4.1.4). Areas with high concentrations of boating users, such as the Allegheny L&D No. 2 pool, and areas with islands immediately downstream of the proposed powerhouses (Muskingum L&D 3, Allegheny L&D 3, Allegheny L&D 7 project sites) would be the most vulnerable to adverse impacts from flow modifications.

In summary, the new public fishing access facilities proposed by the applicants could greatly increase the potential fishing use in the basin. In order for the quality of recreational fishing to be ensured, however, potential project-induced impacts to sport fishing resources (resulting from impacts to water quality and fish habitat) and to recreational users would need to be mitigated.

5.1.1.4 Wetlands

Adverse impacts to wetlands, including riparian zones, will occur from both construction and operation of the projects. Staff estimates a total net loss of wetlands at all projects to be approximately 7 acres (Section 4.1.4). This includes 3.5 acres in wetlands in and around islands and 3.7 acres of riparian vegetation. The loss of riparian vegetation is based on damage during construction that would average approximately 0.2 acres for each of the 19 project sites. The largest area of riparian vegetation that would be affected by the construction of the proposed projects would be at the Muskingum L&D No. 3 site.

The Isle of White, a 2-acre recreational island refuge, lies downstream of the Allegheny L&D No. 7. This island is in the direct path of the tailrace channel of the proposed hydropower plant. Construction and operation activities would seriously affect the wetlands and shoals associated with the island. Channel maintenance and other dredging activities would increase sedimentation, turbidity, and erosion on and around the island. Staff considers it likely that all or a major portion of the vegetation on and around the island would sustain major adverse impacts.

Operation of the project would entail further adverse impacts to the vegetation associated with the Isle of White. The tailrace channel would discharge water just below the upper tip of the island, causing additional losses through erosion of the island. Over time, it is likely that the island would disappear.

Changes in flow rates and flow patterns caused by proposed project operations would alter existing flow regimes and would be likely to alter the survival and establishment of some wetland species. An increase in mudflats and exposed areas could be expected. Increased flows in the tailrace channel would tend to erode the island and destroy vegetation associated with the shallow depths and low flows. The net potential loss of 2 acres of wetland area at the Allegheny L&D No. 7 proposed project site would represent a 7.4 percent decrease in the wetlands area of this pool, which contains about 36 percent of the wetlands areas in the Allegheny River portion of the study area. This loss in wetlands resources on the Allegheny River would be significant.

At the Allegheny L&D No. 3, construction of facilities would disturb or remove approximately 0.5 acre of wetlands areas from the islands and shoreline in the project vicinity (Section 4.1.4.1). Loss of this acreage would result in about a 10 percent decrease in wetlands area in the Allegheny L&D No. 3 pool. The applicant has proposed using crest gates to maintain pool elevation at existing levels and, therefore, minimize impacts on wetlands. The Corps has expressed concerns on the use of crest gates but have indicated a willingness to consider their use at this site. This analysis assumes that crest gates are used. Should approval for their use be given, the potential for increasing wetland areas (primarily emergent vegetation and rooted aquatics) during periods of extremely low flow conditions may exist.

The embayment associated with the Montgomery L&D project consists of approximately 17 acres of wetland habitat and serves as a nursery for fish and a feeding and resting place for migratory waterfowl and transient raptors. The embayment is a unique area on the Ohio River and has been classified as a Resource Category 1 (habitat that is of high value to important fish and wildlife resources that have high ecological significance or public interest and is unique and irreplaceable) for habitat protection by the USFWS. The Pennsylvania Western Conservancy has designated the embayment as a "Special Habitat" area for protection because the embayment contains what may be the last remaining silver maple/American sycamore stand in the Pennsylvania reach of the Ohio River valley.

This embayment also contains the only significant wetland area in the Montgomery L&D pool. Although a porous dike has been proposed by one of the competing applicants as a protective measure, staff considers it likely that construction of the dike itself would have adverse impacts on the embayment, increasing turbidity and sedimentation and possibly changing flow patterns around the embayment. Changes in emergent and submergent vegetation would be expected with changes in flow patterns and velocities. Due to the proximity of the embayment to the project site (approximately 500 feet upstream), significant adverse impacts would be expected from any construction and operation of a hydropower facility at this site.

Staff considers a net loss of 1 acre of wetlands at this site to be significant and irreplaceable because of the uniqueness and scarcity of the resources on the Ohio River. It is not unreasonable to expect that a 1-acre loss of wetlands area would be a low estimate if the project is constructed. In the context of the regional rarity of the wetlands resource and, in particular, the recognized importance of the embayment, staff considers the risk of loss or damage to the wetlands in this embayment to be unacceptable.

Construction of hydropower facilities at the Muskingum L&D No. 3 would not directly remove wetlands associated with the islands located immediately downstream of the dam. It is estimated that about one acre of vegetation on the riverbank across from the large island would be destroyed by construction of the tailrace channel. An increase in turbidity, erosion, and sedimentation associated with dredging and excavation activities would, however, contribute to impacts on the wetlands. The applicant has proposed to use protection measures (hay bales) to protect the large island from adverse impacts during construction. Even with this protective measure, the increased sedimentation and turbidity could affect the wetland vegetation on the edges of the island.

When operating at full capacity, the Muskingum L&D No. 3 project would produce flow velocities on the order of 3 to 10 times greater (5 feet/second compared with 0.5 to 1.5 feet/second) than under current conditions in the backchannel between the large island and the shore. Thus, the island would be subjected to greatly increased erosive pressures. The proposal by the applicant to use riprap to stabilize the banks of the river would result in the permanent loss of riparian vegetation, both upstream and downstream of the project site.

5.1.1.5 River Navigation and Hydraulics

A hydropower plant with a poorly designed intake or discharge could cause highly nonuniform flows and large eddies above and below a navigation dam. These nonuniform flows can make lockage slow and unsafe because the currents can push barges in directions the pilot is not expecting. Project-induced navigation hazards at several dams, or at even one dam with a high volume of barge traffic, could slow river traffic through much of the system. Careful hydraulic design of the projects should eliminate the potential for such impacts (Section 4.1.5.1).

The proposed projects at fixed-crest dams (Allegheny L&D Nos. 2, 3, 4, and 7; and Dashields) would decrease the upstream pool elevation when operating (Section 4.1.5.2). These reductions in pool elevation would cause increases in river velocities of up to 40 percent and could affect other resources such as wetlands, fish habitat, and recreation. These effects can be mitigated with the installation of flashboards or with higher spill flows.

Some of the proposed hydropower projects would decrease the ability of the existing navigation dams to pass flood flows, thereby increasing the elevation of flood waters above the dam. The amount of additional flooding that projects would cause depends on how the they are constructed (Section 4.1.5.3). All of the proposed projects except those at Tygart Dam would require cofferdams in the channel during construction, which could further reduce the ability of dams to pass flood flows. The extent of project construction and operation effects on flood elevations would need to be determined prior to project construction. If needed, flood easements would be purchased by the developer.

Flow rates in the Allegheny and Ohio rivers can vary rapidly due to releases from peaking hydroelectric plants in the basin and due to manual control of navigation dam gates. The hydropower projects generally propose the use of automated control of flow through the turbines. Depending on its design, such automatic control could increase or decrease the existing problems with rapid fluctuations in river flows (Section 4.1.5.4). Proper design and calibration of flow controllers could result in reduced flow fluctuations, a potential benefit of the projects.

5.1.1.6 Other Resources

<u>Land Use</u>

The projects as proposed would have several significant adverse impacts on land use. During construction, activities at the project site would be incompatible with nearby land uses at Allegheny L&D No. 7 and Montgomery (both applications). Construction impacts at Allegheny L&D No. 7 would be of particular significance because the project abuts residential properties and proposes construction of an access route within a residential area. Additional adverse impacts on land use could be associated with the use of off-site construction areas at Allegheny L&D No. 7, Allegheny L&D No. 4, Allegheny L&D No. 3, Tygart (both applications), Opekiska, Hildebrand, Point Marion, Maxwell, Dashields, Montgomery (both applications), New Cumberland (both applications), Pike Island, Gallipolis (10098), and Muskingum L&D No. 3. An increased risk of flooding during the construction period could affect lands near the river upstream of all projects except Tygart.

The principal long-term impacts on land use would be associated with an increased potential for flooding upstream of projects at Allegheny L&D No. 7, Allegheny L&D No. 4, Allegheny L&D No. 3, Hildebrand, Point Marion, Emsworth, Dashields, Montgomery (both applications), New Cumberland (10332), Willow Island, Belleville, and Gallipolis (both applications). Lands affected by increased flood risk would be less suitable for most uses. In addition, the project proposed at Emsworth would take approximately 45 acres of industrial land for project use.

Endangered Species

The relatively rare, swift-water, rocky-bottom area downstream of Muskingum L&D No. 3 may provide habitat for the federally endangered pink mucket pearly mussel and other mussels on the endangered list of the state of Ohio (Section 5.1.1.2). This habitat is also required by several species of nongame fish that are not found in the quiet pools of the rivers in the upper Ohio River Basin. At that site, parts of a one-mile-long reach of shallow tailwater would be markedly changed by flows being shifted to a high-velocity discharge channel along one bank. Live specimens of the pink mucket pearly mussel have not been collected there recently, but relatively fresh shells indicate a living population; other species requiring similar habitat are found there alive. For protection of the habitat, the USFWS has recommended operation with a minimum spillway flow of 1520 cfs (20 percent of average annual flow) in July through March and 2280 cfs for April through June and maintenance of substrate, water velocity, and water quality.

The pink mucket pearly mussel is also found in the Ohio River downstream of the Gallipolis L&D (Section 4.1.2.2.3 and Appendix I). Live specimens have been found 13 miles below the dam, and the species is likely found in the dam tailwater, which has not been surveyed. The Belleville pool below Willow Island L&D contains many species of mussels, and the Belleville L&D tailwater may also harbor this endangered species.

The habitat required by endangered mussel species and other species of fish and invertebrates that need swift, shallow riffles and runs, is rare and dwindling. Alteration of the Muskingum L&D No. 3 tailwater, even with minimum flows over the spillway of 1520 or 2280 cfs (changing seasonally) as a mitigative measure, could result in a regionally significant impact to an important refuge.

Socioeconomics

The proposed projects would have both beneficial and adverse impacts during the construction period. The principal benefit would be increased local employment (ranging from about 22 to 255 employees per project) and the wages associated with that employment (ranging from approximately $1.5 million to $23.5 million per project). This additional employment and wages would provide a significant, albeit temporary, benefit to the currently depressed economy of the region.

Adverse impacts during the construction period include (1) the disturbance of nearby residential or recreational areas at Allegheny L&D No. 7, Tygart (both applications), Opekiska, Montgomery (both applications), and Muskingum L&D No. 3; (2) an increased risk of accidents and accelerated deterioration of secondary roads at Allegheny L&D No. 7, Tygart (both applications), Opekiska, Hildebrand, Point Marion, and Maxwell; and (3) social and economic effects of potentially increased flood elevations upstream of all projects except Tygart.

The proposed projects would have a long-term beneficial impact by increasing local governmental revenues during project operations. All profits from power generation would be realized as governmental revenues for the publicly owned projects at Allegheny L&D No. 4, Allegheny L&D No. 3, Allegheny L&D No. 2, Tygart (7307), Point Marion, Emsworth, Dashields, Montgomery (3490), New Cumberland (6901), Pike Island, Willow Island (both applications), and Belleville. All other projects are considered to be privately owned and would pay property taxes to the governmental jurisdictions in which they are located.

Long-term adverse impacts would include the potential for increased upstream flooding for projects at 12 of the sites (see Land Use discussion in this section). In addition, a major adverse impact would occur if the lowering of DO concentrations by the projects made it necessary for industrial and municipal wastewater dischargers to spend significant amounts of money to upgrade their wastewater treatment facilities.

5.1.2 Alternative 2 - Project Operation to Meet Dissolved Oxygen Standards

The second hydroelectric generating alternative is designed to ensure that the water quality standard for DO of 5 mg/L in the states of Pennsylvania, West Virginia, and Ohio will be met wherever and whenever possible (Section 2.1.2). This objective would be accomplished by increasing minimum spillage flows and requiring projects at six sites to terminate generation during critical periods of the year. The projects that would be subject to the no-generation rule would be Allegheny L&D No. 2, Emsworth, Dashields, Montgomery, New Cumberland, and Pike Island. When flows in the Ohio River fall below 9000 cfs during July through October at the U.S. Geological Survey (USGS) gauging station at Sewickley, Pennsylvania, projects at these six locations would be required to cease generation.

The project-specific environmental impacts of this second hydroelectric alternative are summarized in relative impact values for environmental resources, including target resources (Table 5.1.2-1). Although the major adverse impacts to water quality would be reduced when compared with Alternative 1, DO concentrations would still be lower than pre-project or existing conditions. Therefore, significant impacts to water quality would still occur. Significant adverse impacts are also predicted for fish and wetland habitat, as well as recreation resources.

5.1.2.1 Water Quality

The water quality impacts of Alternative 2 vary from those of Alternative 1 only because generation would be required to cease during low-flow conditions in the Ohio River in summer. Cessation of generation at Allegheny L&D No. 2 and the first five dams on the Ohio below Pittsburgh is predicted to provide sufficient aeration to avoid violations of the states' DO standard of 5 mg/L during most adverse conditions. During such low flows, the spill flows at these dams would produce DO conditions similar to those existing without hydropower in the Ohio River, but these low flows occur only less than 20 percent of the time. Under all other conditions the projects would operate with the spill flows proposed by the applicants, so the impacts of the projects would be the same as under Alternative 1.

Impacts of the projects on the concentrations of volatile compounds and on sediments are expected to be the same as under Alternative 1.

5.1.2.2 Aquatic Ecology and Fisheries

Spilling water at dams to maintain a minimum DO in the rivers corresponding to the state standards of 5.0 mg/L would reduce, but not eliminate, the adverse impacts on fish growth. Maintenance of 5.0 mg/L would still cause a significant, adverse impacts on fish populations in areas where existing concentrations are now much higher. Cessation of generation at six hydropower projects during the low-flow season of July through October (Table 2.1.2-1) would result in all river flows being spilled at these dams. This spillage would alleviate some loss of swift tailwater habitat at these sites but not materially affect impacts to the projects with the most severe impacts on tailwater habitats (Allegheny L&D Nos. 3 and 7, and Muskingum L&D No. 3). There would be no improvement of entrainment effects, except during critical periods when some projects would be shut down.

5.1.2.3 Recreation

Impacts to recreational fishing would be similar to those described for Alternative 1 except at those six sites where the hydroelectric plants would be inoperative during July through October (Table 2.1.2-1). Fishing success at these sites would be reduced as tailrace flows would be diverted away from the public fishing areas and spilled over the gates (or fixed-crests, in the case of Allegheny L&D No. 2 and Dashields L&D). This impact is significant because it would occur during a high-use recreation period. In order to guarantee shoreline fishing opportunities at developed recreation facilities during times when the plants are inoperative flow velocities would need to be maintained in the vicinity of the tailrace fishing areas (e.g., via selective gate openings and/or bypass flow tunnels through the powerhouse).

5.1.2.4 Other Resources

Significant impacts to other resources, including wetlands, river navigation and hydraulics, land use, and endangered and threatened species, are essentially similar to those

Table 5.1.2-1. Relative adverse impact values for project-specific effects under Alternative 2.

	Resource affected 1/						
Project (FERC No.)	DO	FM	FH	WH	R	LU	SE
PROJECT-SPECIFIC IMPACTS			Relative impact values 2/				
Allegheny L&D No. 7	1	2	3	3	3	2	2
Allegheny L&D No. 4	3	2	2	0	1	1	1
Allegheny L&D No. 3	3	2	3	2	2	1	1
Allegheny L&D No. 2	3	2	2	1	1	1	0
Tygart Dam 3/	1	1	1	0	1	2	1
Opekiska	0	2	1	0	1	0	1
Hildebrand	3	2	1	0	1	1	2
Point Marion	3	2	1	0	1	1	2
Maxwell	2	2	1	0	1	0	1
Monongahela L&D No. 4	2	2	1	0	1	0	0
Emsworth	2	2	1	0	1	2	1
Dashields	2	2	1	0	1	1	1
Montgomery 3/	2	3	2	2	2	2	2
New Cumberland 3/	2	2	1	0	1	2	0
Pike Island	2	2	1	0	2	0	0
Willow Island 3/	1	2	1	0	1	1	0
Belleville	1	2	1	0	1	2	1
Gallipolis 3/	1	2	1	0	1	0	1
Muskingum L&D No. 3	2	2	3	3	3	1	1
RELATIVE ADVERSE IMPACT			Number of projects				
No impacts	1	0	0	14	0	5	5
Minor impacts	5	1	13	1	14	8	10
Moderate impacts	8	17	3	2	3	6	4
Major impacts	5	1	3	2	2	0	0

1/ Resource definitions are as follows:
DO = Dissolved oxygen, FM = Fish mortality in turbines
FH = Fish habitat WH = Wetland habitat
R = Recreation LU = Land use
SE = Socioeconomics.

2/ Interpretation of relative impact values is as follows:
0 = No major concerns,
1 = Minor impacts,
2 = Moderate impacts, and
3 = Major, unavoidable impacts.
Recreational benefits associated with the development of applicants' proposed recreational facilities are not included in the impact values reported in this table.

3/ The staff has compared the competing projects at these sites and concludes there are no significant differences in relative impact values.

described for Alternative 1. The socioeconomic impacts would be essentially the same, but some reduction in revenues to local governments from the projects would likely occur in comparison with Alternative 1.

5.1.3 Alternative 3 - Project Operation to Meet Antidegradation Criterion

The third hydroelectric alternative is designed to meet more conservative water quality criterion than the states' current DO standards of 5.0 mg/L. The objective of this alternative is to maintain water quality and DO concentrations at 6.5 mg/L where possible to ensure that hydroelectric development will not adversely affect the fishery resources. Staff's interpretation of the antidegradation criterion is presented in detail in Section 2.1.3. This alternative responds directly to comments received during the scoping process to the effect that hydropower projects must maintain existing DO concentrations downstream from the project dams. As with Alternative 2, impacts to DO concentrations would be avoided by increasing the spill flow requirements at specific hydropower sites (Table 2.1.3-1).

The project-specific environmental impacts of the third hydroelectric alternative are summarized in relative adverse impact values for environmental resources, including target resource (Table 5.1.3-1). With the exception of the Muskingum L&D No. 3 project, all water quality impacts would be reduced to a minor level. The moderate impacts that would remain under this alternative are related to fish mortality in turbines, fish habitat at 2 sites, and land use and socioeconomic issues related to construction. The major significant impacts that are predicted under this alternative would be at sites where important aquatic and wetland habitat exist. These major impacts would occur at Allegheny L&D No. 7, Montgomery L&D, and at Muskingum L&D No. 3.

5.1.3.1 Water Quality

Staff's analyses (Section 4.3.1.1) show that hydroelectric generation with the spill flows required under Alternative 3 would prevent degradation of DO to concentrations less than 6.5 mg/L, which could be harmful to aquatic organisms in all parts of the river where 6.5 mg/L is presently maintained. DO concentrations would go below 6.5 mg/L under this alternative, but only at locations and conditions where they would be less than 6.5 mg/L under existing conditions without the proposed hydropower development. Under Alternative 3, hydropower plants would be expected to cause no changes in DO concentrations that would significantly affect fish resources.

The spill flows required under Alternatives 3 and 4 were determined by using an optimization model that determines the spill flows at each dam that maximize basin-wide power generation while maintaining DO concentrations above 6.5 mg/L (the optimization model is described in Appendix B). The results of the optimization model were verified by checking them with the basin water quality model over a wide range of river flows (Section 5.1.1.1).

The expected impacts of the projects on concentrations of volatile compounds would be reduced under Alternative 3 by the higher spill flows during the July through October critical season. The exception to this would be at Allegheny L&D No. 7, where no additional spill flow would be required.

5.1.3.2 Aquatic Ecology and Fisheries

Spill flows at the proposed project dams would allow for the maintenance of DO concentrations at 6.5 mg/L. Maintenance of DO at this level would not cause impairment to fish growth and would, therefore, provide protection to fish resources. The higher spill flows would also provide substantial alleviation of tailwater habitat impacts at most projects, although not at those with significant downstream channelization of shallow-water habitat (Allegheny L&D Nos. 7 and 3 and Muskingum L&D 3). There would be a reduction of entrainment effects under this alternative because more water would be spilled over the dams or through the gates due to the higher spill flow requirements. Consequently, less water would be diverted through the turbines.

5.1.3.3 Recreation

Impacts to recreational fishing under Alternative 3 would occur at those sites where hydroelectric plants would most likely be inoperative more frequently during July through October. Fishing success at the proposed fishing facilities at these sites would be reduced

Table 5.1.3-1. Relative adverse impact values for project-specific effects under Alternative 3.

Project (FERC No.)	DO	FM	FH	WH	R	LU	SE
	Resource affected 1/						
PROJECT-SPECIFIC IMPACTS	Relative impact values 2/						
Allegheny L&D No. 7	1	2	3	3	3	2	2
Allegheny L&D No. 4	1	1	2	0	0	1	1
Allegheny L&D No. 3	1	2	2	2	2	1	1
Allegheny L&D No. 2	1	1	2	1	0	1	0
Tygart Dam 3/	1	1	1	0	1	2	1
Opekiska	0	2	1	0	1	0	1
Hildebrand	1	1	1	0	1	1	2
Point Marion	1	1	1	0	0	1	2
Maxwell	1	2	1	0	1	0	1
Monongahela L&D No. 4	1	2	1	0	1	0	0
Emsworth	1	1	1	0	0	2	1
Dashields	1	1	1	0	0	1	1
Montgomery 3/	1	3	2	2	1	2	2
New Cumberland 3/	1	1	1	0	1	2	0
Pike Island	1	1	1	0	1	0	0
Willow Island 3/	1	2	1	0	1	1	0
Belleville	1	2	1	0	1	2	1
Gallipolis 3/	1	2	1	0	1	0	1
Muskingum L&D No. 3	2	2	3	3	3	1	1
RELATIVE ADVERSE IMPACT	Number of projects						
No impacts	1	0	0	14	5	5	5
Minor impacts	17	9	13	1	11	8	10
Moderate impacts	1	9	4	2	1	6	4
Major impacts	0	1	2	2	2	0	0

1/ Resource definitions are as follows:
DO = Dissolved oxygen, FM = Fish mortality in turbines
FH = Fish habitat WH = Wetland habitat,
R = Recreation LU = Land use
SE = Socioeconomics.

2/ Interpretation of relative impact values is as follows:
0 = No major concerns,
1 = Minor impacts,
2 = Moderate impacts, and
3 = Major, unavoidable impacts.
Recreational benefits associated with the development of applicants' proposed facilities are not included in the impact values reported in this table.

3/ The staff has compared the competing projects at these sites and concludes there are no significant differences in relative impact values.

because flows would be diverted away from the public fishing areas and spilled through the gates or over the fixed-crest dams. To guarantee shoreline fishing opportunities at developed recreation facilities during times when the plants are inoperative, flow velocities would need to be maintained in the vicinity of the tailrace fishing area.

The new public fishing access facilities with a required minimum level of development, coupled with the protection of water and fish habitat quality afforded under Alternative 3, could enhance the potential recreational fishing use at most of the sites in the basin. The protection of fish populations under this alternative is needed to sustain anticipated increases in recreational fish catches at the hydropower projects in the basin.

5.1.3.4 Other Resources

The adverse impacts to wetlands during operation of the proposed projects would not be as great with the increased spill flows. However, adverse impacts due to pool elevation changes, increased erosion, turbidity, and sedimentation would continue to exist with resultant changes in species composition, changes in areal extent, and increased mudflat areas.

In general, impacts to river navigation and hydraulics would be similar for this alternative to those for Alternative 1. However, because this alternative would reduce generation at some of the dams between July and October, some of these potential impacts would be reduced during these months. Pool elevation and flow patterns would also change as a result of the higher spill flows.

Significant impacts to other resources, including land use and endangered and threatened species, are essentially similar to those described for Alternative 1. The socioeconomic impacts would be essentially the same, but some reduction in revenues to local governments from the projects would likely occur in comparison with Alternative 1. There would be no impact on the wastewater treatment requirements for industrial and municipal dischargers.

5.1.4 Alternative 4 - Projects Selected to Minimize Impacts to All Target Resources

The fourth hydroelectric alternative minimizes adverse impacts to all target resources by not developing hydropower projects at three sites: Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3. The impacts at these three sites cannot be adequately lessened through modified operation, design, or mitigation that has been proposed to date; therefore, no development at these sites is considered in this alternative. Spill flows to maintain DO concentrations at 6.5 mg/L are the same as under Alternative 3.

The project-specific environmental impacts for the fourth hydroelectric alternative are summarized in relative adverse impact values for environmental resources (Table 5.1.4-1). All of the major impacts and many of the moderate impacts would be eliminated with Alternative 4, compared to Alternatives 1, 2, and 3. The fish mortality concerns that would remain are related to the uncertainty of predicted impacts. The land-use and socioeconomic impacts that remain are related to construction in densely populated areas. Some reduction in revenues to local governments from the projects would likely occur in comparison with Alternative 1.

5.1.4.1 Water Quality

Water quality impacts of Alternative 4 would be similar to those of Alternative 3. No significant degradation of DO concentrations would occur. Project-induced impacts on concentrations of volatile compounds would be similar to those of Alternative 3, except that impacts would not occur at the three projects where hydropower development is not recommended.

5.1.4.2 Aquatic Ecology and Fisheries

Alternative 4 should eliminate hydropower-induced, adverse effects on fish growth and production due to lowered DO, minimize adverse tailwater habitat changes (eliminating them at those projects where the impacts would be most severe), and eliminate entrainment damages at the site where entrainment is most likely to be significant. There would still be residual adverse impacts due to fish entrainment and turbine-induced mortality, for which monitoring, compensation, and long-term protective measures would need to be evaluated.

5.1.4.3 Recreation

By removing three projects, the significant site-specific impacts to recreational resources at these sites would be eliminated. The recreational enhancements these three projects could provide cannot compensate for losses of important ecological habitat (Section 5.1.1.2 and 5.1.1.4) in the basin. Hydropower development under Alternative 4 would prevent additional stress on fish populations that would be caused by aquatic and wetland habitat loss. Alternative 4 provides, therefore, for the needed protection and enhancement of recreational fishing in the basin. Impacts at other projects sites under Alternative 4 would be similar to those discussed under Alternative 3. Alternative 4 would provide for additional benefits to recreation compared with Alternatives 1, 2, and 3 because it would avoid major adverse impacts

Table 5.1.4-1. Relative adverse impact values for project-specific effects under Alternative 4.

Project (FERC No.)	DO	FM	FH	WH	R	LU	SE
	Resource affected 1/						
PROJECT-SPECIFIC IMPACTS			Relative impact values 2/				
Allegheny L&D No. 7							
Allegheny L&D No. 4	1	1	2	0	0	1	1
Allegheny L&D No. 3	1	2	2	2	2	1	1
Allegheny L&D No. 2	1	1	2	1	0	1	0
Tygart Dam 3/	1	1	1	0	1	2	1
Opekiska	0	2	1	0	1	0	1
Hildebrand	1	1	1	0	1	1	2
Point Marion	1	1	1	0	0	1	2
Maxwell	1	2	1	0	1	0	1
Monongahela L&D No. 4	1	2	1	0	1	0	0
Emsworth	1	1	1	0	0	2	1
Dashields	1	1	1	0	0	1	1
Montgomery 3/							
New Cumberland 3/	1	1	1	0	1	2	0
Pike Island	1	1	1	0	1	0	0
Willow Island 3/	1	2	1	0	1	1	0
Belleville	1	2	1	0	1	2	1
Gallipolis 3/	1	2	1	0	1	0	1
Muskingum 3							
RELATIVE ADVERSE IMPACT			Number of projects				
No impacts	1	0	0	14	5	5	5
Minor impacts	15	9	13	1	10	7	9
Moderate impacts	0	7	3	1	1	4	2
Major impacts	0	0	0	0	0	0	0

1/ Resource definitions are as follows:
DO = Dissolved oxygen, FM = Fish Mortality in turbines
FH = Fish habitat WH = Wetland habitat
R = Recreation LU = Land use
SE = Socioeconomics.

2/ Interpretation of relative impact values is as follows:
0 = No major concerns,
1 = Minor impacts,
2 = Moderate impacts, and
3 = Major, unavoidable impacts.
Recreational benefits associated with the development of applicants' proposed facilities are not included in the impact values reported in this table.

3/ The staff has compared the competing projects at these sites and concludes there are no significant differences in relative impact values.

to existing established recreational opportunities at three hydropower sites, while protecting and enhancing recreational fishing at 16 hydropower sites in the basin.

5.1.4.4 Wetlands

Significant adverse impacts to wetlands (Section 5.1.1.4) would be eliminated under Alternative 4. The project at Allegheny L&D No. 3 would be licensed only if impacts to wetlands could be minimized using crest gates to maintain pool elevations.

5.1.4.5 River Navigation and Hydraulics

Potential adverse impacts to river navigation and hydraulics would be reduced because Alternative 4 would eliminate generation at three of the dams year-round and would reduce generation at some of the dams between July and October. None of the potential impacts caused by Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3 would occur.

5.1.4.6 Other Resources

Impacts on other resources would be eliminated at three of the sites and for the other 16 sites would be similar to the impacts described for Alternative 1 (Section 5.1.1.6). The socioeconomic impacts would be similar to Alternative 1, but reduction in revenues from the projects to some of the local governments would likely occur. There would be no impact on the wastewater treatment requirements for industrial and municipal dischargers.

5.1.5 Nonhydroelectric Generating Alternatives

The staff believes that a coal-fired steam plant or plants would be the most likely non-hydroelectric generating alternative to the proposed hydroelectric projects (Section 2.2). To replace the 400-plus MW of electrical capacity of the proposed hydropower projects, a coal-fired unit of approximately 400-MW could supply the energy. Such a unit would consume an average of 1900 tons of coal per day, the scrubber would consume about 170 tons of limestone per day, the cooling towers would consume in excess of two million gallons of water per day, and an additional one-third million to one-half million gallons of water per day would be used. The unit would produce about 140 tons of ash per day, with about 0.5 ton of the ash emitted to the atmosphere each day, and the remainder collected and disposed of as solid waste. Scrubber sludge of roughly 370 tons per day would be collected and require disposal. Roughly four acres per year of waste disposal area would be consumed by the unit.

The unit would release approximately 0.5 ton/day of ash, 13 tons/day of sulfur dioxide, and 25 tons/day of oxides of nitrogen. Cooling towers would release roughly two million gallons of water vapor each day. The impacts of these releases would be site specific, depending upon the dispersive capability of the local atmosphere, other local sources of air pollutants, and regional concentrations of the pollutants released by the unit. Before a unit could be constructed, a detailed environmental review would be required under the Clean Air Act (PL 95-95). Compliance with these regulations would ensure that air quality impacts from unit operation would be analyzed and found to be acceptable. In addition, a 400-MW coal unit would represent a small increase in regional coal combustion. However, unit operation would degrade air quality, would increase regional pollution levels, and would contribute to air quality-related problems such as acid rain and regional ozone levels.

5.1.6 Nongenerating Alternatives

The principal nongenerating alternatives to the proposed projects are conservation and load management to reduce energy requirements and to reduce peak demands for capacity. Although environmental impacts of such alternatives are less than those associated with building and operating new hydroelectric units, implementation of such measures has, in many cases, been pushed to the limit of cost-effectiveness (Section 2.3).

5.1.7 No-Action Alternative

The no-action alternative would constitute a denial of all the applications for license to construct, operate, and maintain the proposed projects. This alternative would result in the nonuse of potential energy that could be derived by developing the proposed sites and the consumption of fossil fuel that would be saved if the proposed projects were developed. In general, the no-action alternative would result in no change or a continuation of existing trends for the target and other resources discussed in this EIS.

The no-action alternative would avoid the adverse impacts on water quality from hydropower development. Not licensing the projects, however, would result in some negative impacts on water quality. Development of hydropower at Opekiska L&D on the Monongahela River is expected to improve DO conditions during the summer by eliminating one of the causes of thermal stratification in the Hildebrand pool (Section 4.1.1). This improvement would be lost if the project were not licensed. The potential for aerating rivers using turbine aeration, if this technology proves feasible, would be lost if the projects were not licensed.

Generation of power at nonhydropower plants causes significant impacts on water quality, such as the discharge of cooling water which increases river temperatures and lowers DO concentrations. Generation at coal-fired plants may result in the deposition of acidic precipitation, which degrades water quality. Mining of coal also causes negative impacts on water quality.

The no-action alternative would prevent project-induced decreases in DO, decreases in the rate at which volatile pollutants are removed from the water, and increases in sedimentation. However, this alternative would also prevent beneficial changes some projects could provide and would increase regional effects of power generation at nonhydropower plants.

If the proposed projects were not constructed, the benefits associated with the development of proposed recreational tailrace fishing facilities would not be realized. This loss would be greater at those sites in the study area with difficult access to the tailwaters of the lock and dams.

The no-action alternative would prevent potential project-induced impacts on flow patterns, pool elevations and velocities, and flood water elevations. A possible beneficial effect of the projects that would be lost if no projects were licensed is the projects reducing the unsteadiness of river flows in the basin because of their automated flow control.

5.2 ECONOMIC EVALUATION OF ALTERNATIVES

Staff has conducted economic analyses for each project, under each of the alternatives described in Section 5.1. These alternatives would have different flows that must be spilled at each site and, therefore, allow various amounts of generation during critical periods. It was assumed that the number of generating units and the installed capacity of each project would not change under the alternatives. A summary of the estimated average annual generation and net annual benefits is shown in Table 5.2-1.

Alternative 1 assumes that all projects would be constructed and operated as proposed by the applicants. The minimum spill over the dam or through the gates at each site would be the amount planned by the developer. Projects at all of the sites would have positive net economic benefits under this alternative and produce 1910 gigawatt-hours (GWh) of energy. Operation of projects under these assumptions could lower DO levels below state standards during periods of low flows and high water temperatures.

Alternative 2 is a variation of the applicants' proposals. Projects at all of the proposed sites would also have positive net economic benefits under Alternative 2, and could be constructed and operated without lowering DO below state standards of 5.0 mg/L. It would provide approximately 1,900 GWh of energy, 10 GWh less than Alternative 1 (valued at 0.8 million dollars at a levelized rate of approximately 8 cents per kilowatt-hour). Operation of five projects on the upper Ohio River and at Allegheny L&D No. 2 would cease under this alternative when flow is less than 9000 cfs at the Sewickley gauging station. The reduced generation from this mitigation would be partially offset by a zero spill requirement at Opekiska. At all of the other sites, the applicants' proposed spills have been used to calculate generation for this alternative. For the sites with competing applications, the generation estimates for the first-filed application were used.

Under Alternative 3, all of the projects would be operated to meet the antidegradation criterion and to maintain DO levels of at least 6.5 mg/L, where possible. Identical spill flows were used for each proposed project at sites with competing applications. The increased Alternative 3 spill requirement at Montgomery would limit the economic benefits at the site and make that project feasible only under a favorable combination of interest rates, construction costs, escalation rates, etc. At least one project at all of the other sites would be economically beneficial. The amount of energy available under this alternative would be approximately 1760 GWh, or 150 GWh per year less than with Alternative 1. Projects at 7 of the 19 sites would have their energy reduced by at least 10 percent under Alternative 3 as compared with Alternative 1.

Development of projects at three sites (Allegheny L&D No. 7, Montgomery, and Muskingum L&D No. 3) is not included in Alternative 4. Eliminating these three projects would eliminate approximately 200 GWh of energy from being produced. All of the remaining projects would have the same benefits as under Alternative 3. This alternative would reduce the total generation available under Alternative 1 by 350 GWh per year. The value of the lost energy would be approximately 28 million dollars per year.

Table 5.2-1. Economic comparison of projects as proposed and with staff-recommended mitigation. 1/

Project (FERC No.)	Estimated average annual energy (GWh)				Net benefits (mills/kWh)				Rate of return (percent)			
	Alternative				Alternative				Alternative			
	1	2	3	4	1	2	3	4	1	2	3	4
Allegheny L&D No. 7	64.9	64.9	64.3	0	17.0	17.0	16.7	0	11.4	11.4	11.3	0
Allegheny L&D No. 4	56.5	56.5	47.2	47.2	13.5	13.5	0.1	0.1	10.9	10.9	9.0	9.0
Allegheny L&D No. 3	71.9	71.9	68.4	68.4	12.3	12.3	8.7	8.7	10.8	10.8	10.2	10.2
Allegheny L&D No. 2	62.8	58.3	54.4	54.4	19.5	14.6	9.9	9.9	11.8	11.0	10.3	10.3
Tygart (7307)	85.3	85.3	85.3	85.3	40.1	40.1	40.1	40.1	17.4	17.4	17.4	17.4
Tygart (7399)	104.2	104.2	104.2	104.2	-3.2	-3.2	-3.2	-3.2	7.2	7.2	7.2	7.2
Opekiska	31.5	33.9	33.9	33.9	15.7	18.2	18.2	18.2	11.1	12.0	12.0	12.0
Hildebrand	28.2	28.2	25.9	25.9	13.1	13.1	9.6	9.6	10.4	10.4	9.6	9.6
Point Marion	17.1	17.1	15.2	15.2	24.7	24.7	17.4	17.4	12.9	12.9	11.5	11.5
Maxwell	43.9	43.9	40.5	40.5	36.2	36.2	32.3	32.3	17.3	17.3	16.0	16.0
Monongahela L&D No. 4	31.5	31.5	31.2	31.2	21.9	21.9	21.3	21.3	13.2	13.2	13.0	13.0
Emsworth	91.1	91.1	85.6	85.6	33.6	33.6	30.5	30.5	15.4	15.4	14.5	14.5
Dashields	96.8	92.2	77.7	77.7	16.7	13.5	0.9	0.9	11.5	10.9	9.1	9.1
Montgomery (2971)	119.1	118.6	90.3	0	7.7	7.6	-6.2	0	9.1	9.1	6.9	0
Montgomery (3490)	99.3	99.3	93.1	0	3.7	3.7	-1.5	0	9.4	9.4	8.8	0
New Cumberland (6901)	178.9	176.7	139.3	139.3	24.1	23.4	8.0	8.0	13.1	13.0	10.1	10.1
New Cumberland (10332)	203.8	203.8	168.0	168.0	4.5	4.5	-5.6	-5.6	8.5	8.5	6.9	6.9
Pike Island	236.4	230.6	195.6	195.6	33.1	31.9	23.2	23.2	15.7	15.3	13.0	13.0
Willow Island (6902)	163.3	163.3	163.3	163.3	14.5	14.5	14.5	14.5	11.2	11.2	11.2	11.2
Willow Island (9999)	163.3	163.3	172.2	172.2	3.2	3.2	5.8	5.8	8.3	8.3	8.7	8.7
Belleville	267.8	267.8	267.8	267.8	35.3	35.3	35.3	35.3	15.6	15.6	15.6	15.6
Gallipolis (9042)	227.7	227.7	233.7	233.7	19.1	19.1	19.9	19.9	11.9	11.9	12.2	12.2
Gallipolis (10098)	251.7	251.7	251.7	251.7	11.8	11.8	11.8	11.8	10.0	10.0	10.0	10.0
Muskingum River 3	36.0	36.0	36.0	0	14.2	14.2	14.2	0	10.8	10.8	10.8	0
Totals	1910	1900	1760	1560								

1/ Source: Staff; see Section 2.1.1 and Table 2.1.1-3 for comparison of the proposed projects.

In the draft EIS, staff presented a net present value analysis that showed that the majority of the projects would have positive net economic benefits. It was concluded that this would not guarantee that all of the projects under alternatives 3 and 4 would be financially attractive and constructed by the applicants. Staff solicited comments from the applicants on the financial feasibility of their projects under each of the alternatives.

Comments from the applicants indicate that they use a variety of methods to determine whether their projects would be financially feasible. Several used a rate-of-return analysis and others a cost-benefit method or present-worth analysis to gauge viability. The applicants' comments included claims that the projects would be feasible under all proposed alternatives and that the projects remain feasible with the increased spill flows even though net revenues would be significantly reduced. One applicant did not analyze the option recommended in the EIS. All of the applicants that evaluated alternatives 3 and 4 concluded that their projects would be feasible with staff's proposed mitigation.

The applicants have not obtained power-sales contracts for the Ohio River projects and cannot reasonably be expected to obtain contracts until after licenses are issued by the Commission. The staff's analysis shows that the projects would have 100 percent equity rates of return, as indicated in Table 5.2-1. At these levels, the projects would be marginally to very attractive to investors.

5.3 COMPARISON OF ALTERNATIVES

Alternatives 1 through 4 in this EIS are scenarios for hydropower development in the upper Ohio River Basin that would cause a wide range of environmental impacts. The impacts of these four alternatives are summarized in Section 5.1 and in Tables 5.1.1-1, 5.1.2-1, 5.1.3-1, and 5.1.4-1. Because impacts of the proposed projects would be mitigated by requiring spill flows (which do not provide generation) and by not developing some sites, reductions in environmental impacts cause reductions in power generation.

Alternative 1 would cause major impacts to water quality, fisheries, recreation, and wetlands. DO concentrations that would be toxic to or would reduce the growth of many species of fish would result. Significant reductions in the recently improved fisheries of the Ohio River Basin could occur, with resulting reductions in recreation. Three projects would cause significant adverse impacts to critical fish habitat and wetlands, with a net loss of at least 7 acres of wetlands. Benefits to recreation would result from development of fishing access at power plants, and socioeconomic benefits would result from increased employment. This alternative would allow generation of approximately 1910 GWh per year.

Alternative 2 would reduce water quality impacts enough that the ambient DO standard of 5 mg/L would not be violated as a result of project operation, but overall impacts would be very similar to those of Alternative 1. Reductions in DO that do not violate standards but still significantly affect aquatic life would occur. Impacts to fisheries, recreation, and wetlands would be similar to those under Alternative 1. Benefits to recreation would result from development of fishing access at power plants, and socioeconomic benefits would result from increased employment. Alternative 2 would allow annual generation of approximately 1900 GWh, or 99 percent of the power generated under Alternative 1.

Alternative 3 would eliminate significant adverse impacts to water quality by requiring spill flows sufficient to provide DO concentrations above 6.5 mg/L. Water quality impacts to fisheries and recreation would not occur. Major adverse impacts to fish habitat, recreation, and wetlands would still occur at three sites where fish habitat and wetlands would be affected. Benefits to recreation would result from development of fishing access at power plants, and socioeconomic benefits would result from increased employment. Alternative 3 would allow annual generation of approximately 1760 GWh, or 92 percent of the power generated under Alternative 1.

Alternative 4 would avoid major impacts to all of the target resources by allowing development at all sites except the three where unmitigable major impacts to fish habitat, recreation, and wetlands would occur. Because these major impacts are concentrated at only three sites, they can be avoided by not developing these sites, with a comparatively small decrease in the generating capacity of the basin. Compared with Alternative 3, Alternative 4 would result in the elimination of all major adverse environmental impacts with a 11 percent decrease in power production. Benefits to recreation would result from development of fishing access at power plants, and socioeconomic benefits would result from increased employment.

Alternative 4 would allow annual generation of approximately 1560 GWh, or 82 percent of the power generated under Alternative 1.

The trade-offs between power generation and impacts to resources for the four hydroelectric generating alternatives are summarized in Table 5.3-1 and Figure 5.3-1.

The nonhydroelectric generating alternatives, the nongenerating alternatives, and the no-action alternative would allow no development of the basin's hydropower potential. Although impacts to the target resources evaluated in this EIS would be avoided by these alternatives, other impacts to the environment would occur from power generation using other sources if these alternatives were selected (Sections 4.5 and 4.6).

5.4 RECOMMENDED ACTION

5.4.1 Recommended Alternative

From its environmental analysis, the staff recommends Alternative 4 as its preferred alternative for development of hydropower projects in the upper Ohio River Basin. Sixteen hydropower projects would be constructed and operated with acceptable environmental impacts with the implementation of staff's recommended mitigation measures. This alternative allows generation of about 82 percent of the power proposed by project applicants but prevents projects from causing DO concentrations low enough to affect aquatic life from occurring, by requiring spill flows. In addition to protecting water quality, this alternative protects other target resources by avoiding the significant impacts to wetlands, fisheries, and recreation that would occur at three proposed hydropower sites. The recreational enhancements these three projects could provide cannot compensate for losses of important ecological habitat at the sites. Enhanced recreational fishing at these sites would cause additional stress on fish populations, aggravating impacts caused by habitat loss. The protection of wetlands and fish habitat provided by Alternative 4 is important for maintaining the overall biological integrity of the basin.

The staff has compared the competing hydropower applications at Tygart, New Cumberland, Willow Island, and Gallipolis L&D. Staff concludes that there are no significant differences between competing applications, either in environmental acceptability or in power generating capabilities.

Therefore, at this time the preferred alternative is to recommend hydropower development for the following projects in the upper Ohio river Basin:

Allegheny River

Allegheny River L&D No. 4 (FERC No. 7909)
Allegheny River L&D No. 3 (FERC No. 4447)
Allegheny River L&D No. 2 (FERC No. 4017)

Tygart River

Tygart Dam (FERC No. 7307)
Tygart Dam (FERC No. 7399)

Monongahela River

Opekiska L&D (FERC No. 8990)
Hildebrand L&D (FERC No. 8654)
Point Marion L&D (FERC No. 7660)
Maxwell L&D (FERC No. 8908)
Monongahela L&D No. 4 (FERC No. 4675)

Ohio River

Emsworth L&D (FERC No. 7041)
Dashields L&D (FERC No. 7568)
New Cumberland L&D (FERC No. 6901)
New Cumberland L&D (FERC No. 10332)
Pike Island L&D (FERC No. 3218)
Willow Island L&D (FERC No. 6902)
Willow Island L&D (FERC No. 9999)
Belleville L&D (FERC No. 6939)
Gallipolis L&D (FERC No. 9042)
Gallipolis L&D (FERC No. 10098)

The staff has determined that the construction and operation of hydropower projects proposed at Allegheny River L&D No. 7, Montgomery L&D, and Muskingum River L&D No. 3 would cause significant adverse environmental impacts. Following an analysis of proposed and available mitigation, staff considers these impacts to be unavoidable because adequate site-specific mitigative measures are not known at this time. In addition, staff is not aware of any appropriate off-site compensation in the study area that could mitigate these adverse impacts.

Table 5.3-1. Summary of trade-offs between power generation and impacts to environmental resources.

	Alternative One	Alternative Two	Alternative Three	Alternative Four
Number of sites developed:	19	19	19	16
Major impacts 1/	18	13	7	0
Moderate impacts 2/	38	43	27	18
Estimated annual power production, gigawatt-hours	1,910	1,900	1,760	1,560

1/ From Tables 5.1.1-1, 5.1.2-1, 5.1.3-1, and 5.1.4-1. The number in this row is determined by (a) counting how many of the 7 resources would receive major impacts from each project, and (b) summing the number of these impacts over all sites.

2/ From Tables 5.1.1-1, 5.1.2-1, 5.1.3-1, and 5.1.4-1. The number in this row is determined by (a) counting how many of the 7 resources would receive moderate impacts from each project, and (b) summing the number of these impacts over all sites.

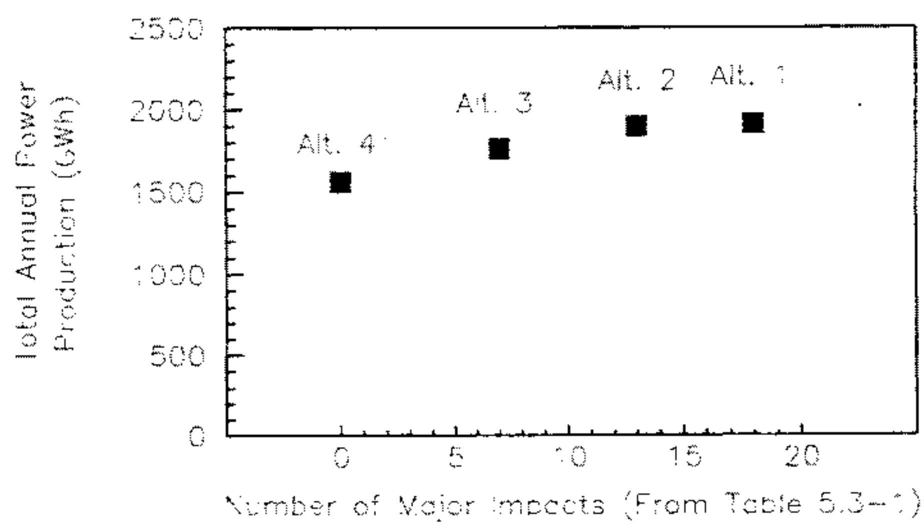

Figure 5-3. Tradeoffs between hydroelectric energy production and environmental impacts (impact metric is number of sites with major impacts).

A summary of the significant adverse impacts at these three projects follows:

Allegheny L&D No. 7. The proposed project at this site would have significant, unavoidable adverse impacts to the target resources identified as fisheries, recreation, and wetlands. The impacts to these resources at this site are related to the Isle of White, a 2-acre island located immediately downstream from the proposed powerhouse. This island is used as a recreational refuge by fishermen because the 14 acres of shallow water (shoal) in the backchannel provide important habitat to fish. Access to the island is obtained by boating and mooring on the island and by wading from the shore to the island.

Construction of the project would require the dredging of the shoal and, therefore, would cause substantial removal of this important aquatic habitat. Increased sedimentation, turbidity, and erosion around the island due to construction activities would significantly impact wetlands and riparian vegetation. Operation of the project would cause further impacts to wetland vegetation related to erosion of the island caused by the turbulent tailrace discharge; over time, it is likely the island would disappear. The total loss of 2 acres of wetland area associated with project construction and operation is considered by staff to be a significant loss in wetland resources on the Allegheny River.

The loss of recreational access to the Isle of White, the potential loss of the island over time, and the significant adverse impact to aquatic habitat and wetlands at the project site would result in an overall significant adverse impact on the quality of recreational fishing in the area. In addition, construction of the project is expected to seriously disrupt the adjacent neighborhood.

The development of the applicant's proposed recreational facilities at the site would not adequately mitigate these environmental impacts. Development of the project is not recommended until and unless mitigation measures are designed, in consultation with the appropriate federal and state agencies, to prevent impacts to wetlands and fish habitat downstream of the dam, including protection of the Isle of White and adjacent shoals. Should the project be licensed, the recommended spill flow is 500 cfs. A Phase I archeological survey of the project area would need to be completed prior to project licensing. If any archeological or historic properties are discovered, the recommendations for archeological and cultural resources (Section 5.4.2.5) would apply.

Montgomery L&D. This project would have significant adverse impacts to the target resources identified as fisheries, wetlands, and recreation. The impacts to these resources at this site are related to its proximity to the Montgomery Embayment, a 17-acre embayment and wetland that is approximately 500 feet upstream of the proposed powerhouse. The embayment contains unique riparian vegetation, serves as a valuable spawning and nursery area for fish, and provides an important recreational fishery. The embayment is classified by the USFWS as Resource Category 1 because of its unique and irreplaceable habitat.

Construction of the proposed project would disturb these unique and valuable resources in the embayment. Operation of the project would alter flow patterns in and near the embayment, potentially causing changes in wetlands and fish habitat. Juvenile and adult fish attracted to, or spawned in, the embayment would be susceptible to turbine mortality at the proposed project. At this time, no fish protection devices have been demonstrated adequate to protect the embayment fishery from entrainment in the proposed hydropower turbines. Development of the project is not recommended until and unless mitigation measures are designed, in consultation with the appropriate federal and state agencies, to prevent impacts to the wetlands, fishery, and recreation resources of the Montgomery Embayment. A potential mitigation measure that could be considered is closing the existing opening to the embayment and creating a new opening to it at the upstream end. Should the project be licensed, it should be operated with a spill flow of 13,000 cfs during the summer critical season of July through October, and 4,000 cfs the rest of the year. A Phase I archeological survey of the project area would need to be completed prior to project licensing. If any archeological or historic properties are discovered, the recommendations for archeological and cultural resources (Section 5.4.2.5) would apply.

Muskingum L&D No. 3. The proposed project at this site would have significant, unavoidable adverse impacts to the target resources identified as fisheries, recreation, and wetlands. The impacts to these resources at this site are related to the islands and fish habitat in the Muskingum River downstream of the dam. Downstream of the dam is approximately 1000 feet of shallow and rapid water that provides important fish habitat. This area may also provide habitat for the federally listed endangered pink mucket pearly mussel and other freshwater mussels listed by the state of Ohio as endangered or threatened species. Discharge flow from the proposed powerhouse would affect the large island separating the main river channel from the narrow and shallow bank channel. The area at the site of the proposed project is managed by the Ohio Department of Natural Resources solely for recreation, as part of the state's Muskingum River Parkway.

Construction of the project would require dredging of some of the shallow aquatic habitat. Operation of the project would cause significant adverse impacts to wetlands and aquatic habitat by redirecting most of the river flow through a narrow backchannel behind the island, resulting in erosion of the backchannel and the island. Project operation would also significantly reduce flows through much of the existing shallow, rapid habitat in the main river channel just downstream of the dam.

Mitigation proposed by the applicant to reduce erosion of the island would cause adverse impacts to the island's riparian vegetation. The loss of existing recreation access, fish habitat, and wetlands habitat would result in an overall significant adverse impact to recreational use of the area, which would not be adequately mitigated by the applicant's proposed recreation facilities. Development of the project is not recommended until and unless mitigation measures are designed, in consultation with the appropriate federal and state agencies, to prevent impacts to the recreation, fish and mussel habitat, and wetlands resources of the site. Should the project be licensed, it should be operated with a spill flow of 2280 cfs during the months of April, May, and June and 1520 cfs the rest of the year, as recommended by the USFWS for protection of the endangered pink mucket pearly mussel. If licensed, the recommendations for threatened and endangered species (Section 5.4.2.5) would apply at this project. In addition, before the project is licensed a study should be conducted by the applicant and approved by the FERC and the Ohio EPA to determine spill flows adequate to maintain DO concentrations of 6.5 mg/L from the project downstream to the Ohio River during conditions when DO concentrations are above 6.5 mg/L without hydropower. The spill flows so determined should be implemented.

5.4.2 Basin-Wide Recommendations

The following actions and mitigation measures are recommended to reduce impacts that occur at more than one site, for the recommended Alternative 4. These recommendations will be used as a basis for specific license articles for any project licensed by the Commission. In addition, special license articles applicable to projects at Corps dams and standard license articles applicable to hydropower licensing will be required of all projects that are licensed by the Commission. These articles are included in Appendix H.

5.4.2.1 Recommendations on Water Quality

1. Developers should operate their projects to maintain DO concentrations at or above 6.5 mg/L, throughout the basin wherever and whenever possible, for the protection of water quality, fisheries, and recreational fishing. Maintenance of DO concentrations is especially important during the summer critical season when low flows and high temperatures contribute to low DO concentrations; for the proposed projects the "critical season" is defined as the months of July through October. Maintenance of 6.5 mg/L of DO immediately downstream of the project tailrace is not necessarily sufficient to maintain 6.5 mg/L throughout the downstream pools. Spill flows (defined as flow that passes over the crest of a fixed-crest dam or through the gates of a gated dam and does not include flows used for lockage, leakage, or hydropower generation) are the most reliable mitigation to maintain DO concentrations, so the spill flows necessary to maintain 6.5 mg/L under reasonably expected conditions, listed for each project in Section 5.4.3, are recommended. The recommended spill flows take into consideration that under some conditions, DO concentrations are less than 6.5 mg/L without hydropower and that some dams are not important aerators. If a system-wide DO modeling and management program is developed (Recommendation 7, below), spill flows determined by such a program can supersede those in Section 5.4.3. If effective mechanical aeration is approved (Recommendation 8, below), spill flows may be reduced. When river flows are less than the recommended spill flows, the spill should be reduced to maintain run-of-the-river operation (recommendation 3, below).

2. Developers should be required to temporarily spill more (or less) water than the staff's recommended spill flows upon notification by FERC, acting on recommendations from the

Corps, ORSANCO, or appropriate state water quality management agencies for water quality management in case of incidents such as low DO events, spills, etc., whether or not such incidents result from hydropower operations. Hydropower projects should not be permitted to contribute to violations of state DO standards under any conditions. When state DO standards are violated in the basin or a violation is anticipated by FERC, ORSANCO, the Corps, or appropriate state water quality management agencies, all projects upstream of the violation that may contribute to it should maximize aeration. Aeration should be maximized by either ceasing generation or using mechanical aeration, if available.

3. Developers at all projects, except at Tygart, should operate the projects in an instantaneous run-of-river mode. The developers should, in operating the projects, at all times act to minimize the fluctuation of the upstream pool elevation. Instantaneous run-of-river operations may be temporarily modified if required by operating emergencies beyond the control of the project operator and for short periods upon mutual agreement between the developer, the Corps, and appropriate state fish and wildlife agencies. As part of the design review of the project by the Corps (Appendix H), the design of automatic flow controls and their influence on existing unsteady river flows should be reviewed. (Flows at Tygart are discussed in Section 5.4.3.)

4. Developers should, prior to plant operation, install, operate, and maintain high quality, permanent dissolved oxygen (DO) monitors that monitor DO concentrations and water temperatures hourly, at sites that adequately represent DO upstream and downstream of their projects, at all times. The data from the monitors should be provided to ORSANCO electronically at a frequency determined by ORSANCO. Selection and installation of the monitors should be done after consultation with ORSANCO, and the monitors should be maintained in accordance with standards developed by ORSANCO for their monitors. Annual data analysis reports should be filed with the Commission, ORSANCO, the Corps, the USFWS, and appropriate state water quality management agencies on the anniversary date of the license. These reports should, at a minimum, include daily minimum, maximum, and mean DO concentrations; daily minimum, maximum, and mean water temperatures; the number of days the monitors were out of service; the number of events when DO concentrations were less than 6.5 mg/L and the length of each such event; and the number of events when DO concentrations were less than state DO standards and the length of each such event.

5. Developers should design and implement, after consultation with ORSANCO, the Corps, the USFWS, and appropriate state water quality management agencies, water quality monitoring plans for Commission approval that provide occasional summer DO measurements taken throughout the pools in the basin. This information is needed to ensure water quality protection between the dams. The plans for individual developers should be designed so that all the plans together result in complete coverage of the area affected by hydropower development. Implementation of the monitoring plans should begin during the first summer (after July 1) following issuance of a license.

6. Developers should construct and operate stream flow gages as required by standard license Article 8 (Appendix H) to provide continuous monitoring of the flow through the turbine and bypass flow channels. The Corps should be consulted on the design and installation of the gages. Flow data should be made continuously and instantaneously available to the Corps lockmaster at each Corps navigation dam and to the Corps operator at Tygart Dam. Flow data should be made available to the appropriate state water quality management agencies within 30 days of written request.

7. Project developers should participate in a basin-wide water quality management group, such as ORSANCO, the Corps, or an interagency group including state water quality management agencies, that can make provisions for allowing spill flows to be determined by a real-time simulation model of the basin. The purpose of this participation is to promote basin-wide synthesis and modeling of water quality and flow information for protecting water quality and improving generating capacity in the basin. Basin-wide monitoring and simulation of flows and DO concentrations would allow spill flows to be determined from actual daily conditions instead of from the seasonal conditions that spill flows recommended by staff were based on. This recommendation would allow generation to take place whenever it could without degrading water quality significantly. Summer conditions with high DO concentrations, such as high flows or high primary production of DO by algae, occur frequently enough that the development of real-time simulation of the basin would allow for enough additional hydropower generation to pay for the costs of such a system.

8. Developers are encouraged to conduct research on the economic and technical viability of aeration sources other than spill flows at hydropower plants. If aeration techniques such as injection of air into turbine draft tubes or specially designed aeration weirs can economically provide sufficient DO to replace aeration from spillage, developers should be allowed to replace some spill flow with artificial aeration. Recommendations from the developers on changes in spill flow requirements to include artificial aeration should take into account benefits of spill flows for resources other than DO and should be filed with the Commission for approval after the developers have consulted with ORSANCO, the Corps, the USFWS, and appropriate state water quality management agencies. If artificial aeration is used, procedures should be developed to avoid excessive supersaturation. All projects should be built in such a way that installation of air injection systems is not precluded. Adequate space for injection ports in the turbines and air supply lines should be provided, and installation of a sufficient power supply should not be precluded.

9. Developers should determine project effects on flood elevations. Prior to construction, developers should file a report with the Commission, the Corps and state and local emergency planning agencies, after consultation with the Corps, showing what changes in flood elevations are predicted to be caused by the project. Within five years of issuance of a license, the developers should obtain, in accordance with standard license article 5 (Appendix H), any real estate easements required by project-induced changes in flood elevations.

In addition, licenses already issued for projects at Allegheny River L&D Nos. 5, 6, 8, and 9 include articles requiring the licensees to conduct studies to determine spill flows needed to protect water quality and fish resources. The studies conducted for this EIS indicate that it may be beneficial to reevaluate the interim spill flows at these licensed projects. A determination of whether the interim spill flows are adequate for protection of these resources should be made. This determination may be assisted by staff's use of the water quality models developed for this EIS to determine how these licensed projects interact with the proposed projects. For example, initial model results indicate that higher spill flows at Allegheny L&D 8 would reduce downstream DO degradation and allow more generation at downstream projects.

5.4.2.2 Recommendations on Aquatic Ecology and Fisheries

1. Developers should, within 12 months following issuance of the license and after consultation with the Pennsylvania Fish Commission, West Virginia Department of Natural Resources, or the Ohio Department of Natural Resources, as appropriate for the project location, and the U. S. Fish and Wildlife Service, file for Commission approval functional design drawings of the intake structure that provide for installation of devices (1) to measure fish passage; and (2) to accommodate later installation of a fish screen, bypass facility, or other structures, should they be found necessary for protection of fish from entrainment and turbine-induced mortality in the studies recommended below.

2. Developers should, after consultation with the Pennsylvania Fish Commission, West Virginia Department of Natural Resources, the Ohio Department of Natural Resources, and the U. S. Fish and Wildlife Service, jointly develop a study plan to first monitor fish entrainment and then to quantify turbine-induced mortality at selected, representative sites. These studies should include fish eggs, larvae, juveniles, and adults according to the life stages that are entrained. Within six months of the issuance of licenses, developers should meet with resource agencies and FERC staff in a FERC-sponsored meeting to develop plans for a joint approach to the study. Within 12 months from the issuance of the license, developers should file a copy of the study plan and a schedule for filing the results of the study with the Commission for approval, along with comments from the above agencies on the adequacy of the study and the schedule. The Commission would reserve the right to require modification to the plan and its schedule. The results of the study should be submitted to the Commission according to the approved schedule along with the comments from the consulted agencies relating to the results of the study. Further, if results of the study indicate that changes in project structures or operations of a magnitude less than installation of full-scale fish-protection devices are necessary to minimize adverse effects on fish resources at projects in the region, each developer should submit a schedule to the Commission for approval for implementing the specific changes in its project structures or operations, along with comments from the above agencies on the adequacy of the specific changes. At the same time, copies of the schedule should be served upon the agencies consulted.

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3. Developers should, after consultation with the Pennsylvania Fish Commission, West Virginia Department of Natural Resources, or the Ohio Department of Natural Resources, as appropriate for its location, and the U. S. Fish and Wildlife Service, develop a mitigative plan for compensating the appropriate state for fish losses due to fish mortality during entrainment in turbines until and unless effective fish-protection devices are established and installed. Compensation plans should consider how the fish passage and entrainment mortality information developed in recommendation 2 (above) would be used. The plans shall also consider the possibility that no fish protection devices will be found effective and that compensation may be a long-term mitigation measure. Within 12 months from the issuance of the license, developers should file a copy of the compensation plan and a schedule for implementing the plan with the Commission for approval, along with comments from the above agencies on the adequacy of the plan and the schedule. The Commission would reserve the right to require modification to the compensation plan and its schedule.

4. Developers should, after consultation with the U. S. Fish and Wildlife Service, West Virginia Department of Natural Resources, Ohio Department of Natural Resources, and the Pennsylvania Fish Commission, jointly prepare a plan for a bioengineering test facility for fish bypass systems, applicable to the upper Ohio River Basin, that would minimize fish entrainment and turbine-induced mortalities at licensed plants in the region. The facility should be established at one (or a few) of the projects on the upper Ohio River system, to be selected after consultation among the developers, the above agencies, and FERC staff, and after review of estimates of annual fish passage at representative sites. The facility(ies) would construct, test, and evaluate engineering prototypes of fish guidance and bypass systems applicable to the region. Within six months of the issuance of licenses, developers shall meet with the resource agencies listed above and FERC staff in a FERC-sponsored coordinating meeting to develop plans for jointly funding and operating the bioengineering test facility. Within 12 months of the issuance of licenses, developers should file a copy of the plan for operation and management of the bioengineering test facility and a schedule for implementing the plan with the Commission for approval, along with comments from the above agencies on the adequacy of the plan and schedule. The Commission would reserve the right to require modification of the plan and the schedule.

   A report on the results of testing fish-protection devices at the bioengineering facility(ies) should be submitted to the resource agencies listed above and the Commission annually beginning 12 months from the Commission approval of the plan, along with comments from the consulting agencies relating to the results of the prototype testing. Further, if the results of the prototype tests indicate that changes in project structures or operations would be effective for minimizing entrainment into turbines in the region, developers should include, for Commission approval, functional design drawings of fish screens, bypass facilities, or other structures and a schedule for implementing the specific changes in project structures or operations, along with comments from the above agencies on the adequacy of the specific changes and alterations to other forms of compensation that would result. At the same time, copies of the schedule should be served upon the agencies consulted. A summary of results and recommendations for implementation should be provided to the Commission and consulting agencies at no less than 2-year intervals.

5. Developers should, after consultation with the Pennsylvania Fish Commission, West Virginia Department of Natural Resources, or the Ohio Department of Natural Resources, as appropriate for its location, and the U. S. Fish and Wildlife Service, develop a plan to monitor fish resources in the vicinity of its project. The plan should include, but not be limited to, monitoring angler catch rates and the composition, density, and age-class distribution of game fish populations upstream and downstream of the project. Within 12 months of the date of issuance of the license, each developer should file the monitoring plan with the Commission for approval, along with comments from the above agencies on the adequacy of the plan. The Commission would reserve the right to require modification of the plan.

   Within 6 months of Commission approval, the monitoring plan should be implemented and continue for no less than 5 years after project operation commences. The results of the monitoring should be given to the consulting agencies and filed with the Commission on an annual basis. At the end of 5 years the developers should file with the Commission a final report on the results of the monitoring that should include a recommendation on the adequacy of the monitoring data to establish the effectiveness of compensation and mitigation measures and a recommendation on whether the monitoring should be discontinued.

Comments on the results and recommendations from the above agencies should be included in the final report. If results of the monitoring indicate that fishery resources are being adversely affected by hydropower operation, each developer should include, for Commission approval, recommendations to minimize these effects through changes in the measures established in the mitigative plan (recommendation 3 on compensation above) or changes in project structures or operation, a schedule for implementing the changes, and comments from the consulted agencies (above) on the recommendations and schedule. The Commission would reserve the right to modify the recommendations or the schedule.

5.4.2.3 Recommendations for Recreation Resources

1. Developers should construct and maintain new public fishing access facilities in the tailwater areas. Recreational facilities should include, at a minimum, a fishing pier(s), multilevel grouted/paved walkways parallel to the shoreline, access to riverward coffers, bank undulations, reefs, parking lots, access paths from the parking lot to the shoreline fishing areas, restrooms, fish-cleaning shelters, provisions for handicapped use, solid waste disposal, lighting to permit night fishing, drinking water and public information signs. A revised recreation plan that conforms to the standards outlined above should be filed with the Commission for approval within six months from the date of issuance of the license and prior to project construction. The filing should include a drawing showing the type and location of the facilities to be provided at the project, a construction schedule, and documentation of consultation with the local resource agencies. In the event that sufficient lands are not available for the construction of a standard level of recreational development, a recreational compensation plan should be filed with the Commission. Recreational compensation measures could include the provision of off-site recreational facilities, and the upgrading of existing access facilities. The compensation plan should be developed in consultation with the appropriate state and federal resource agencies.

2. Developers should construct all permanent recreational facilities prior to or concurrent with the date of start-up of project operation.

3. In designing the hydraulic modeling of powerhouse placement, as required by the Corps, developers should also incorporate modeling of fishing piers, submerged dikes, riverward and landward coffer cells, temporary fishing facilities for use during construction, and bypass facilities to determine the final alignments of these fishing facilities. Developers should file with the Commission a report that discusses the design and results of the hydraulic modeling and documents the consultation with the state and federal resource agencies.

4. Developers should maintain flows in the tailrace fishing areas when the power plants are inoperative during the normal fishing season. Approximately 10 percent of the mean annual flow, up to 2,000 cfs, needs to be maintained in the tailrace fishing areas during times when the power plants are not generating (e.g., during low flows and maintenance). Developers should file a plan with the Commission specifying the design details for maintaining the needed flow velocities in the vicinity of the tailrace fishing areas, by means such as selective gate openings and/or bypass flow channels through or around the powerhouse. The plan should incorporate the results of physical hydraulic modeling and consultations with the appropriate state and federal resource agencies. Bypass flow systems should be designed so that the discharge is well aerated. Aeration to around 90 percent of saturation should be feasible with simple and reliable techniques such as deflectors to spray the flow through the air combined with deep plunge pools. Such aerating outlets for bypass systems should be designed to avoid injury to fish passing through them.

5. Developers should provide fishing access in areas outside of the construction limits during construction of the projects. Recreational developments during construction should include, at a minimum, parking; designated trails to fishing areas; temporary piers (jetties) and fish attractants to maximize fishing below the coffer dams and immediate construction limits; and signs indicating safe fishing areas, construction limits, and the project purpose. A plan for the provision of fishing access during construction should be filed with the Commission for approval within six months from the date of issuance of the license and prior to project construction. The filing should include a drawing that indicates the type and location of the access facilities to be provided during project construction and documentation of consultation with the appropriate state and federal resource agencies. In the event that sufficient lands are not available for the provision

of temporary fishing access facilities during construction, a recreational compensation plan should be filed with the Commission. Compensation measures could include the provision of off-site recreational facilities and the upgrading of existing access facilities in the project area. The compensation plan should be developed in consultation with the appropriate state and federal resource agencies.

6. Developers should monitor recreational use at their project locations to determine whether the facilities are meeting recreational needs. Completion of standardized visitation forms, creel studies, and annual meetings with state and federal resource agencies should be done to monitor the extent of recreational use at each project site. These studies should begin in the first year following licensing so that baseline data are collected prior to project operation. Developers should file a report with the Commission every five years, on the license anniversary, on the monitoring results. This plan should include, at a minimum, (a) a discussion of the adequacy of the developer's recreational facilities, (b) a discussion of the need for additional recreational facilities at the project site, and (c) any recreational plans proposed by the developer to accommodate or control visitation of the project area. The developer should conduct its monitoring and prepare its report in consultation with state and federal resource agencies.

5.4.2.4 Recommendations for Wetlands

1. At least 90 days before the scheduled start of any land-clearing or land-disturbing activities, developers should file with the Commission a plan to monitor wetland/riparian vegetation both upstream and downstream of the project site for the first 5 years of project operation. If recreation facilities are developed in sites remote from the project site, monitoring of effects on riparian vegetation due to the construction and development of recreation facilities should be required and appropriate plans developed. The potential to create new wetlands of comparable types to replace wetlands that are lost should be investigated in consultation with appropriate federal and state agencies. Any new wetlands created by developers should be included in the monitoring study. The monitoring plan should include a schedule for: (a) implementation of the program; (b) consultation with the appropriate federal and state agencies concerning the results of the monitoring, and (c) filing the results and agency comments with the Commission. If the monitoring plan reveals any loss or degradation of vegetation due to project operation, the Commission may direct the developer to mitigate such loss and to implement specific changes in project structures and/or operation. The Commission may require changes to the plan. No land-disturbing activities should begin until the developer is notified that the plan complies with these requirements.

   The developer should prepare the plan after consultation with the wetland coordinators or offices of the Corps, U. S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the appropriate state agency. The developer should include with the plan documentation of consultation and copies of comments and recommendations. If the developer does not adopt a recommendation, the filing should include the developer's reasons, based on project-specific information.

5.4.2.5 Recommendations for Other Resources

1. Endangered and Threatened Species

   Developers at Willow Island L&D, Belleville L&D, and Gallipolis L&D should, after consultation with the U.S. Fish and Wildlife Service, the West Virginia Department of Natural Resources, and the Ohio Department of Natural Resources develop monitoring plans for the dam tailwaters, including proposed turbine discharge areas, for the necessary habitat and occurrence of rare and endangered freshwater mussels, particularly the federally endangered pink mucket pearly mussel (*Lampsilis abrupta*) and species listed as endangered by the state of Ohio. Within 12 months from the issuance of a license, developers should file a copy of the monitoring plan with the Commission for approval, along with comments from the above agencies on the adequacy of the monitoring and a schedule for filing the results. The Commission would reserve the right to require modification to the plan and its schedule.

   The results of the monitoring should be filed with the Commission according to the approved schedule along with the comments from the consulted agencies relating to the results. Further, if results of the monitoring indicate that changes in project structures or operations are necessary to protect the habitats of rare and endangered freshwater mussel resources, a schedule should be submitted to the Commission for implementing the specific changes in project structures or operations, along with comments from the above agencies on the adequacy of the specific changes. At the same time, copies of the schedule should be served upon the agencies consulted.

2. Land Use

Developers requiring lands outside the project boundaries specified in the license application, for use as laydown, marshalling, or storage areas, or for any other use during the construction period, should coordinate such proposed use with the planning agency of the local governmental jurisdiction in which the land is located. To accomplish this coordination, developers should submit to the local planning agency and request the agency's comments on (1) a map showing the location of the land to be used outside the project boundaries, (2) a narrative description of the activities which will take place there, and (3) a description of any expected differences in the pre- and post-construction conditions at the site. These materials, along with any comments received from the local planning agency and the developer's response to such comments, should be submitted to the Commission prior to construction.

3. Aesthetics

At least 90 days before the scheduled start of land-disturbing or land-clearing activities, developers should file with the Commission a plan to avoid or minimize disturbances to the quality of the existing visual resources of the project area resulting from constructing and operating the project. The plan at a minimum, should include (a) the developer's strategy for blending the project works into the existing landscape character; revegetating, stabilizing, and landscaping new construction areas and areas immediately adjacent to the project site disturbed by previous construction or that presently impact the visual resources of the surrounding area; grading, planting grasses, repairing slopes damaged by erosion, and preventing future erosion; (b) an implementation schedule; (c) monitoring and maintenance programs for project construction and operation; and provisions for periodic review and revision. The Commission may require changes to the plan. No land-clearing or land-disturbing activities should begin until the developer is notified that the Commission has approved the plan.

Developers should prepare the plan after consultation with appropriate federal and state agencies and other interested entities. Developers should include with the plan documentation and copies of comments and recommendations. If the developer does not adopt a recommendation, the filing should include the developer's reasons, based on visual and landscape conditions at the site.

4. Socioeconomics

Developers of hydropower projects at Tygart, Opekiska, Hildebrand, and Maxwell should establish a level of reimbursement, compensation, or mitigation for the deterioration caused to local secondary roads by construction-related traffic (see Section 4.1.6.3). The developer of the projects located at these sites should submit a proposed method of reimbursement, compensation, or mitigation to the chief executive officer of each local government responsible for maintaining the roadways that would be used by construction traffic travelling between the project construction site and a state-maintained, all-purpose highway or road. Prior to construction the developer at these hydropower sites should submit this proposal to the Commission along with any comments received from the local governments involved.

5. Archeological and Historic Resources

The developers, before starting any land-clearing or land-disturbing activities within the project boundaries, should consult with the appropriate State Historic Preservation Officer (SHPO) and the appropriate District Office of the Corps. If the developer discovers previously unidentified archeological or historical properties during the course of constructing or developing project works or other facilities at the project, the developers should stop all land-clearing and land-disturbing activities in the vicinity of the properties and consult with the SHPO and the Corps. If such archeological or historical properties are discovered, the developer should file for Commission approval a cultural resource management plan prepared by a qualified cultural resource specialist after having consulted with the SHPO and the Corps.

The management plan should include (a) a description of each discovered property indicating whether it is listed on or eligible to be listed on the National Register of Historic Places, (b) a description of the potential effect on each discovered property, (c) proposed measures for avoiding or mitigating effects, (d) a schedule for mitigating effects and conducting additional studies, and (e) copies of letters from the SHPO and the Corps agreeing to the plan. The Commission may require changes to the plan. The developers should not resume land-clearing or land-disturbing activities in the vicinity of a property discovered during construction until informed by the Commission that the management plan has been approved.

6. Contaminated Sediment Test and Disposal Plan

At least 90 days before the scheduled start of land-disturbing or land-clearing activities, the developer should file with the Commission a plan to conduct tests for, minimize inputs of, and safely dispose of toxic substances and spoils. Developers should sample river sediments and bank soils that will be disturbed during construction, or by erosion during operation, to determine the presence of chemical contamination. Any contaminated materials that are disturbed should be disposed of in accordance with applicable state and federal regulations. The plan, at a minimum, should include: (a) a description of the methods to be employed in testing bottom sediments at regular intervals of time for the presence of heavy metals and other toxic substances in the streambed and bank of the project area; (b) a description of the developer's measures to minimize inputs of sediment and other potentially toxic substances to the stream; (c) a description of the developer's planned measures to avoid disturbing or to safely dispose of disturbed toxic substances and spoils; (d) an implementation schedule; (e) monitoring and maintenance program plans during project construction and operation; and (f) provisions for periodic review and revision of the plan. The Commission may require changes to the plan. No land-disturbing or land-clearing activities should begin until the developer is notified that the plan has been approved by the Commission.

The developer should prepare the plan after consultation with the Corps, the U. S. Environmental Protection Agency, federal and state fish and wildlife agencies, other state environmental resource agencies as appropriate, and each federal agency having managerial authority over any part of the project lands. The developer should obtain any required permits for disposal of contaminated materials in wetlands or for dredging in wetlands. The developer should include with the plan documentation of consultation and copies of comments and recommendations. If the developer does not adopt a recommendation, the filing should include the developer's reasons, based on project-specific information.

7. Raptor Protection Transmission Line Design Plan

At least 90 days before the scheduled start of construction, developers should file with the Commission a transmission line design plan, prepared in accordance with the guidelines set forth in "Suggested Practices for Raptor Protection on Power Lines", Raptor Research Report No. 4, Raptor Research Foundation, Inc., 1981. Protective devices should be installed on all lines crossing the river or paralleling the river for protection of raptors or migratory waterfowl. The plan should include detailed design drawings of the transmission line clearly showing phase spacing, configuration, and grounding practices to prevent or minimize electrocution hazards. A construction schedule should be included. The plan should consider the timing of construction activities to avoid disturbances to migrating and feeding of raptors and migratory waterfowl. The Commission may require changes to the design plan. No transmission line construction should begin until the developer is notified that the plan has been approved by the Commission.

The developer should prepare the plan after consultation with the U. S. Fish and Wildlife Service, the Corps, and state fish and wildlife resources agencies. The developer should include with the plan documentation of consultation and copies of comments and recommendations. If the developer does not adopt any recommendation, the filing should include the developer's reasons, based on project-specific information.

8. Revegetation and Maintenance of Disturbed Areas

   At least 90 days before the scheduled start of any land-clearing or land-disturbing activities, both on and off the site, developers should file with the Commission a plan to revegetate all disturbed areas with plant species beneficial to wildlife and native to the project area. Upland abandoned strip mines or borrow pits should be contoured and revegetated after disposal of spoil material. Disposal of spoil material in abandoned strip mines or borrow pits, commercial landfills, or reuse at the project site during construction or sale for reuse is recommended. Disposal of spoil material on agricultural or forested lands requiring clearing is not recommended. Developer should clear and maintain transmission line rights-of-way using mechanical means, if at all feasible. All rights-of-way should be replanted with low shrubs/trees and native species to provide habitat for wildlife resources. The plan for revegetation should include the project construction site, spoil disposal sites, and transmission line rights-of-way. No land-disturbing activities should begin until the developer is notified that the plan has been approved by the Commission. The plan should, as a minimum, include: (a) a description of the plant species to be used and planting densities; (b) fertilization and irrigation requirements; (c) a monitoring program to evaluate the effectiveness of the plantings; (d) provisions for the filing of monitoring reports with the Commission; (e) a description of procedures to be followed if monitoring reveals that revegetation is not successful; (f) an implementation schedule that provides for revegetation as soon as practicable after the beginning of land-clearing or land-disturbing activities within the disturbed area.

   The plan should be prepared in close coordination with the erosion, dust, slope, and sediment control plan (Recommendation 9 below) and after consultation with the Corps, state surface mining regulatory agencies, federal and state fish and wildlife resource agencies, state water and air quality agencies, and the Soil Conservation Service. Developers should include with the plan documentation of consultation and copies of comments and recommendations. If the developer does not adopt a recommendation, the filing should include the developer's reasons based on project specific recommendations.

9. Control of Erosion, Dust, and Slope Stability

   Within 1 year from the date of issuance of a license, developers should, after consultation with the Corps, the U. S. Environmental Protection Agency, state water quality agencies, and state fish and wildlife resource agencies, prepare and file with the Commission a plan to control erosion, dust, and slope stability at the project construction site and at spoil disposal areas, and to minimize the quantity of sediment or other potential water pollutants resulting from construction and operation of the project. The plan should include provisions for identifying and mapping any erosive soils and potentially unstable slopes; an implementation schedule; monitoring and maintenance programs for project construction and maintenance; provisions for periodic review of the plan and for making any necessary revisions to the plan. In the event that the developer does not concur with any agency recommendations, developer should provide a discussion of the reasons for not concurring based on actual site geological, soil, and groundwater conditions.

5.4.3 Site-Specific Recommendations

The following actions and mitigation measures are recommended for individual sites. The recommended spill flows mentioned here are summarized in Table 2.1.3-1. These spill flows are subject to temporary modification for water quality management, in accordance with Recommendation 2, Section 5.4.2-1.

1. Allegheny L&D No. 4: Aeration at Allegheny L&D No. 4 is important to make up for aeration lost at the licensed projects at upstream dams. The recommended spill is 8000 cfs during the critical season of July through October, and 1000 cfs the rest of the year. The critical season spill flow was determined by using the water quality optimization model to maintain 6.5 mg/L, and the noncritical season flow was determined to be adequate for aeration and habitat protection.

2. Allegheny L&D No. 3: The proposed project at this site would have impacts on fisheries, recreation, and wetlands; licensing of this project is recommended only if mitigation for these impacts is implemented. The impacts to these resources at this site are related to the extensive islands (Fourteen Mile Island), gravel bars, and wetlands upstream and downstream of the dam. The gravel bars and wetlands provide habitat for fish and

terrestrial species. The shallow backwater between Fourteen Mile Island and the north bank provides wading access for recreational fishing. To mitigate impacts to wetlands from pool elevation changes, licensing of this project is recommended only if crest gates are installed. The design and operation of such gates must be in accordance with Corps recommendations. The crest gates must not reduce the aeration capacity of the dam (as measured by using the linear aeration model discussed in Sect. 4.1.1.1), unless spill flows are increased to make up for decreased aeration capacity.

To mitigate for fish habitat disturbed by the project, the developer should file for Commission approval a plan for development of new gravel habitat in the channel that will receive powerhouse flows. This plan should be filed within 12 months following issuance of a license, implemented before plant operations begin, and developed in consultation with the USFWS and the Pennsylvania Fish Commission. The plan should consider use of clean gravel excavated for powerhouse construction for construction of fish habitat similar to that disrupted by the project. Physical hydraulic modeling should be used to design the habitat.

A revised recreation plan should be filed with the Commission after consulting with state and federal agencies regarding any additional recreational compensation measures that may be needed.

Spill flows at Allegheny L&D No. 3 are required to maintain water quality, fish habitat, and a minimum flow depth over the concrete structure. The recommended spill flow is 1,000 cfs year-round.

3. Allegheny L&D No. 2: Aeration at Allegheny L&D No. 2 is important for maintenance of DO concentrations in the Ohio River. The recommended spill is 7000 cfs during the critical season of July through October and 1000 cfs the rest of the year. The critical season spill flow was determined by using the water quality optimization model to maintain 6.5 mg/L, and the noncritical season flow was determined to be adequate for aeration and habitat protection.

   During the detailed design of the project and before beginning construction, the developer should coordinate with the chief executive officer (or official designated by the chief executive officer) of O'Hara Township, Pennsylvania, to ensure that the location and design of the project access route and transmission line are compatible with the township's plans and policies.

4. Tygart Dam: Maintenance of near-saturation DO concentrations at the Tygart Dam project is important because (a) below the dam, the river enters a long deep stretch, where surface aeration is expected to be relatively low, and where the river receives a wastewater discharge; and (b) the hydropower project would withdraw water from low in the reservoir, where DO concentrations may be low. In addition, the proposed intake for the hydropower project would be higher than the existing gate discharges, so potential problems resulting from reduced flushing of the deep, cold water layer in the reservoir may occur. Entrainment of reservoir fishes through hydropower turbines is likely, yet numbers and possible mitigative measures are uncertain. The unique situation at Tygart relative to other sites evaluated indicates the need for special study. Within 12 months following the date of issuance of a license, the developer should file a plan with the Commission, the Corps, and the West Virginia Department of Natural Resources, that includes measures designed to ensure that (a) the discharge from the powerhouse would be at least 90 percent saturated with DO at all times except in winter and spring when DO concentrations are not critical, using proven technologies such as turbine or penstock aeration, spill flows, a multi-level intake, or an aeration weir; (b) the water temperature regime below the dam will not be adversely affected; (c) supersaturation sufficient to cause trauma to fish would be avoided; (d) the size of the cold, deoxygenated bottom strata of the lake would not be significantly expanded as a result of the project, and (e) entrainment of fish through turbines is measured and minimized. This plan should be filed with the Commission for approval and implemented when operation of the project starts.

   Flow releases at Tygart should be as specified by the Corps to avoid peaking, pulsating, or averaging. Spillage through the dam gates for flushing of walleye should be provided, in compliance with agreements between the Corps and the WVDNR.

During detailed design and before beginning construction, the developer should revise the proposed transmission line route to avoid a water tank of the Southwestern Water District.

During the months of May through August, the developer should limit construction activities to weekdays between the hours of 8:00 a.m. and 6:00 p.m.

5. Opekiska L&D: This dam provides little aeration and can decrease DO concentrations during stratified conditions. A zero spill flow is recommended. The project should be designed to withdraw water from all elevations of the Opekiska pool.

   The developer should limit the hauling of spoil materials and other movements of heavy vehicles on local secondary roads to the hours between 8:00 a.m. and 6:00 p.m.

6. Hildebrand L&D: The recommended spill is 1500 cfs during the critical season of July through October, and 500 cfs the rest of the year. The critical season spill flow was determined by using the water quality optimization model to maintain 6.5 mg/L, and the non-critical season flow was determined to be adequate for aeration and habitat protection. The developer should coordinate plans for the project with the owners of a residential development currently under construction in the vicinity to minimize adverse impacts on the residential area during construction and operation of the project. The developer should compensate owners of the residential area for any deterioration of the roadways owned by the residential development caused by traffic associated with the construction of the hydropower project.

7. Morgantown: If a license application for Morgantown is accepted for filing, the recommended spill flow is 1500 cfs during the critical season of July through October and 500 cfs the rest of the year. The critical-season spill flow was determined by the water quality optimization model to maintain 6.5 mg/L, and the noncritical season flow was determined to be adequate for aeration and habitat protection.

8. Point Marion L&D: The recommended spill is 1000 cfs during the critical season of July through October and 500 cfs the rest of the year. The critical-season spill flow was determined by the water quality optimization model to maintain 6.5 mg/L, and the non-critical season flow was determined to be adequate for aeration and habitat protection.

9. Maxwell L&D: The recommended spill is 500 cfs the entire year. The spill flow was determined by the water quality optimization model to maintain 6.5 mg/L during the critical season of July through October and is adequate for aeration and habitat protection during the noncritical season.

10. Monongahela L&D No. 4: The recommended spill is 500 cfs the entire year. The spill flow was determined the water quality optimization model to maintain 6.5 mg/L during the critical season of July through October and is adequate for aeration and habitat protection during the noncritical season.

11. Emsworth L&D: The recommended spill is 8000 cfs during the critical season of July through October and 4000 cfs the rest of the year. The critical season spill flow was determined by the water quality optimization model to maintain 6.5 mg/L, and the non-critical season flow was determined to be adequate for aeration and habitat protection. The spill flow should be split as specified by the Corps to provide some aeration in the main channel as well as in the backchannel. The DO monitors should be placed so DO concentrations in both the backchannel and main channel can be determined.

    Porous dike intake and outlet structures should not be installed unless physical modeling indicates they are required to prevent unacceptable and otherwise unmitigable erosion or navigation impacts. Many potential problems with porous dikes make their use less acceptable than other forms of mitigation. These potential problems include mortality of zooplankton and ichthyoplankton during passage through the dike; inability to backflush the dike because of clogging of the proposed air backwash systems and the lack of currents to carry backwashed sediments and debris away from the dike; interference of dikes with navigation; and the expense of construction and maintenance and accumulation of sediment and debris on the dike, increasing head loss through it (e.g., winter and spring suspended solids concentrations at Emsworth dam frequently exceed 50 mg/L; at the 19,000 cfs proposed maximum generating flow of the Emsworth project that includes a porous dike, 50 mg/L of sediment is a load of over 2,500 tons of sediment per day).

12. Dashields L&D: The recommended spill is 14,000 cfs during the critical season of July through October and 4000 cfs the rest of the year. The critical-season spill flow was determined by the water quality optimization model to maintain 6.5 mg/L, and the non-critical season flow was determined to be adequate for aeration and habitat protection.

13. New Cumberland L&D: The recommended spill is 15,000 cfs during the critical season of July through October and 4000 cfs the rest of the year. The critical-season spill flow was determined by the water quality optimization model to maintain 6.5 mg/L, and the non-critical season flow was determined to be adequate for aeration and habitat protection.

14. Pike Island L&D: The recommended spill is 6000 cfs during the critical season of July through October and 4000 cfs the rest of the year. The critical-season spill flow was determined by the water quality optimization model to maintain 6.5 mg/L, and the non-critical season flow was determined to be adequate for aeration and habitat protection.

15. Willow Island L&D: This dam does not provide significantly more aeration than can be expected from a hydropower project. No spill flow is recommended.

16. Belleville L&D: This dam does not provide significantly more aeration than can be expected from a hydropower project. No spill flow is recommended.

    The developer should construct a new road segment approximately 450 feet long from State Route 68 to the portion of the existing access road that follows the axis of the dam. This revised access route will avoid impacts to the Belleville community during construction and operation of the project. The developer should consult with ODNR, USFWS, and the Corps to minimize impacts of this access road to the slough it would cross. The road should be built in accordance with all applicable regulations and wetlands permit requirements.

17. Gallipolis L&D: This dam does not provide significantly more aeration than can be expected from a hydropower project. No spill flow is recommended. The developer for FERC No. 10098, if licensed, should consult with WVDNR, USFWS, and the Corps before final development of plans for the transmission line crossing the Flatfoot Creek wetlands. Any necessary alterations in placement of poles and other site-specific mitigation measures to minimize impacts to these wetlands should be developed in consultation with these agencies. The developer should obtain all required permits and comply with appropriate regulations in constructing the transmission line.

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8. LIST OF RECIPIENTS

8.1 FEDERAL AGENCIES

Advisory Council on Historic Preservation
Bonneville Power Administration
Coast Guard
Department of Agriculture, Forest Service
Department of Agriculture, Soil Conservation Service
Department of the Army, Corps of Engineers, Huntington District
Department of the Army, Corps of Engineers, Louisville District
Department of the Army, Corps of Engineers, Ohio River Division
Department of the Army, Corps of Engineers, Pittsburgh District
Department of the Army, Corps of Engineers, Waterways Experiment Station
Department of Commerce, National Marine Fisheries Service
Department of Energy
Department of Health, Education and Welfare
Department of the Interior, Fish and Wildlife Service
Department of the Interior, Geological Survey, Water Resources Division, Pittsburgh
Department of Transportation
Environmental Protection Agency
Environmental Protection Agency, Region III
Environmental Protection Agency, Region IV
Environmental Protection Agency, Region V
National Park Service, Mid-Atlantic Region
Tennessee Valley Authority

8.2 OHIO STATE AND LOCAL AGENCIES

Attorney General of Ohio
Buckeye Hills-Hocking Valley Regional Development District, Marietta
Chairman, Board of Commissioners, Belmont County
Chairman, Board of Commissioners, Gallia County
Chairman, Board of Commissioners, Jefferson County
Chairman, Board of Commissioners, Mahoning County
Chairman, Board of Commissioners, Washington County
Governor of Ohio
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Mayor, City of East Liverpool
Mayor, City of Jackson
Mayor, City of Stubenville
Mayor, City of Toronto
Mayor, City of Wellsville
Ohio River Basin Commission
Ohio Valley Regional Development Commission
Ohio River Valley Water Sanitation Commission
State of Ohio, Bureau of Employment Services
State of Ohio, Department of Agriculture
State of Ohio, Department of Natural Resources
- Division of Environmental Analysis
- Division of Parks and Recreation
- Division of Soil and Water Districts
- Division of Water Transportation
- Division of Wildlife

State of Ohio, Environmental Protection Agency
State of Ohio, Historic Preservation Office
State of Ohio, Historical Society
State of Ohio, Office of Outdoor Recreation Services
State of Ohio, Public Utilities Commission
State of Ohio, State Clearinghouse

8.3 PENNSYLVANIA STATE AND LOCAL AGENCIES

Allegheny County Health Department, Pittsburgh
Attorney General of Pennsylvania
Chairman, Board of Commissioners, Allegheny County
Chairman, Board of Commissioners, Armstrong County
Chairman, Board of Commissioners, Beaver County
Chairman, Board of Commissioners, Butler County
Chairman, Board of Commissioners, Fayette County
Chairman, Board of Commissioners, Washington County
Chairman, Board of Commissioners, Westmoreland County
Commonwealth of Pennsylvania, Department of Agriculture
Commonwealth of Pennsylvania, Coastal Zone Management Office
Commonwealth of Pennsylvania, Department of Environmental Resources
- Bureau of Dams and Waterways Management
- Bureau of Environmental Planning
- Bureau of Forestry
- Bureau of Soil and Water Conservation
- Bureau of State Parks
- Bureau of Water Quality Management
- Bureau of Water Resources Management

Commonwealth of Pennsylvania, Fish Commission
Commonwealth of Pennsylvania, Game Commission
Commonwealth of Pennsylvania, Historical and Museum Commission
Commonwealth of Pennsylvania, Department of Labor and Industry
Commonwealth of Pennsylvania, Public Utility Commission
Commonwealth of Pennsylvania, State Clearinghouse
Governor of Pennsylvania
Governor's Energy Council
Greene County Planning Commission
Mayor, Borough of Bethel Park
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Mayor, Borough of Homestead
Mayor, Borough of Pleasant Hills
Mayor, Borough of West Mifflin
Mayor, City of Pittsburgh
Mayor, O'Hara Township
Mayor, Monongahela County
Mayor, Penn Hills Township
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Mayor, Town of Donora
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Mayor, Town of Monessen
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Supervisor, Borough of Coraopolis
Supervisor, Borough of Sewickley
Supervisor, Borough of Sharpsburg
Supervisor, Borough of Springdale
Supervisor, Town of Aometonia
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8.4 WEST VIRGINIA STATE AND LOCAL AGENCIES

Attorney General of West Virginia
BEL-O-MAR Regional Council and Interstate Planning Commission
Commissioner, Hancock County
Governor of West Virginia
Mayor, City of Fairmont
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State of West Virginia, Department of Natural Resources
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State of West Virginia, Office of Community and Industrial Development
State of West Virginia, Public Utilities Commission
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Supervisor, Town of Applegate
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8.5 OTHER STATE AND LOCAL AGENCIES

Illinois Environmental Protection Agency
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City of New Martinsville, West Virginia
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