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Columbus, OH 43215
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Via Electronic Filing

December 14, 2018

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Subject: Racine Hydroelectric Project (FERC No. 2570)
Filing of Proposed Study Plan for Relicensing Studies

Dear Secretary Bose:

AEP Generation Resources Inc. (AEPGR), a unit of American Electric Power (AEP), is the Licensee, owner, and operator of the 47.5 megawatt (MW) Racine Hydroelectric Project (Project No. 2570) (Project or Racine Project), located on the Ohio River at Ohio River Mile (OHRM) 237.5, near the Town of Racine in Meigs County, Ohio. The Project is located at the U.S. Army Corps of Engineers' (USACE) Racine Locks and Dam and is operated in a run-of-river mode.

The existing license for the Project was issued by the Federal Energy Regulatory Commission (FERC or Commission) for a 50-year term, with an effective date of December 27, 1973 and expires November 30, 2023. Accordingly, AEPGR is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with 18 CFR §5.11 of the Commission's regulations, AEPGR is filing the Proposed Study Plan (PSP) describing the studies that the Licensee is proposing to conduct in support of relicensing the Project.

AEPGR filed a Pre-Application Document (PAD) and associated Notice of Intent (NOI) with the Commission on July 2, 2018, which initiated the ILP. The Commission issued Scoping Document 1 (SD1) for the Project on August 21, 2018. SD1 was intended to advise resource agencies, Indian Tribes, non-governmental organizations, and other stakeholders as to the proposed scope of FERC's Environmental Assessment (EA) for the Project and to seek additional information pertinent to the Commission's analysis.

On September 26, and 27, 2018, the Commission held public scoping meetings in Pomeroy, Ohio. During these meetings, FERC staff presented information regarding the ILP and details regarding the study scoping process and how to request a relicensing study, including the Commission's study criteria. In addition, FERC staff solicited comments regarding the scope of issues and analyses for the EA. Pursuant to 18 CFR §5.8(d), a public site visit of the Project was conducted on September 26, 2018.

Resource agencies, Indian Tribes, and other interested parties were afforded a 60-day period to request studies and provide comments on the PAD and SD1. The comment period was initiated with the Commission's August 21, 2018 notice and concluded on October 30, 2018. During the

comment period, a total of five stakeholders filed letters with the Commission providing general comments, comments regarding the PAD, comments regarding SD1, and/or study requests.

Proposed Study Plan

AEPGR has evaluated all the study requests submitted by the stakeholders, with a focus on the requests that specifically addressed the seven criteria set forth in §5.9(b) of the Commission's ILP regulations, as discussed above. For the study requests that did not attempt to address the seven study criteria, where appropriate, AEPGR considered the study in the context of providing the requested information in conjunction with one of AEPGR's proposed studies.

The purpose of this PSP is to present the studies that are being proposed by AEPGR and to address the comments and study requests submitted by resource agencies and other stakeholders. This PSP also provides FERC, regulatory agencies, Indian Tribes, and other stakeholders with the methodology and details of AEPGR's proposed studies. At this time, AEPGR is proposing to conduct the following studies as described in detail in the PSP:

1. Water Quality Study;
2. Recreation Study;
3. Cultural Resources Study;
4. Mussel Survey;
5. Fisheries Survey;
6. Fish Entrainment and Impingement Study; and
7. Eastern Spadefoot Habitat Suitability Assessment.

AEPGR is filing the PSP with the Commission electronically and is distributing this letter to the parties listed on the attached distribution list. For parties listed on the attached distribution list who have provided an email address, AEPGR is distributing this letter via email; otherwise, AEPGR is distributing this letter via U.S. mail. All parties interested in the relicensing process may obtain a copy of the PSP electronically through FERC's eLibrary system at https://elibrary.ferc.gov/idmws/search/fercgensearch.asp under docket number P-2570, or on AEPGR's website at www.aephydro.com/HydroPlant/Racine. If any party would like to request a CD containing an electronic copy of the PSP, please contact Jonathan Magalski, Environmental Specialist Consultant, at the phone number or email address listed below.

Comments on the PSP, including any additional or revised study requests, must be filed within 90 days of the filing date of this PSP which is no later than March 14, 2019. Comments must include an explanation of any study plan concerns, and any accommodations reached with AEPGR regarding those concerns (18 CFR §5.12). Any proposed modifications to this PSP must address the Commission's criteria as presented in 18 CFR §5.9(b).

As necessary, after the comment period closes, AEPGR will prepare a Revised Study Plan (RSP) that will address interested parties' comments to the extent practicable. Pursuant to the ILP,

AEPGR will file the RSP with the Commission on or before April 13, 2019, and the Commission will issue a final Study Plan Determination by May 13, 2019.

Initial Proposed Study Plan Meeting

In accordance with 18 CFR §5.11(e) of the Commission's regulations, AEPGR intends to hold an initial Proposed Study Plan Meeting (PSP Meeting) to describe the background, concepts, and study methods described in the PSP. The PSP Meeting will begin at 9:00 AM on January 10, 2019, at AEP Ohio's Athens Service Center, located at 9135 State Route 682 in Athens, Ohio.

To assist with meeting planning and logistics, AEPGR respectfully requests that individuals or organizations who plan to attend the meeting please RSVP by sending an email to me at jmmagalski@aep.com on or before January 4, 2019. Also, please note that AEP Ohio's Athens Service Center is a secure building, and meeting attendees will need to be accompanied by an escort to the conference room.

If there are any questions regarding the PSP or PSP Meeting, please do not hesitate to contact me at (614) 716-2240 or at the email address above.

Sincerely,

Jonathan M. Magalski
Environmental Specialist Consultant
American Electric Power Services Corporation, Environmental Services

Enclosures

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Proposed Study Plan

Racine Hydroelectric Project

(FERC No. 2570)

December 14, 2018

Prepared by:

HDR

Prepared for:

AEP Generation Resources Inc.

AMERICAN ELECTRIC POWER

BOUNDLESS ENERGY

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List of Acronyms

ACHP	Advisory Council on Historic Preservation
ADA	Americans with Disabilities Act
ADCP	Acoustic Doppler Current Profiler
AEP	American Electric Power
AEPGR	AEP Generation Resources Inc.
AIRs	Additional Information Requests
APE	Area of Potential Effect
ARPA	Archaeological Resources Protection Act
CFR	Code of Federal Regulations
cfs	cubic feet-per-second
CPUE	Catch-per-unit of effort
DO	Dissolved Oxygen
EA	Environmental Assessment
Emsworth Back Channel Project	Emsworth Back Channel Hydroelectric Project (FERC No. 13761)
Emsworth Project	Emsworth Locks and Dam Hydroelectric Project (FERC No. 13757)
EPRI	Electric Power Research Institute
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission (or Commission)
FLA	Final License Application
FR	Federal Register
GIS	Geographic Information Systems
GPS	Global Positioning System
hp	horsepower
HPMP	Historic Properties Management Plan
ILP	Integrated Licensing Process
ISR	Initial Study Report
kV	kilovolt
kVA	kilovolt-amperes
kW	kilowatt
mg/L	milligrams per liter
Montgomery Project	Montgomery Locks and Dam Hydroelectric Project (FERC No. 13768)
MW	megawatt
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966

NGOs	non-governmental organizations
NOI	Notice of Intent
NRHP	National Register of Historic Places
ODNR	Ohio Department of Natural Resources
ODOW	Ohio Division of Wildlife
Ohio EPA	Ohio Environmental Protection Agency
OHRM	Ohio River Mile
ORSANCO	Ohio River Valley Water Sanitation Commission
PAD	Pre-Application Document
PLC	programmable logic controller
PM&E	protection, mitigation and enhancement
Project	Racine Hydroelectric Project (or Racine Project)
PSP	Proposed Study Plan
QHEI	Qualitative Habitat Evaluation Index
RC Byrd	Robert C. Byrd Hydroelectric Project
RM	river mile
RTE	rare, threatened, and endangered
RSP	Revised Study Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
SHPO	State Historic Preservation Office
STPs	shovel test pits
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report
WVDNR	West Virginia Department of Natural Resources
YOY	young-of-year

1 Introduction and Background

AEP Generation Resources Inc. (AEPGR or Licensee), a unit of American Electric Power (AEP), is the Licensee, owner, and operator of the 47.5 megawatt (MW) Racine Hydroelectric Project (Project No. 2570) (Project or Racine Project), located on the Ohio River at Ohio River Mile (OHRM) 237.5, near the Town of Racine in Meigs County, Ohio.

The existing license for the Project was issued by the Federal Energy Regulatory Commission (FERC or Commission) for a 50-year term, with an effective date of December 27, 1973 and expires November 30, 2023. Accordingly, AEPGR is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with 18 CFR §5.11 of the Commission's regulations, AEPGR is filing this Proposed Study Plan (PSP) describing the studies that the Licensee is proposing to conduct in support of relicensing the Project.

1.1 Study Plan Overview

AEPGR filed a Pre-Application Document (PAD) and associated Notice of Intent (NOI) with the Commission on July 2, 2018, to initiate the ILP. The PAD provides a description of the Project and summarizes the existing, relevant, and reasonably available information to assist the Commission, resource agencies, Indian Tribes, non-governmental organizations (NGOs), and other stakeholders to identify issues, determine information needs, and prepare study requests.

The National Environmental Policy Act of 1969 (NEPA), the Commission's regulations, and other applicable statutes require the Commission to independently evaluate the environmental effects of issuing new licenses for the Project, and to consider reasonable alternatives to relicensing. At this time, the Commission has expressed its intent to prepare an Environmental Assessment (EA) that describes and evaluates the site-specific and cumulative potential effects (if any) of issuing the new license, as well as potential alternatives to relicensing. The EA is being supported by a scoping process to identify issues, concerns, and opportunities for resource enhancement associated with the proposed action. Accordingly, the Commission issued Scoping Document 1 (SD1) for the Project on August 21, 2018. SD1 was intended to advise resource agencies, Indian Tribes, NGOs, and other stakeholders as to the proposed scope of the EA and to seek additional information pertinent to the Commission's analysis. As provided in 18 CFR §5.8(a) and §5.8(b), the Commission issued a notice of commencement of the relicensing proceeding concomitant with SD1.

On September 26, and 27, 2018, the Commission held public scoping meetings in Pomeroy, Ohio. During these meetings, FERC staff presented information regarding the ILP and details regarding the study scoping process and how to request a relicensing study, including the Commission's study criteria. In addition, FERC staff solicited comments regarding the scope of issues and analyses for the EA. Pursuant to 18 CFR §5.8(d), a public site visit of the Project was conducted on September 26, 2018.

Resource agencies, Indian Tribes, and other interested parties were afforded a 60-day period to request studies and provide comments on the PAD and SD1. The comment period was initiated with the Commission's August 21, 2018 notice and concluded on October 30, 2018.

FERC's ILP regulations require that stakeholders who provide study requests include specific information in the request in order to allow the Licensee, as well as Commission staff, to determine a requested study's appropriateness and relevancy to the Project and proposed action. As described in 18 CFR §5.9(b) of the Commission's ILP regulations, and as presented by FERC staff during the September 26 and 27, 2018 scoping meetings, the required information to be included in a study request is as follows:

(1) Describe the goals and objectives of each study and the information to be obtained (§5.9(b)(1));

This section describes why the study is being requested and what the study is intended to accomplish, including the goals, objectives, and specific information to be obtained. The goals of the study must clearly relate to the need to evaluate the effects of the Project on a particular resource. The objectives are the specific information that needs to be gathered to allow achievement of the study goals.

(2) If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied (§5.9(b)(2));

This section must clearly establish the connection between the study request and management goals or resource of interest. A statement by an agency connecting its study request to a legal, regulatory, or policy mandate needs to be included that thoroughly explains how the mandate relates to the study request, as well as the Project's potential impacts.

(3) If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study (§5.9(b)(3));

This section is for non-agency or Indian Tribes to establish the relationship between the study request and the relevant public or tribal interest considerations.

(4) Describe existing information concerning the subject of the study proposal and the need for additional information (§5.9(b)(4));

This section must discuss any gaps in existing data by reviewing the available information presented in the PAD or information relative to the Project that is known from other sources. This section must explain the need for additional information and why the existing information is inadequate.

(5) Explain any nexus between project operation and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirements (§5.9(b)(5));

This section must clearly connect Project operations and Project effects on the applicable resource. This section can also explain how the study results would be used to develop protection, mitigation, and enhancement (PM&E) measures that could be implemented under a new FERC license. The PM&E measures can include those related to any mandatory conditioning authority under Section 401 of the Clean Water Act[1] or Sections 4(e) and 18 of the Federal Power Act, as applicable.

(6) Explain how any proposed study methodology is consistent with generally accepted practices in the scientific community or, as appropriate, considers relevant tribal values and knowledge. This includes any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration (§5.9(b)(6));

This section must provide a detailed explanation of the study methodology. The methodology may be described by outlining specific methods to be implemented or by referencing an approved and established study protocol and methodology.

(7) Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs (§5.9(b)(7));

This section must describe the expected level of cost and effort to conduct the study. If there are proposed alternative studies, this section can address why the alternatives would not meet the stated information needs.

During the comment period, a total of five stakeholders filed letters with the Commission providing general comments, comments regarding the PAD, comments regarding SD1, and/or study requests. A total of seven study requests were submitted by the U.S. Fish and Wildlife Survey (USFWS), West Virginia Department of Natural Resources (WVDNR), and the Ohio Department of Natural Resources (ODNR). No other formal study requests were received from stakeholders during the comment period. The U.S. Environmental Protection Agency (USEPA) filed general information, statements, and/or informal study requests related to the Project. FERC filed comments and an additional information request, which is addressed in this PSP in Section 6. Copies of the letters filed with the Commission are provided in Appendix A of this document. The ILP requires AEPGR to file this PSP within 45 days from the close of the October 30, 2018 comment period (i.e., on or before December 14, 2018).

The purpose of this PSP is to present the studies that are being proposed by AEPGR and to address the comments and study requests submitted by resource agencies and other stakeholders. This PSP also provides FERC, regulatory agencies, Indian Tribes, and other stakeholders with the methodology and a detail of AEPGR's proposed studies. As necessary, after the comment period closes, AEPGR will prepare a Revised Study Plan (RSP) that will address interested parties' comments to the extent practicable.

[1] 33 United States Code (U.S.C.) §1251 *et seq.*

Pursuant to the ILP, AEPGR will file the RSP with the Commission on or before April 28, 2019, and the Commission will issue a final Study Plan Determination by May 13, 2019.

1.2 AEPGR's Proposed Study Plan

AEPGR has evaluated all the study requests submitted by the stakeholders, with a focus on the requests that specifically addressed the seven criteria set forth in §5.9(b) of the Commission's ILP regulations, as discussed above. For the study requests that did not attempt to address the seven study criteria, where appropriate, AEPGR considered the study in the context of providing the requested information in conjunction with one of AEPGR's proposed studies.

Based on AEPGR's review of the requested studies, FERC criteria for study requests under the ILP, and other available information (e.g., associated with the previous licensing effort or resulting from ongoing monitoring activities), AEPGR is proposing seven studies to be performed in support of issuing a new license for the Project. Information regarding each of these studies is provided in Sections 7 through 13 of this PSP. For each of AEPGR's proposed studies, this PSP describes:

1. The goals and objectives of the study;
2. The defined study area;
3. A summary of background and existing information pertaining to the study;
4. The nexus between Project operations and potential effects on the resources to be studied;
5. The proposed study methodology;
6. Level of effort, cost, and schedules for conducting the study; and
7. Discussion of alternative approaches.

1.2.1 Comments on the Proposed Study Plan

Comments on this PSP, including any additional or revised study requests, must be filed within 90 days of the filing date of this PSP (i.e., no later than March 14, 2019). Comments must include an explanation of any study plan concerns, and any accommodations reached with AEPGR regarding those concerns (18 CFR §5.12). Any proposed modifications to this PSP must address the Commission's criteria as presented in 18 CFR §5.9(b).

1.2.2 Proposed Study Plan Meeting

In accordance with 18 CFR §5.11(e), AEPGR plans to hold a PSP Meeting on January 10, 2019 in Athens, Ohio. The purpose of the PSP Meeting will be to clarify the intent

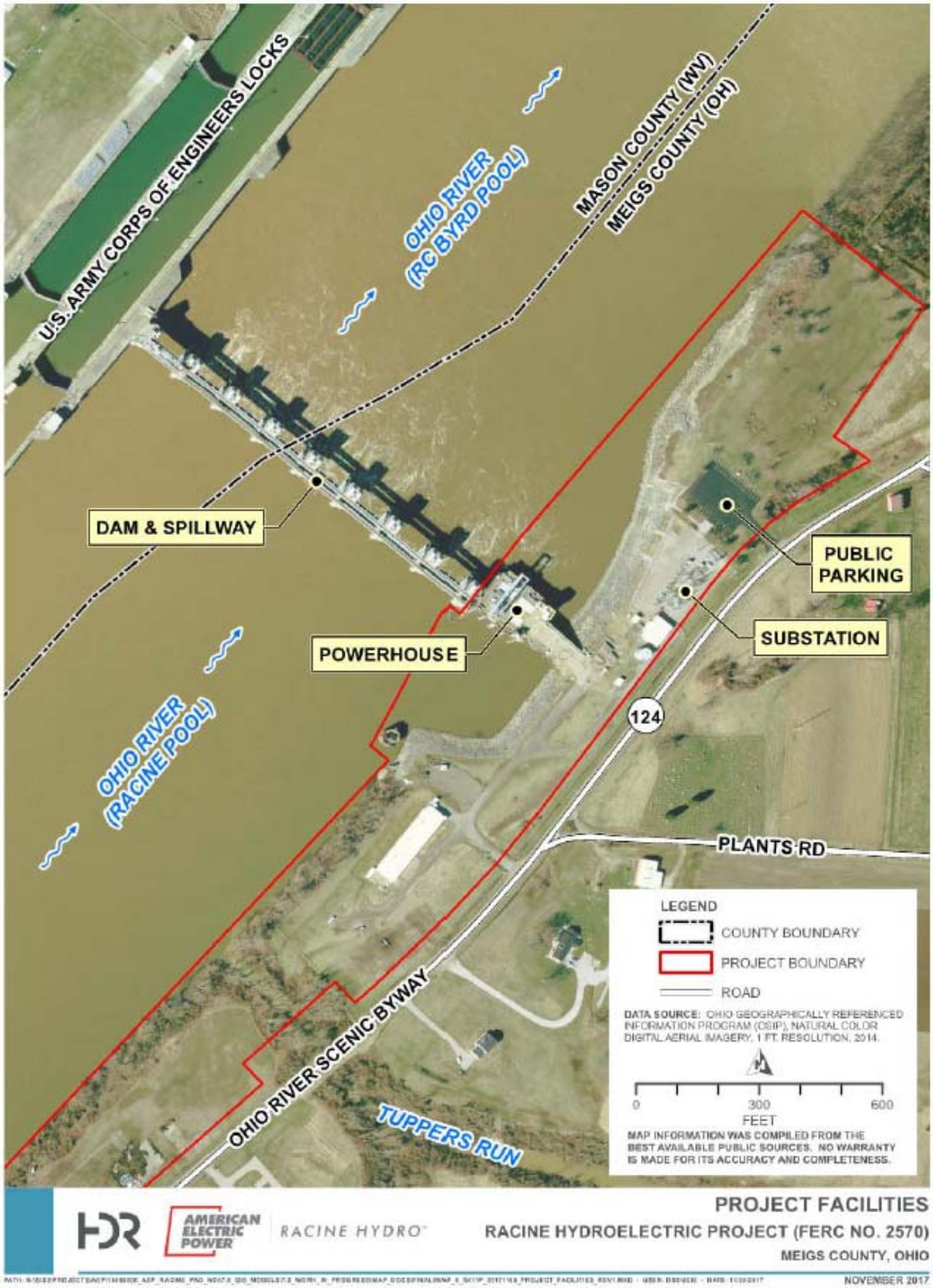
and contents of this PSP, explain information gathering needs, and resolve outstanding issues associated with the proposed studies. Additional details regarding the meeting are presented in Section 5 of this document.

1.3 Project Description and Location

The Racine Project facilities include an intake canal, a powerhouse with two horizontal bulb turbines (each connected to a generator), a cellular cofferdam connecting the powerhouse to the right abutment, and a tailrace. The intake canal, which leads to the powerhouse's intake structure, is about 350 feet-long and 110 feet-wide. The intake structure, which is integral with the powerhouse, contains two 21.75 feet-wide by 60 feet-high intake openings for each of the two generating units, providing four openings total. Each intake opening has a set of steel trashracks. Two sets of stoplogs are provided so both units can be dewatered at the same time. The reinforced concrete powerhouse is a water-retaining structure approximately 132 feet-long and 210 feet-wide. The powerhouse contains two horizontal bulb turbines, each connected to a direct-coupled generator; each turbine/generator unit has an installed capacity of 24 MW at a flow of 16,000 cubic feet-per-second (cfs) under a gross head of 22 feet. The turbine/generator units discharge to a tailrace that returns the flow to the river 450 feet downstream of the dam. The 9 kilovolt (kV) generator leads are connected to a 9/69 kV step-up transformer by a 475 foot-long transmission line. The step-up transformer is connected to the Racine bus where it connects to the grid.

The Project is located on the Ohio River near the Town of Racine in Meigs County, Ohio (Figure 1-1). The Project is located at the U.S. Army Corps of Engineers' (USACE) Racine Locks and Dam and is operated in a run-of-river mode.

Figure 1-1. Racine Hydroelectric Project Facilities



2 Execution of the Study Plan

As required by Section 5.15 of FERC's ILP regulations, AEPGR will prepare progress reports on a quarterly basis, file an Initial Study Report (ISR), hold a meeting with stakeholders and FERC staff to discuss the initial study results (ISR Meeting), and prepare and file an Updated Study Report (USR) and convene an associated USR Meeting, as appropriate. AEPGR will submit all study documents that must be filed with the Commission via FERC's eFiling system.

2.1 Process Plan and Schedule

The Process Plan and Schedule is presented in Table 2-1. Gray shaded milestones are unnecessary if there are no study disputes. If the due date falls on a weekend or holiday, the due date is the following business day. Early filings or issuances will not result in changes to these deadlines.

Table 2-1. Process Plan and Schedule

Milestone	Responsible Party	Time Frame	Estimated Date
File NOI and PAD (18 CFR §5.5(d))	AEPGR	As early as 5.5 years but no later than 5 years prior to license expiration	July 2, 2018
Initial Tribal Consultation Meeting (18 CFR §5.7)	FERC	No later than 30 days of filing NOI and PAD	August 1, 2018
Issue Notice of PAD/NOI and SD1 (18 CFR §5.8(a))	FERC	Within 60 days of filing NOI and PAD	August 31, 2018
Conduct Scoping Meetings and Site Visit (18 CFR §5.8(b) (viii))	FERC	Within 30 days of NOI/PAD notice and SD1 issuance	September 26-27, 2018
Comments on PAD, SD1, and Study Requests (18 CFR §5.9(a))	Stakeholders	Within 60 days of NOI/PAD notice and issuance of SD1	October 30, 2018
Issuance of Scoping Document 2 (SD2) (18 CFR §5.10) (if necessary)	FERC	Within 45 days of deadline for filing comments on SD1	December 12, 2018
File PSP (18 CFR §5.11)	AEPGR	Within 45 days of deadline for filing comments on PAD	December 14, 2018
Study Plan Meeting(s) (18 CFR §5.11(e))	AEPGR	Meeting to be held within 30 days of filing PSP	January 10, 2018
Comments on PSP (18 CFR §5.12)	Stakeholders	Within 90 days of filing PSP	March 14, 2019
File RSP (18 CFR §5.13(a))	AEPGR	Within 30 days of deadline for comments on PSP	April 13, 2019

Milestone	Responsible Party	Time Frame	Estimated Date
Comments on RSP (18 CFR §5.13(b))	Stakeholders	Within 15 days following RSP	April 28, 2019
Issuance of Study Plan Determination (18 CFR §5.13(c))	FERC Director	Within 30 days of RSP	May 13, 2019
Formal Study Dispute Resolution Process (18 CFR §5.14(a)) (if necessary)	Agencies and Tribes with mandatory conditioning authority	Within 20 days of study plan determination	June 2, 2019
Dispute Resolution Panel Convenes (18 CFR §5.14(d)) (if necessary)	Dispute Resolution Panel	Within 20 days of a notice of study dispute	June 22, 2019
Comments on Study Plan Disputes (18 CFR §5.14(i)) (if necessary)	AEPGR	Within 25 days of notice of study dispute	June 27, 2019
Third Panel Member Selection Due (18 CFR §5.14(d)(3)) (if necessary)	Dispute Resolution Panel	Within 15 days of when Dispute Resolution Panel convenes	July 7, 2019
Dispute Resolution Panel Technical Conference (18 CFR §5.14(j)) (if necessary)	Dispute Resolution Panel, AEPGR, Stakeholders	Prior to engaging in deliberative meetings	-
Dispute Resolution Panel Findings and Recommendations (18 CFR §5.14(k)) (if necessary)	Dispute Resolution Panel	No later than 50 days after notice of dispute	July 22, 2019
Study Dispute Determination (18 CFR §5.14(1)) (if necessary)	FERC Director	No later than 70 days after notice of dispute	August 11, 2019
Conduct First Season of Studies (18 CFR §5.15)	AEPGR	-	Spring/Fall 2019
Study Progress Report (18 CFR §5.15(b))	AEPGR	AEPGR will provide summary updates every three months	June 2019 to September 2020

Milestone	Responsible Party	Time Frame	Estimated Date
Initial Study Report (18 CFR §5.15(c))	AEPGR	Pursuant to the Commission-approved study plan or no later than 1 year after Commission approval of the study plan, whichever comes first	May 12, 2020
Initial Study Report Meeting (18 CFR §5.15(c)(2))	AEPGR and Stakeholders	Within 15 days of filing the initial study report	May 27, 2020
File Initial Study Report Meeting Summary (18 CFR §5.15(c)(3))	AEPGR	Within 15 days of initial study report meeting	June 11, 2020
File Meeting Summary Disagreements (18 CFR §5.15(c)(4)) (if necessary)	Stakeholders	Within 30 days of study results meeting summary	July 11, 2020
File Responses to Meeting Summary Disagreements (18 CFR §5.15(c)(5)) (if necessary)	AEPGR	Within 30 days of filing meeting summary disagreements	August 10, 2020
Resolution of Disagreements (18 CFR §5.15(c)(6)) (if necessary)	FERC Director	Within 30 days of filing responses to disagreements	September 9, 2020
Conduct Second Season of Studies (if necessary)	AEPGR	-	Summer/Fall 2020
File Updated Study Report (18 CFR §5.15(f)) (if necessary)	AEPGR	Pursuant to the Commission approved study plan and schedule provided in §5.13 or no later than two years after Commission approval	May 12, 2021
Updated Study Report Meeting (18 CFR §5.15(f)) (if necessary)	AEPGR and Stakeholders	Within 15 days of updated study report	May 27, 2021
File Updated Study Report Meeting Summary (18 CFR §5.15(f)) (if necessary)	AEPGR	Within 15 days of study report meeting	June 11, 2021
File Meeting Summary Disagreements (18 CFR §5.15(f))	Stakeholders	Within 30 days of study results meeting summary	July 11, 2021

Milestone	Responsible Party	Time Frame	Estimated Date
File Responses to Meeting Summary Disagreements (18 CFR §5.15(f)(5))	AEPGR	Within 30 days of filing meeting summary disagreements	August 10, 2021
Resolution of Disagreements (18 CFR §5.15(f)) (if necessary)	FERC Director	Within 30 days of filing responses to disagreements	September 9, 2021
File Preliminary Licensing Proposal or Draft License Application (18 CFR §5.16(a))	AEPGR	No later than 150 days prior to the deadline for filing the Final License Application (FLA)	July 3, 2021
Comments on Preliminary Licensing Proposal or Draft License Application Due (18 CFR §5.16(e))	Stakeholders	Within 90 days of filing Preliminary Licensing Proposal or Draft License Application	October 1, 2021
File License Application (18 CFR §5.17)	AEPGR	No later than 24 months before the existing license expires	November 30, 2021

3 Responses to Stakeholder Study Requests

3.1 Study Requests Deemed Appropriate for Study

A total of seven formal study requests were made by stakeholders. Many study requests were duplicative or similar in purpose and scope to that of other study requests. Where possible, AEPGR consolidated common themes and elements resulting in seven individual studies, which are detailed in Sections 7 through 13 of this PSP, to address study requests and comments made by FERC, resource agencies, and stakeholders.

3.2 Study Requests Deemed Not Appropriate for Study

3.2.1 Fish Protection and Upstream and Downstream Passage Study

The WVDNR and USFWS have requested a study of fish protection measures and upstream and downstream passage at the Project. AEPGR is not proposing to conduct a Fish Protection and Upstream and Downstream Passage Study at this time. In the first instance, AEPGR believes that such a study would be premature and that the need for additional information regarding fish passage or protection alternatives at the Project has not been demonstrated.

Each of the U.S. Army Corps of Engineers (USACE's) navigational dams along the Ohio River create, at minimum, partial obstacles to fish migration (USACE 2016). The USACE does not operate fish passage facilities at any of the locks and dams along the Ohio River, and the USACE has not provided definitive plans to construct fish passage structures at these facilities. At the Racine Locks and Dam, resident fish are able to move upstream and downstream past the dam via the locks during navigational operations. Additional downstream passage may occur via flow released through the dam's gates, spilling over the dam, or passing through the Project intakes and turbines during hydroelectric operations.

AEPGR believes that it is not appropriate to conduct fish protection and passage studies at this time, as there is no evidence to indicate that Project operations are having an adverse effect on fish populations in the Ohio River. The results of the previous entrainment study conducted at the Racine Project indicated that the predominant fish entrained were gizzard shad (*Dorosoma cepedianum*) and freshwater drum (*Aplodinotus grunniens*). Based on the study's results, mortality was estimated to be, at most, 10 percent of those fish entrained (Wapora, Inc. 1987). Given the high reproductive potential of these fish, FERC's Final Environmental Impact Statement (FEIS) concluded that the mortality rate would not result in negative impacts to these fish populations. More recent studies of fish impingement, entrainment, and mortality at hydropower facilities along the Ohio River have also demonstrated that the operation of large bulb-type turbines, consistent with the turbines at the Racine Project, have little to no appreciable effect on

fish populations. As an example, FERC recently analyzed the effects of impingement, entrainment, and turbine mortality on fish at the Robert C. Byrd Hydroelectric Project (FERC No. 12796) (RC Byrd Project), which is under construction downstream from the Racine Project. The RC Byrd Project will utilize large, bulb turbines with adjustable Kaplan runners similar to the Racine Project[2]. FERC's 2015 EA of the RC Byrd Project's effects on impingement, entrainment, and turbine mortality concluded that:

[i]n summary, most fish would not be susceptible to impingement on the intake screens due to the relatively large spacing between bars, but most small and medium size fish would be susceptible to entrainment through the project turbine…Fish entrained into the turbine units would have a low probability of blade strike. The survival rate for most small and medium size fish likely to be entrained would be high. The majority of the fish impacted by the turbines would likely consist of young fish of highly prolific species that have the ability to compensate for losses. Therefore, the estimated entrainment and mortality would only minimally effect fish populations in the project vicinity (FERC 2015).

Entrainment mortality that has no appreciable impact on fish populations cannot be characterized as "losses" to the fishery (see *City of New Martinsville v. FERC*, 102F.3d at 571 (D.C. Cir. 1996)). Where evidence of a problem has not been shown, the licensee does not have a duty to perform studies to determine whether a problem exists (see *City of Centralia, WA v. FERC*, 213F.3d 742 at 749 (D.C. Cir. 2000)).

As discussed in this PSP, AEPGR is proposing to synthesize existing fisheries data, conduct a tailrace fisheries survey, and complete an updated, Entrainment and Impingement Evaluation using recent fisheries data to assess turbine-induced fish mortality and to evaluate the effects of Project operations on the fish community. AEPGR will consult with stakeholders regarding the need (if any) for fish protection measures at the Project based on the fisheries data and the results of the Entrainment and Impingement Evaluation.

AEPGR also notes that the longitudinal fragmentation of the Ohio River and the lack of "safe, timely, and efficient fish passage" identified in the USFWS's study request are caused not by the Racine Project but by the USACE's Racine Locks and Dam facility that was placed into service in 1967 (which replaced an earlier lock and dam structure). The Racine Project was licensed by the Commission in 1973 and neither the lock structures nor the dam are Project features. AEPGR does not own or operate the Racine Locks and Dam, and the hydroelectric Project itself (which physically spans only a portion of the river) is not serving as a barrier to upstream or downstream fish passage. Any modification to the USACE's dam to provide fish passage is the responsibility of USACE, and FERC cannot compel the USACE to develop and construct fish passage at the Racine Locks and Dam through a new license issued to AEPGR. The USACE has

[2] While the proposed bulb-type units at the RC Byrd Project are very similar to the Racine Project's generating units, AEPGR notes that FERC's License Order for the RC Byrd Project authorized the installation of trashracks with a clear bar spacing of eight inches. The Racine Project's trashracks have a bar spacing of 6.125 inches, center-to-center.

recognized that the navigational dams along the Ohio River can have an adverse effect on fish populations (USACE 2016). To that end, the USACE has studied fish passage at the locks and dams along the Ohio River, including intensive studies of structural fish passage at the Emsworth, Dashields, and Montgomery locks and dams along the Upper Ohio River. The USACE's multi-disciplined study "identified a number of highly complex technical issues that rendered structural fish passage alternatives not feasible or highly infeasible" (USACE 2016). AEPGR also notes that given that none of these three upstream dams include hydropower, results of the USACE's fish passage study were not influenced by river flows being diverted for the production of electricity. FERC has similarly concluded that construction of fish protection devices at the Racine Project would not be practical and "offered little assurance of effectiveness[3]Therefore, AEPGR believes it is premature to study how Project operations could impact fish passage at the Racine Locks and Dam, unless or until the USACE develops a conceptual approach to providing fish passage.

3.2.2 Eel Surveys

AEPGR is proposing to conduct a Fisheries Study as described in Section 11 of this PSP. The USFWS has requested that the Fisheries Study include American eel-targeted surveys focused on detecting adult silver eels moving downstream in the fall, and yellow (juvenile) eels moving upstream during the spring. AEPGR is not proposing to conduct American eel-targeted surveys. For the reasons discussed in Section 3.2.1 of this PSP, AEPGR does not believe that it is appropriate to conduct eel passage studies at this time. As further described in Section 11.9 of this PSP, American eel have been documented in the Ohio River upstream to Pittsburgh and they have been documented in the Ohio River Valley Water Sanitation Commission's (ORSANCO) Ohio River main stem fish population database. AEPGR is proposing to complete a Fish Entrainment and Impingement Study in support of Project relicensing; because American eel have been documented in the main stem of the Ohio River and included in ORSANCO's Ohio River main stem fish population database, AEPGR intends to include American eel in the Fish Entrainment and Impingement Study. Additional, targeted eel sampling is not necessary, as existing information from previous fisheries surveys is sufficient for an Entrainment Analysis.

3.2.3 In-Field Turbine Mortality Studies

The study requests from the USFWS and WVDNR recommended that AEPGR conduct in-field studies to verify the results of the desktop Entrainment and Impingement Study. As further discussed in Section 12.9 of this PSP, AEPGR is not proposing to conduct any in-field sampling as part of this study. Desktop entrainment and impingement studies are consistent with generally accepted practices in the scientific community. The Commission did not require in-field sampling to verify the results of desktop entrainment

[3] Order Requiring Fish Mitigative and Monitoring Plan, 41 FERC ¶ 62,241 (December 14, 1987)

and impingement studies conducted in support of recent (since 2010) licensing and relicensing proceedings for other hydroelectric projects at USACE facilities along the Ohio River. AEPGR notes that recent studies of fish impingement, entrainment, and mortality at hydropower facilities along the Ohio River have demonstrated that the operation of large bulb-type turbines with Kaplan runners, consistent with the turbines at the Racine Project, have little to no appreciable effect on fish populations. In-field sampling would significantly increase the cost of this study, pose significant challenges (e.g., nets being placed in high velocity, high volume conditions), and it has not been demonstrated why the proposed alternative would not be sufficient to meet the stated information needs.

4 Study Reports

AEPGR expects to report on the progress and results of studies within the framework afforded by the ISR, and associated ISR Meeting, as well as the USR, and associated USR Meeting. Based on the exact timing of completion of work for each study, AEPGR may issue draft products between the ISR and USR to the extent practicable. At this time, AEPGR is proposing to file technical study reports with the Commission and to provide stakeholders access to the study reports consistent with the schedule presented in Table 4-1. AEPGR notes that adverse weather conditions or other circumstances may necessitate modifications to this schedule. As necessary, AEPGR will update stakeholders of changes in the schedule in quarterly study progress reports.

Table 4-1. Preliminary Schedule for Study Reporting

Study	Anticipated Date of Study Report
1. Water Quality Study	May 12, 2020 (Concurrent with ISR)
2. Recreation Study	May 12, 2020 (Concurrent with ISR)
3. Cultural Resources Study	May 12, 2020 (Concurrent with ISR)
4. Mussel Survey	May 12, 2020 (Concurrent with ISR)
5. Fisheries Survey	May 12, 2020 (Concurrent with ISR)
6. Fish Entrainment and Impingement Study	May 12, 2020 (Concurrent with ISR)
7. Eastern Spadefoot Habitat Suitability Assessment	May 12, 2020 (Concurrent with ISR)

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5 Proposal for the PSP Meeting

Pursuant to 18 CFR §5.11(e) of the Commission's ILP regulations, AEPGR is providing information regarding the PSP Meeting that will be held for the purposes of clarifying the PSP, explaining information gathering needs, and resolving outstanding issues associated with the proposed studies. The Commission's regulations and the approved Process Plan and Schedule require AEPGR to conduct the PSP Meeting within 30 days of the filing of this PSP. Accordingly, AEPGR will hold the PSP Meeting on January 10, 2019 at AEP Ohio's Athens Service Center, located at 9135 State Route 682 in Athens, Ohio.

AEPGR respectfully requests that individuals or organizations that plan on attending the PSP Meeting RSVP no later than January 4, 2019, by emailing Jon Magalski at the address below. Also, please note that AEP Ohio's Athens Service Center is a secure facility, and meeting attendees will need to be accompanied by an escort to the conference room.

Additional details regarding the meeting are presented below.

- Date: January 10, 2019
- Time: 9:00 a.m. (until 5:00 p.m., if necessary)
- Location: AEP Ohio's Athens Service Center
  9135 State Route 682
  Athens, OH 45701
- For additional information, please contact:

  Jonathan Magalski
  Environmental Specialist Consultant
  American Electric Power Service Corporation
  C/o AEP Generation Resources Inc.
  1 Riverside Plaza, Columbus, OH 43215
  (614) 716-2240
  jmmagalski@aep.com

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6 FERC Additional Information Requests (AIRs)

In its comments dated October 26, 2018, FERC staff requested additional information about the Racine Project based on their review of the PAD. The following sections identify the AIRs and AEPGR's response to each requested item.

6.1 Aquatic Resources

AIR 1: *Section 5.3.2, Flows, of the PAD presents the daily flow data and section 5.3.3, Flow Duration Curves, presents the flow duration curves for the project. In section 5.3.3, Flow Duration Curves, of the PAD, you state that the flow data provided was obtained from the U.S. Geological Survey (USGS) gage on the Ohio River at Greenup dam (gage no. 03216600) using 1987 through 2016 as the period of record. Please describe how the USGS data was adjusted to reflect the difference in drainage areas between the project and Greenup dam.*

AEPGR Response: As stated in Section 5.3.3 of the PAD, the annual and monthly flow duration curves were developed using data from the USGS Gage 03216600 Ohio River at Greenup Dam near Greenup, KY. The hydrology information was linearly prorated to the Project site based on the drainage areas (62,000 square miles at the USGS gage vs. 40,130 square miles at the Project site), which equates to a proration ratio of approximately 0.647.

The linear proration method estimates flows for a region of interest by utilizing one or more reference basins with available representative data. The linear proration method gives an estimate of flows for a given watershed of interest by scaling the reference basin as follows:

$$Q_{target} = \left(\frac{A_{target}}{A_{reference}} \right) Q_{referenc}$$

Where: Q_{target} is the flow (cfs) for the basin of interest.

$Q_{reference}$ is the flow (cfs) for the reference basin.

A_{target} is the drainage area (square miles) for the basin of interest.

$A_{reference}$ is the drainage area (square miles) for the reference basin.

AIR 2: *In section 5.3.7, Existing Water Quality Data, of the PAD, you state that in 1987, a dissolved oxygen study was conducted to evaluate the effects of a recently installed air injection system at the project on downstream dissolved oxygen levels (AEP Service Corporation and Indiana Power Company, 1988). Please file a copy of this report.*

AEPGR Response: AEPGR has included a copy of this report in Appendix B of this PSP.

6.2 Developmental Resources

AIR 3: *Item 7, on page 2 of the notice of intent, provides an installed capacity of 24 megawatts (MW) for the project. Section 1, Introduction and Background, of the PAD provides a project capacity of 47.5 MW. In section 4.3.6, Turbines and Generators, table 4.3-1 of the PAD, you state that each of the project's two turbine-generator units have a rated capacity of 24 MW. Please provide the installed capacity of the project and, if it is not 48 MW, please explain how this capacity is calculated.*

AEPGR Response:

The turbine manufacturer, Elin of Austria, stated that each turbine would produce 24 MW at the Racine site if the model conditions were met. Alden laboratory created a performance model of Racine around 1981. The model was based on the head at Racine as well as laminar flow into the intake structure. The intake channel for Racine was not fully developed, causing the site to lose the laminar flow model requirement. The result was the full potential of the units (24 MW each) cannot be realized. The existing, rated capacities of Units 1 and 2 are 23.4 MW and 23 MW, respectively, for a total of 46.4 MW (see discussion in AEPGR's response to the Commission's AIR 4, below).

AIR 4: *In section 4.3.6, Turbines and Generators, table 4.3-1, of the PAD, you state that each turbine has a rated capacity of 24,000 kilowatts (kW) and a rated horsepower (hp) of 29,502.5. However, a turbine with a rated horsepower of 29,502.5 corresponds to a rated capacity of 22,128 kW. Please provide a rated turbine horsepower and a rated generator capacity consistent with 18 CFR 11.1(i) of the Commission's regulations.*

AEPGR Response: In 2016, AEPGR Hydro Operations conducted capacity testing with the following results. Horsepower was calculated using the following formula: kW x 1.341 = hp rating.

- Unit 1 is rated at 23,400 kW, using 24,000 x 1.341 = 31,380 hp.
- Unit 2 is rated at 23,000 kW, using 23,000 x 1.341 = 30,844 hp.

AIR 5: *In section 4.3.7, Transmission, of the PAD, you state that the project's transmission line is not included in the current license and is not considered part of the project. In an August 10, 2018, filing, you clarified that transmission facilities are included in the current project license and that these facilities should have been included as existing project facilities in the PAD. You identified these facilities to include the 9 kilovolt (kV) generator leads, the 9,169 kV, 50,000 kilovolt-amperes (kVA) step-up transformer, and an approximately 475-foot-long, 69 kV line and appurtenances to connect to the 69 kV bus at Racine. Please clarify whether the 475-foot-long transmission line is above ground or underground.*

AEPGR Response: The 475 feet of generator leads run in conduit and cable tray, both inside and outside of the plant. Approximately 125 feet of the 475 feet is underground outside of the plant.

AIR 6: *The primary transmission line terminates at the interconnection with the grid. Please provide the owner of the interconnection and their relationship to AEP Generation Resources Inc. (AEP Generation).*

AEPGR Response: AEPGR is the owner of the interconnection with the grid.

AIR 7: *In section 4.4, Project Operations, of the PAD, you state that the U.S. Army Corps of Engineers provides advance notification to AEP Generation of any changes in discharge that may include ice passage and trash passage. However, section 4.4 does not describe how the project is operated under cold-weather conditions or how the trash rack is operated during its cleaning. Please describe how the project is operated under cold weather conditions, how the trash racks are cleaned, and what is done with the debris removed from the trashrack.*

AEPGR Response: The Project does not change operations during cold weather conditions. The trash rake is automatic and it traverses the intake screens making programmed stops that coincide with the width of the rake head until the entire intake screen has been raked and cleaned. Once the cycle is complete, it automatically starts over.

The trash rake automatically rakes the intake screens regardless of weather conditions. The trash rake deposits the debris into a hopper that travels with the trash rake. Once the hopper is full, there is a sensor that signals the programmable logic controller (PLC). The PLC program then causes the trash rake to travel to the eastern side of the intake screens where the hopper automatically dumps into a debris chute discharging into the tailrace of the Project.

AIR 8: *In section 4.4.2, Dependable Capacity, of the PAD, you state that the dependable capacity was determined as the amount of load that can be carried under adverse hydrologic conditions during a period of peak demand. Please provide the flow associated with adverse hydrologic condition used to estimate a dependable capacity of 46 MW.*

AEPGR Response: The estimated dependable capacity of the Project and flows used to estimate dependable capacity are being reviewed by AEPGR. At this time, AEPGR is completing additional calculations and anticipates providing FERC and stakeholders with the flow associated with the adverse hydrologic condition used to estimate dependable capacity in the RSP.

AIR 9: *Section 5.6(d)(2)(iii) of the Commission's regulations requires, in part, that a PAD contain a detailed description of all existing and proposed project facilities, including information on the physical composition, dimensions, and general configuration of any dams, spillway, penstocks, powerhouses, tailraces, and other structures proposed to be*

included as part of the project. Sections 4.3.5, Powerhouse and Intake, and 5.4, Fish and Aquatic Resources, of the PAD, reference the project's trashracks and tailrace, respectively. However, information on the composition, dimensions, and general configuration of these structures are not provided in the PAD. Therefore, please provide a detailed description of the tailrace structure, including its location, dimensions, and construction materials, and the trashracks, including its dimensions and bar spacing.

AEPGR Response: The intake area is 126 feet-long with four sections of intake screens. Each intake screen is 21 feet-wide and 88 feet-high and has a bar spacing of 6.125 inches center-to-center.

Each unit has a tailrace discharge chute constructed of reinforced concrete with a height of 39 feet, a width of 32 feet and Length of 58 feet. The discharge chutes are located 127 feet downstream of the forebay bulkhead slot.

AIR 10: *Section 5.6(d)(2)(v)(A) of the Commission's regulations requires that a PAD contain a complete description of the current license requirements, including any amendments to the license made during the license term. Section 4.5.1 Current License Requirements, of the PAD, appears to be missing license articles, or does not provide information on amendments to the license since it was issued in 1973. For example, section 4.5.1 does not include Article 49 of the current license, which requires the licensee to install facilities for the admission of air into the draft tubes, and during power generation, operate such facilities whenever dissolved oxygen concentrations in the water below the dam is below 5.0 milligrams per liter (mg/L). Article 49 also requires that dissolved oxygen concentrations downstream of the dam be continuously monitored. Please provide a complete description of license requirements and amendments for the project that meets the requirements of the Commission's regulations.*

AEPGR Response:

Since the Project's license was issued in 1973, various license articles have been revised or modified. The major milestones related to the Project's license include:

- December 30, 1985 Order Amending License: Order amending Article 8 specifying rate of return;
- December 14, 1987 Order Requiring Fish Mitigative and Monitoring Plan: Order directing the Licensee to develop a plan to mitigate for turbine-induced mortality and a plan to monitor fish resources in the Ohio River;
- February 28, 1992 Order Modifying and Approving Proposed Plan: Order deleting the monitoring requirement of Article 49; and
- September 16, 1997 Order on Remand: Order deleting requirement to finance compensatory mitigation for turbine-induced mortality required by Article 51.

The articles of the 1973 license (as modified by subsequent Commission orders) represent the applicable license terms under which AEPGR now operates the

Project. A summary of the most applicable of these articles related to Project operations and environmental measures is provided below.

- Article 9: Requires the Licensee to install gages and stream-gaging stations as the Commission may deem necessary. Also requires the Licensee to install and maintain standard meters to determine electrical energy generation. The installation of gages or meters must be under the supervision of, or in cooperation with, the District Engineer of the United States Geological Survey.
- Article 13: Article safeguards the Secretary of the Army's right to use water and/or to implement rules in the interest of navigation. Requires the Licensee to maintain a minimum flow of 6,300 cubic feet per second, as measured immediately below the Racine dam, when such flow can be provided either from stream inflow or from water in storage.
- Article 16: Requires the Licensee to install fish passage facilities if so required by the Commission or Secretary of the Interior, or any state fish and wildlife agencies.
- Article 18: Construct, maintain, and operate recreational facilities including modifications thereto, such as access roads, wharves, launching ramps, beaches, picnic and camping areas, sanitary facilities, and utilities as may be prescribed by the Commission. AEPGR maintains a formal recreation area downstream from the Project.
- Article 19: Allow the public free access, to a reasonable extent, to project waters and adjacent project owned lands owned by the licensee for the purpose of full public utilization of such lands and waters for navigation and for outdoor recreational purposes, including fishing and hunting.
- Article 38: Requires the Licensee to cooperate with the appropriate State and local agencies in the identification of historical structures, if any, within the project area and, if necessary, cooperate in developing a plan for protection or relocation of such structures.
- Article 39: Orders the design and construction of all facilities that are an integral part of the dam or that could affect the integrity of the navigation system, including construction procedure and sequence, are subject to review and approval of the USACE's Huntington District Engineer.
- Article 42: Requires the Licensee, prior to initiation of power operations, to enter into an agreement with the District Engineer, specifying (1) details of an operating plan including limitations on fluctuations and (2) reasonable rules and regulations pertaining to operations of the Licensee.
- Article 49: This article states the Licensee shall install facilities for the admission of air into the draft tubes and shall, during power generation periods, operate such facilities whenever the dissolved oxygen (DO) concentration in the water below the dam is below 5.0 mg/L. The requirement to monitor DO was deleted by the Commission's February 28, 1992 Order.

- Article 50: Requires the Licensee to, in cooperation with ORSANCO and the USACE, conduct post-operational studies to determine the effects, if any, of project operation on the quality of the all waters, docks, and recreational facilities associated with the Project.
- Article 51: Requires the Licensee to file within five years from the date of issuance of the license, for Commission approval, a revised Exhibit S, including, among other things, the results of post-operational studies conducted in cooperation with the Ohio and West Virginia Departments of Natural Resources, to determine the effect, if any, of operation of the project on the fishery resource. Also directs the Licensee to file plans for the construction, maintenance, and operation of fish protective devices should they be deemed necessary as a result of data obtained from the studies. In December 1987, the Commission issued an order determining that the construction of fish protection devices was not a practical option and offered little assurance of effectiveness. As an alternative, the Commission required the Licensee to develop a mitigation plan to compensate for turbine-induced mortality, as well as a plan to monitor for five years changes in local fish resources. The Commission's September 16, 1997 Order remanded the compensatory mitigation fund requirement.
- Article 52. Article stating that construction must commence construction within two years from the effective date of the license, and shall be completed by four years from the issue date of the license.

AIR 11: *Exhibit G, sheet 1 of 2 shows the project boundary and principal project works, which includes an area of 28.3 acres. Please explain the project use of the area southwest of the storage building and to the northeast of the public parking area shown on Exhibit G, sheet 1 of 2.*

AEPGR Response: The area southwest of the storage building is a staging area for construction projects. The area northeast of the public parking area is used for public recreation; there are approximately six picnic tables and a couple of grills. The area is mowed weekly.

AIR 12: *Exhibit F, does not show the functional replacement dam. Please provide a revised Exhibit F that shows the as-built information for the functional replacement dam.*

AEPGR Response: During the relicensing process AEPGR will be updating the Exhibit F drawings to ensure that the existing Project facilities are accurately represented in the drawings. Revised Exhibit F drawings will be filed according to FERC's regulations with the FLA.

7 Water Quality Study

7.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issue to be analyzed in the EA for the Project relicensing.

- Effects of continued project operation on water quality (e.g., dissolved oxygen and water temperature) in the Ohio River downstream of the project.

In Section 6.2.2 of the PAD, AEPGR proposed to conduct a Water Quality Study to monitor temperature and DO at the Project. On October 30, 2018, the WVDNR formally requested water quality studies. The USFWS and ODNR also expressed support for conducting a Water Quality Study at the Project.

7.2 Goals and Objectives

AEPGR's proposed study focuses on collecting and establishing baseline information on water quality in the vicinity of the Project. The proposed study employs standard methodologies consistent with the scope and level of effort of water quality monitoring conducted at other hydropower projects on the Ohio River and in this region. AEPGR believes that the information provided by this study will be sufficient to analyze the Project's potential effects on water quality and will provide baseline water quality data to determine compliance with applicable water quality standards and designated uses. The goals and objectives of this study are to:

- Gather baseline water quality data to determine compliance with state water quality standards.

7.3 Study Area

The study area for the Water Quality Study includes the intake-area immediately upstream and near-vicinity downstream of the Project.

7.4 Background and Existing Information

Existing relevant and reasonably available information regarding water quality in the Project vicinity was presented in Section 5.3 of the PAD (AEPGR 2018). The PAD included historical water quality data collected by ORSANCO over the past five years (2013 – 2017). These data demonstrate that the Project waters meet the state standards regarding water temperature and DO and that Project operations appear to have little to no effect on water quality in the Ohio River.

7.5 Project Nexus

Operation of the hydropower facilities may impact water quality parameters such as temperature and DO in the Racine Pool and areas downstream from the Project.

7.6 Methodology

7.6.1 Task 1 – Continuous Water Temperature and DO Monitoring

AEPGR proposes to monitor water quality and temperature at the following general locations:

- Reservoir (intake area)
- Tailrace
- Downstream area

AEPGR will consult with stakeholders to determine the specific location of each monitoring device within the general areas listed above. DO and temperature continuous data loggers, set to record at 15-minute intervals, will be deployed at the monitoring locations.

All water quality monitoring locations will be georeferenced using Global Positioning System (GPS). These GPS locations will be included in a Geographic Information Systems (GIS) database layer to support the documentation and reporting of collected data.

The water temperature and DO data loggers will be deployed from May 1, 2019 through October 31, 2019. As necessary, the loggers will be weighted on the bottom and tied off to permanent structures for stability. Data will be downloaded from the loggers on a monthly basis. In the event that atypical weather and flow conditions (as compared to historical weather and flow conditions) are experienced during the monitoring period, AEPGR will consult with agencies and other stakeholders to determine if a second year of study is warranted.

Two loggers will be placed at each sampling location in order to provide backup data. For each location a primary logger and a secondary logger will be identified. Data will be preferentially reported and analyzed from the primary logger at each location; in the event of data loss from the primary logger, data from the secondary logger will be used. Consistency between logger data will also be incorporated into the data quality assurance process. Water quality equipment will be cleaned and calibrated prior to deployment, and antifouling measures will be employed as appropriate.

7.6.2 Task 2 – Routine Water Quality Monitoring

In-situ water quality measurements for temperature, DO, pH, and specific conductance will be collected on a monthly basis at each of the sample locations of the continuous loggers from May 1 through October 31. In addition, similar data will be collected during the fisheries and mussel survey activities. Water quality data will be collected as river flow conditions allow.

7.6.3 Task 3 – Reservoir Profile Data

AEPGR will consult with the USFWS, ODNR, and WVDNR to identify locations in the Racine reservoir to obtain water quality profiles. Water quality profiles will be collected via boat on a monthly basis from May 1 through October 31, 2019.

Beginning at the water's surface and moving in 1-meter increments, a vertical profile of temperature and DO will be collected until the bottom is reached. Measurements will be taken in 0.5-meter increments upon discovery of a thermocline and within 1 meter of the surface and bottom.

7.7 Analysis and Reporting

Results of this study, including continuous water temperature and DO data, monthly in-situ water quality data, will be summarized in the final study report. Raw data will be provided in appendices to the study report. AEPGR anticipates that the Water Quality study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

7.8 Schedule and Level of Effort

AEPGR anticipates that Tasks 1 and 2 of this study will be completed by November 2019. The study report will be prepared and provided to the applicable parties in conjunction with the ISR (and updated accordingly with the USR) that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The estimated level of effort for this study is approximately 350 hours. AEPGR estimates that this study will cost approximately $50,000 to complete.

7.9 Discussion of Alternative Approaches

The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

8 Recreation Study

8.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Adequacy of existing public access and recreational facilities to meet current and future recreation needs.

In Section 6.2.6 of the PAD, AEPGR proposed to conduct a Recreation Study to assess recreational opportunities and potential improvements at Project recreation facilities. On October 26, 2018, FERC provided comments on the recreation study proposed in the PAD; and on October 30, 2018, the WVDNR formally requested a recreation study. The USFWS's October 30, 2018 comments on the PAD also supported a recreation study at the Project.

8.2 Goals and Objectives

The Recreation Study will collect information regarding current recreation use levels and the condition of the existing Project recreation facilities. The goals and objectives of this study are presented below.

- Characterize current recreational use of the Project area;
- Gather information on the condition of AEPGR's FERC-approved recreation facilities and identify any need for improvement; and
- Evaluate potential impacts of the Project on existing recreational facilities and opportunities.

8.3 Study Area

The study area includes the Project boundary.

8.4 Background and Existing Information

Section 5.7.6 of the PAD describes existing information about recreation facilities and opportunities in the Project area. The Racine Project provides one formal (Licensed) recreational facility maintained and operated by AEPGR and open to the public. The amenities at the Project's formal recreation area include a picnic area, parking lot, tailwater fishing access pier, and Americans with Disabilities Act (ADA) -compliant portable toilet. The USACE does not permit boating activities near the Racine Locks and Dam or in the tailrace of the Project.

In a survey of approximately 50,000 anglers by the Ohio Division of Wildlife (ODOW), many anglers reported a preference of concentrating fishing effort in the tailwaters below dams, as well as in the embayments and other tributaries targeting desirable sport fish species (ODNR 2003).

8.5 Project Nexus

The Project currently provides public recreational opportunities. The results of this study, in conjunction with existing information, will be used to inform analysis in the license application regarding potential Project effects on public recreation.

8.6 Methodology

8.6.1 Task 1 – Stakeholder/Agency Interviews

AEPGR will reach out to stakeholders who have expressed interest in participating in this study either at the PSP meeting or in comments filed subsequent to the PSP or RSP and request their participation in an interview regarding recreation at the Project. AEPGR will conduct scheduled interviews with individuals to gather additional information about existing recreational amenities, demand, current use patterns (seasonal, monthly, weekend/weekday), safety issues, overcrowding, traffic, and other potential issues to characterize existing recreational use at the Project. The interviews are intended to focus on stakeholders that are knowledgeable about recreation in the Project area. These interviews are intended to capture perspectives that could not be discerned from traffic counters or observations.

8.6.2 Task 2 – Online Survey

AEPGR has developed an interview/survey instrument that draws from general concepts and guidance from the *National Visitor Use Monitoring Handbook* (USFS 2007) as well as from other relicensing studies approved by FERC for recreation visitor use surveys. This survey will be administered through a website (online) and will offer respondents the opportunity to provide survey responses electronically, which will allow respondents to complete a survey at a later time upon returning home from their visit.

The online survey will also provide a means to capture data from recreationists who do not frequent the Ohio River. AEPGR will post a brief description of the purpose and intent of the survey, as well as the website address, at the FERC-approved Project recreation site near the Project tailrace. Additionally, notice of the survey will be posted on the Project's relicensing website. AEPGR will notify stakeholders when the online survey is available.

The questionnaire that will be used for the online survey is provided in Appendix C of this study plan. The questionnaire is designed to collect information about:

- General user information;

- Resident/visitor;
- Purpose and duration of visit;
- Distance traveled;
- Day use/overnight lodging;
- History of visiting the site or area;
- Types of recreational activities respondents participated in during their visit, including primary and secondary recreation activities;
- Other recreational sites that respondents visited during their trip;
- General satisfaction with recreational opportunities, facilities, and the respondents overall visit and/or areas that need improvement;
- Effects of Project operations on recreation use and access; and
- Accessibility of facilities.

8.6.3 Task 3 – Recreational Use Documentation

AEPGR anticipates placing trail cameras at the Project's formal recreation area to document recreational usage. A total of five trail cameras will be installed from May 2019 through May 2020 to collect site visitor data and document use patterns. AEPGR anticipates placing cameras at the locations described in Table 8-1.

Table 8-1. Proposed locations of trail cameras

Location	Purpose	Function
Parking area entrance	Collect data on vehicles entering and exiting the parking area	Motion-activated photos
Parking area	Collect data on the number of vehicles parked in the lot	Time-lapse photos*
Fishing pier stairway	Collect data on visitors to the fishing pier	Motion-activated photos
Fishing pier	Collect data on recreationists using the fishing pier	Time-lapse photos
Picnic area	Collect data on recreationists using the picnic area	Time-lapse and motion-activated photos

* Time-lapse photos are photos taken at regular intervals. For example, cameras can be programmed to take a time lapse photo every four hours.

The trail cameras will record time and date-stamped photos and vehicle usage at the FERC-approved recreation area that can be analyzed to develop recreational use figures.

8.7 Analysis and Reporting

Results of the personal interviews, online surveys, and an analysis of and photos from the trail cameras will be summarized in the final study report. AEPGR anticipates that the Recreation Study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

8.8 Schedule and Level of Effort

AEPGR intends to conduct the Recreation Study from May 2019 through May 2020. Upon completion of field work, the data will be analyzed and the study report will be prepared and provided to applicable parties, in conjunction with the ISR that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The estimated level of effort for this study is approximately 280 hours. AEPGR estimates that this study will cost approximately $40,000 to complete.

8.9 Discussion of Alternative Approaches

In comments on the preliminary study plans presented in the PAD, FERC staff requested that AEPGR conduct monthly five-minute spot counts to record the number of vehicles parked at the Project's recreation site and the number of users observed. FERC also requested that AEPGR install a traffic counter at the entrance to the parking area during the recreation season to collect site visitation data.

AEPGR has proposed an alternative approach that utilizes trail cameras to document site visitation data, parking lot usage, and the number/types of recreationists at the Project's recreation facility. Trail cameras have previously been successfully used to document recreation usage and to record parking lot activity at recreation sites by recreation management agencies and hydropower licensees (Olsen and Wagner 2014; Hining and Rash 2016; HDR 2017). AEPGR believes that this alternative methodology is a cost-effective means of providing recreational visitor and use data that can be analyzed. This approach also provides advantages over traditional traffic counters and spot counts. For example, a motion-activated trail camera recording vehicles entering and exiting the recreation area parking lot could be used to estimate the average duration of a visit to the site on a holiday. Traffic counters and spot checks would not be

able to provide that level of resolution. Additionally, trail cameras can provide information on recreational usage during off-peak periods (e.g., evenings, early mornings, and wintertime). For these reasons, AEPGR believes that the installation of trail cameras at the Project's recreation facility is a better, more efficient means of collecting recreation visitor and use data than spot counts and traffic counters.

The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

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9 Cultural Resources Study

9.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of continued project operation and maintenance on properties that are included or eligible for inclusion in the National Register of Historic Places (NRHP).

In Section 6.2.8 of the PAD, AEPGR proposed to conduct a Cultural Resources Study. In FERC's Schedule B comments on the preliminary study plans included in AEPGR's PAD, FERC requested that AEPGR provide additional details on the proposed Cultural Resources Study, which are addressed in this section of the PSP.

9.2 Goals and Objectives

The proposed Cultural Resources Study will identify potential historic properties within the Project's Area of Potential Effect (APE). This study will also assess the potential effects of continued Project operations and maintenance activities on historic and cultural resources, should any be present. The goals and objectives of this study are to:

- Consult with Ohio State Historic Preservation Office (SHPO), West Virginia SHPO, the USACE, and potentially affected Indian Tribes to determine an appropriate APE for the Project;
- Conduct background research and an archival review;
- Conduct a Phase I Reconnaissance Survey (Reconnaissance Survey) of the Project's APE; and
- Prepare a draft Historic Properties Management Plan (HPMP) in consultation with the appropriate SHPO(s), USACE, and federally recognized Indian Tribes that includes appropriate measures for the management of historic properties within the Project's APE, including specific PM&E measures.

9.3 Study Area

The study area for the Cultural Resources Study includes the APE (Figure 9-1). AEPGR intends to define an APE in consultation with the Ohio SHPO, West Virginia SHPO, USACE, and Indian Tribes as a component of the Cultural Resources Study. AEPGR tentatively proposes the following APE which will be refined through consultation:

> *The APE for the Racine Project includes all lands and waters within the FERC Project boundary. The APE also includes lands and properties outside*

of the Project boundary where Project-related activities that are conducted in compliance with the FERC license may affect historic properties.

9.4 Background and Existing Information

In considering a new license for the Project, FERC is the lead agency for compliance with applicable federal laws, regulations, and policies pertaining to historic properties, including National Historic Preservation Act of 1966, as amended (NHPA)[4]. Section 106 of the NHPA (Section 106)[5] directs federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.

The regulations implementing Section 106 (36 CFR Part 800) define "historic properties" as any pre-contact or historic period district, site, building, structure, or individual object included in or eligible for inclusion in the NRHP.

Based on a review of publicly available information from the Ohio SHPO and West Virginia SHPO, there are no known or reported archaeological sites within or in the vicinity of the Project boundary. There are no proposed modifications to the physical plant or major operational changes for the Project at this time.

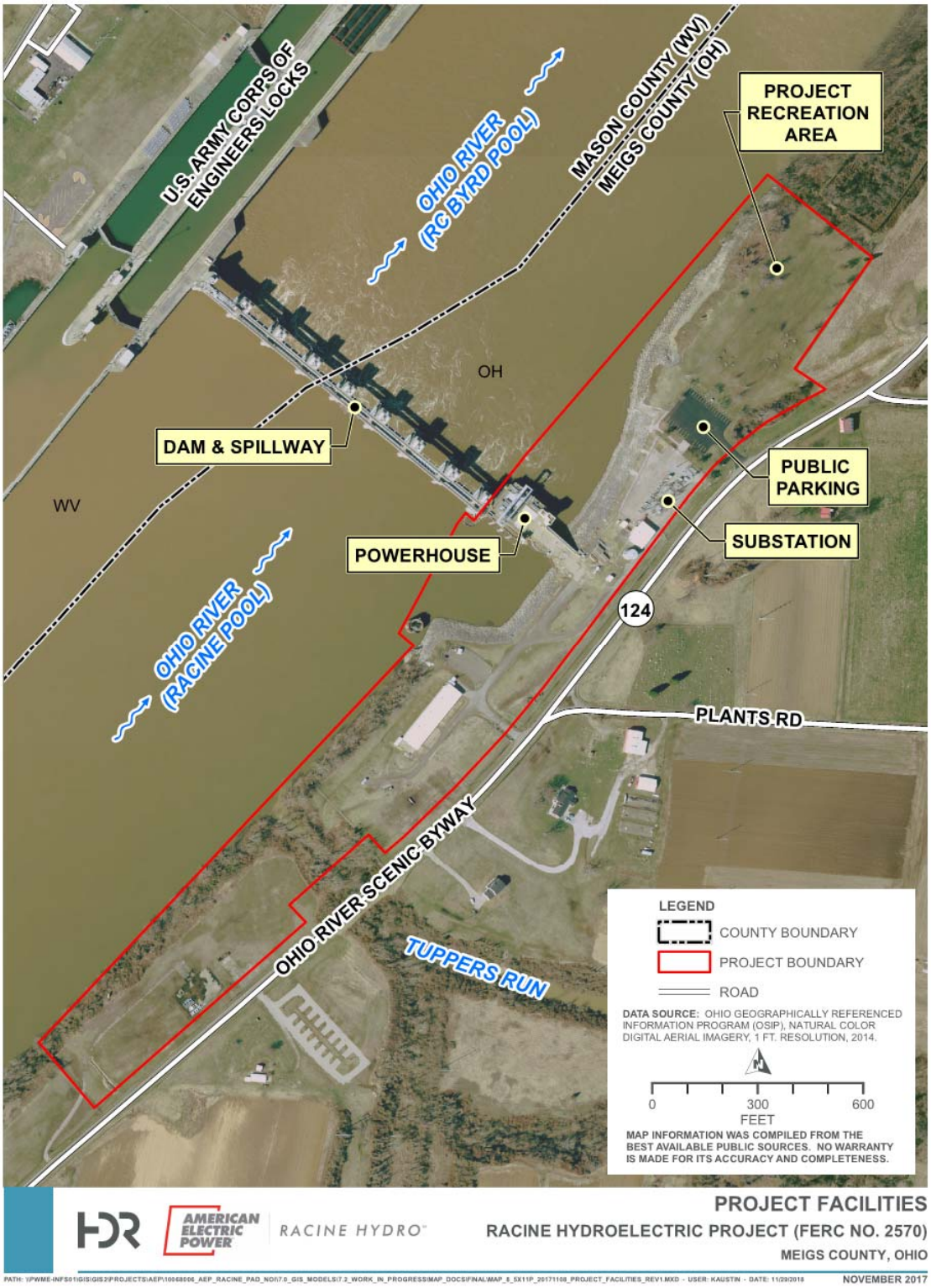
9.5 Project Nexus

At present, there is no evidence that archaeological or historic resources are currently being affected by the Project's operations or Project-related activities. However, the Project has the potential to directly or indirectly affect historic properties listed in or eligible for inclusion in the NRHP.

[4] 54 U.S.C. § 300101 *et seq*.

[5] 54 U.S.C. 306108

Figure 9-1. FERC-approved Boundary and Proposed APE for the Racine Project



9.6 Methodology

9.6.1 Task 1 – APE Determination

AEPGR has tentatively proposed an APE as presented in Section 9.3. Pursuant to the implementing regulations of Section 106 at 36 CFR § 800.4(a), AEPGR will consult with the Ohio SHPO, West Virginia SHPO, USACE, and potentially affected Indian Tribes, to determine and document the APE for the Project as defined in 36 CFR § 800.16(d)[6].

9.6.2 Task 2 – Background Research and Archival Review

AEPGR will conduct background research and an archival review to inform the specific research design and the historic and environmental contexts. AEPGR will review relevant sources of information that may include, but are not necessarily limited to:

- Information on archaeological sites, historic architectural resources, and previous cultural resource studies on file with Ohio SHPO and West Virginia SHPO;
- A review of NRHP listings in Ohio and West Virginia in proximity to the Project;
- Historic maps and aerial photographs of the APE;
- Relevant documents related to Project construction;
- Relevant information available from local repositories;
- Information on the current and historical environment, including mapped soils, bedrock geology, physiography, topography, and hydrology in the vicinity of the APE;
- Relevant historical accounts of the Project area;
- Any additional relevant information made available by the Ohio SHPO, West Virginia SHPO, USACE, Indian Tribes, or other stakeholders.

9.6.3 Task 3 - Reconnaissance Survey

AEPGR will conduct a Reconnaissance Survey of the Project's APE, to include both an archaeological and architectural survey. Prior to conducting the Reconnaissance Survey, AEPGR will consult with the USACE to determine if a permit under the Archaeological Resources Protection Act (ARPA) is required for this fieldwork. The proposed methods for the Reconnaissance Survey will take into account the nature and extent of potential effects on historic properties, and the likely nature and location of historic properties within the APE (36 CFR 800.4(b)(1)). The Reconnaissance Survey will be directed by

[6] AEPGR is proposing to consult with the West Virginia and Ohio SHPOs to define the APE for this undertaking as the Project is located entirely within Ohio and near the Ohio/West Virginia border. If the consulting parties concur with the definition of the APE as presented in this PSP, AEPGR does not anticipate additional consultation with the West Virginia SHPO, as the proposed APE is entirely within the State of Ohio.

qualified cultural resources professionals[7] retained by AEPGR and will be in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Federal Register [FR] 44716, Sept. 1983).

9.6.3.1 Archaeological Survey

The Project's APE is believed to have been significantly disturbed by construction of the USACE's locks and dam and the Racine Project. Based on the background research and archival review, AEPGR will conduct a visual reconnaissance of the APE to identify any undisturbed areas where intact cultural deposits may be present. Pursuant to the Advisory Council on Historic Preservation's (ACHP) Section 106 Archaeology Guidelines[8], if areas within the APE are identified as (a) areas undisturbed by previous construction, and (b) areas where Project-related effects are likely to occur that could impact an archaeological site (if any site is present), these areas may warrant additional investigation. If an area is identified that warrants further investigation, then AEPGR will conduct hand excavation of shovel test pits (STPs) at intervals of 15 meters or less. STPs will be excavated in natural stratigraphic layers or 10-centimeter levels within natural levels. Soil from each natural level in each unit will be screened through ¼-inch mesh hardware cloth to test for the presence of archaeological resources.

If archaeological material is observed during the Reconnaissance Survey, AEPGR will conduct a preliminary assessment of the archaeological site that will consist of the delineation of site boundaries. The maximum length and width of each site will be measured and recorded and the site's location geo-located. Site dimensions and elevations will be recorded on standardized field forms along with sketch maps of site settings and notations regarding landform, site aspect, temporal affiliations (if possible) and density of observed materials, site condition, any evidence of Project-related effects, and the nature of site deposits. Site boundaries will be located on Project maps and USGS topographic maps. Based on the judgment of the archaeologist, visual reconnaissance may be augmented by limited subsurface testing (e.g., shovel test pits). AEPGR will geo-locate, record, and collect any observed artifacts, features, or other pre-contact or historic period cultural material (as appropriate), and any new archaeological sites discovered will be documented on Ohio Archaeological Inventory Form.

Treatment and disposition of any human remains that may be discovered will be managed in a manner consistent with the Native American Graves Protection and

[7] For this study, a "qualified cultural resources professional" is defined as an individual who meets the Secretary of the Interior's Professional Qualification Standards (48 Federal Register [FR] 44738-44739, Sept. 1983).

[8] ACHP's Section 106 Archaeology Guidance states that "[A] federal agency is not expected to conduct a 100 percent survey of the area of potential effects. Rather, the identification effort should be conditioned by where effects are likely to occur and the likely impact of these effects on listed or eligible archaeological sites. For example, archaeological identification efforts for a license renewal from FERC likely would not involve the entire APE. Instead it would be directed to those locations within the APE that are experiencing Project-related effects associated with operation, usually along the shoreline" (ACHP 2009)

Repatriation Act (NAGPRA) (P.L. 101-601; 25 U.S.C. 3001 et seq.)[9], and the ACHP's Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects (ACHP 2007). Any human remains, burial sites, or funerary objects that are discovered will at all times be treated with dignity and respect. In the event that any Native American graves and/or associated cultural items are inadvertently discovered, AEPGR will immediately notify the USACE, appropriate SHPO and potentially affected Indian Tribes.

9.6.3.2 Architectural Survey

As a component of the Reconnaissance Survey, AEPGR will also conduct an intensive survey of historic architectural resources to evaluate the NRHP eligibility of historic buildings and structures within the Project's APE pursuant to the Ohio SHPO's Guidelines for Conducting History/Architecture Surveys in Ohio (Ohio SHPO 2014). AEPGR will conduct additional property-specific research on historic buildings and structures within the APE, and complete an Ohio Historic Inventory Form for identified properties to document historic buildings and structures (if any) and provide sufficient information to the Ohio SHPO to determine their eligibility for the NRHP[10].

9.6.3.3 Reporting

AEPGR will prepare a Cultural Resources study report that presents the results of the Reconnaissance Survey, including the archaeological and architectural surveys. The Cultural Resources study report will incorporate the results of the background research and archival review, including a cultural history of the research area and a description of previous work in and around the APE.

AEPGR will consult with the appropriate SHPOs, USACE, and potentially affected Indian Tribes regarding the Cultural Resources study report, including any recommendations for additional archaeological investigations (i.e., archaeological site evaluations) or management measures. AEPGR will prepare and file with FERC a record of consultation with the Ohio SHPO, West Virginia SHPO, USACE, potentially affected Indian Tribes, and other parties (as appropriate), regarding the APE and the results and recommendations of the Cultural Resources study report.

[9] Pursuant to 43 CFR Part 10, NAGPRA applies to human remains, sacred objects, and items of cultural patrimony (described as "cultural items" in the statute) located on federal or tribal lands or in the possession and control of federal agencies or certain museums. Regardless of where cultural items are discovered, the principles described in NAGPRA's implementing regulations will serve as guidance for AEPGR's actions should the remains or associated artifacts be identified as Native American and to the extent such principles and procedures are consistent with any other applicable requirements.

[10] All buildings and structures within the proposed APE are located within the State of Ohio.

9.6.4 Task 4 – Historic Properties Management Plan

AEPGR will consult with appropriate SHPO(s), USACE, potentially affected Indian Tribes, and other parties, as appropriate, to develop an HPMP for the Project. The measures provided in the HPMP will assist AEPGR in managing historic properties within the Project's APE throughout the term of the new license.

The HPMP will be prepared in accordance with the Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects, promulgated by the Commission and the ACHP on May 20, 2002. The HPMP will address the following items (ACHP and FERC 2002):

- Identification of the APE for the Project and inclusion of a map or maps that clearly show the APE in relation to the existing and proposed Project boundary;
- Additional studies to assist in identifying or managing historic properties within the APE;
- Continued use and maintenance of any historic properties;
- Potential effects on historic properties resulting from the continued operation and maintenance of the Project;
- Protection and treatment of historic properties threatened by potential ground-disturbing activities;
- Protection and treatment of historic properties threatened by other direct or indirect Project-related activities, including routine Project maintenance and vandalism;
- The resolution of unavoidable adverse effects on historic properties;
- Treatment and disposition of any human remains that are discovered, taking into account any applicable state laws and the Council's Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects (ACHP 2007);
- Compliance with the Native American Graves Protection and Repatriation Act (25 U.S.C. §3001), for tribal or federal lands within the Project's APE;
- Provisions for unanticipated discoveries of previously unidentified cultural resources within the APE;
- A dispute resolution process;
- Categorical exclusions from further review of effects;
- Public interpretation of the historic and archaeological values of the Project, if any; and
- Coordination with consulting parties during implementation of the HPMP.

9.7 Analysis and Reporting

Based on the results of Task 3, AEPGR will prepare a report on the results of the Reconnaissance Survey. The report will include: 1) documentation of APE consultation,

2) a summary of information obtained through the background research and archival review, 3) maps and descriptions of reported archaeological and historic resources within the Project's APE, 4) an assessment of the APE's archaeological sensitivity and potential, 5) the results of archaeological field investigations, 6) an assessment of the NRHP-eligibility of the Project's features, and 7) recommendations regarding additional cultural resource studies and/or management measures for identified resources. AEPGR will consult with the appropriate SHPO(s), potentially affected Indian Tribes, and the USACE regarding the results and recommendations presented in the report. AEPGR anticipates that the Cultural Resources study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency or Tribal correspondence and/or consultation
- Literature cited

9.8 Schedule and Level of Effort

AEPGR anticipates initiating Task 1 during the summer of 2019. Tasks 1 and 2 will be completed by fall of 2019. Task 3, the Cultural Resources study report, will be prepared and provided to the applicable parties in conjunction with the ISR that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. AEPGR will prepare a draft HPMP in consultation with the consulting parties. Following review and comment by the applicable parties, AEPGR will file a draft HPMP with the Commission concurrent with the PLP or DLA. The estimated level of effort for this study is approximately 400 hours. AEPGR estimates that this study will cost approximately $50,000 to complete.

9.9 Discussion of Alternative Approaches

The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

10 Mussel Survey

10.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of continued project operation on the following federally listed threatened and endangered species: running buffalo clover; Indiana bat; Northern long-eared bat; and the fanshell, pink mucket, sheepnose, and snuffbox mussels.

On October 30, 2018, USFWS and WVDNR formally requested mussel surveys. ODNR also supported the USFWS and WVDNR requests for mussel surveys.

10.2 Goals and Objectives

The goals and objectives of this study are to conduct a field survey to evaluate the mussel community downstream of the Project.

10.3 Study Area

The study area for the Mussel Survey extends from the downstream extent of the USACE's restricted area below the Racine Dam downstream to OHRM 239.

10.4 Background and Existing Information

Existing relevant and reasonably available information regarding mussels in the Project vicinity was presented in Section 5.4.7 of the PAD (AEPGR 2018). The distribution of mussels has been documented in several reports (Ecological Specialists, Inc. 2000, EnviroScience 2005a, 2005b). No recent mussel surveys have been performed immediately downstream of the Racine Project to AEPGR's knowledge.

10.5 Project Nexus

Hydroelectric dams alter flow which may impact mussel propagation and survival.

10.6 Methodology

10.6.1 Task 1 – Collector's Permit

AEPGR's consultant will obtain any necessary collector / survey permits that may be required to conduct the mussel sampling work and will not begin fieldwork prior to receiving the necessary permits.

10.6.2 Task 2 – Mussel Survey

A qualitative mussel survey will be conducted between May 1 through October 1 (water temperature and river flow dependent) in representative habitats (e.g., pool, riffle, run) along a 1.5 reach downstream of the Racine Project in accordance with the WVDNR's West Virginia Mussel Survey Protocols requests[11]. The USFWS, ODNR, and WVDNR concurred that the West Virginia Mussel Survey Protocols are appropriate for this study. Mussel surveys will be conducted in the vicinity of the dam to the greatest extent possible, taking into account safety and security restrictions. AEPGR will coordinate with resource agencies and other stakeholders to determine survey locations. Depending on water depths and flow conditions, the surveys are expected to consist of qualitative visual timed-searches using SCUBA. Starting from the downstream end of a transect or survey site, the survey will consist of searching for freshwater mussels or shell material in a meandering or "zig-zag" pattern, with a focus to include representative habitats within the river reach. Shoreline areas within the proposed survey areas will also be searched for evidence of shell material or middens. Any mussels observed will be counted and identified to species and carefully placed back into the same habitat. Basic habitat information such as substrate type (e.g. gravel, cobble, boulder), water depth, habitat type (e.g., riffle, run, pool), cover type (e.g. woody debris), stream width, and qualitative water velocity will be recorded. Data will be recorded on field data sheets (Appendix D) and mussel locations marked on field maps. Representative photographs will be taken for each species as vouchers. Water quality data will be collected from representative locations in the proposed survey areas at the beginning and end of each field day during the mussel survey.

10.7 Analysis and Reporting

Results of this study will be summarized in the final study report. AEPGR anticipates that the Mussel Survey study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

[11] West Virginia Mussel Survey Protocols, 2018 is available at http://www.wvdnr.org/Mussels/Main.shtm.

10.8 Schedule and Level of Effort

AEPGR anticipates that this study will be completed by November 2019. The study report will be prepared and provided to the applicable parties in conjunction with the ISR that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The estimated level of effort for this study is approximately 450 hours. AEPGR estimates that this study will cost approximately $80,000 to complete.

10.9 Discussion of Alternative Approaches

The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

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11 Fisheries Study

11.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of entrainment and impingement mortality on resident fish populations.

On October 30, 2018, the USFWS and WVDNR formally requested fish surveys.

11.2 Goals and Objectives

The Fisheries Study will synthesize the body of existing fisheries data and supplement the extensive database with a targeted tailrace fisheries survey downstream from the Racine Dam. Specifically, the objectives of this study are to:

- Review and synthesize the fisheries data from the Racine and RC Byrd pools collected ORSANCO, ODNR, Electric Power Research Institute (EPRI), and others to create a comprehensive fisheries database for the Racine and RC Byrd pools; and
- Conduct a tailrace fishery survey in the river reach extending from the limit of the USACE's restricted area downstream to river mile (RM) 239 (1.5 miles downstream from the Racine Dam).

11.3 Study Area

The study area for the synthesizing existing data includes the Racine Pool, located upstream from the Racine Project, and the downstream RC Byrd Pool. AEPGR is proposing to collect survey data to supplement the extensive, existing database within a study area extending from the downstream extent of the USACE's restricted area below the Racine Dam downstream to OHRM 239.

11.4 Background and Existing Information

Existing relevant and reasonably available information regarding fisheries in the Project vicinity was presented in Section 5.4.4 of the PAD. As described in Section 5.4.4 of the PAD, the fish communities in both the Racine Pool and downstream RC Byrd Pool have been thoroughly documented by ORSANCO and others. ORSANCO conducts fisheries surveys in several Ohio River pools on an annual basis. Typically, 4 of the 19 pools are sampled each year, achieving a complete river-wide survey every 5 years. The objective of these surveys is to provide background information on the status of fish populations, as needed to provide insight into the overall health of the Ohio River (FERC 2015). Annual sampling is conducted by ORSANCO between July 1 and October 31 by boat electrofishing. Boat electrofishing is conducted at night and fish are netted, measured,

inspected for anomalies, and identified to the lowest possible taxonomic level before being returned to the river (ORSANCO 2015). The most recent ORSANCO fisheries surveys in the Project area were conducted in the Racine Pool in 2010 and 2015, and in the RC Byrd Pool in 2008 and 2013. Tabulated fisheries data prepared by ORSANCO for sampling results in the Racine and R.C. Byrd pools indicates that thousands of fish were collected and measured and during each sampling event[12]. ORSANCO evaluated the health of both pools as being in "Good" condition subsequent to the most recent survey events.

The extensive ORSANCO survey data is supplemented by additional, recent fisheries data collected in the RC Byrd Pool by the ODNR (2012), EPRI (2014 and 2015), and by the City of Wadsworth, Ohio in 2010 in support of the original license application for the RC Byrd Project. In total, eight separate fisheries surveys have been conducted in the Project vicinity since 2010.

11.5 Project Nexus

Potential Project effects on fishery resources may include fish impingement, entrainment, and flow modifications. Information on the existing fish community will help identify the fish species potentially affected by Project operations. While ORSANCO and others have conducted extensive fish surveys, only limited sampling by ODNR has been conducted in the tailwater downstream from the Racine Dam. The tailwater habitat is important to darter species, including darter species listed in the State of Ohio as threatened (USFWS 2018).

11.6 Methodology

11.6.1 Task 1 – Data Review and Synthesis

As described in the PAD and summarized in this PSP, a significant amount of fisheries data has been collected from the Racine and RC Byrd pools over the previous eight years. While some data has been coalesced into a single database (i.e., ORSANCO's Ohio River main stem fish population database includes ODNR sampling data), the entirety of current fish population data from the Racine and RC Byrd pools has not been synthesized into a single database. AEPGR will review the existing data described in Section 11.4 as well as any additional fish sampling data made available by stakeholders. Based on available information, AEPGR will compile a single database that describes the fish communities in both pools. This database will be used to identify species upstream and downstream from the Project and to analyze seasonal and spatial trends of the fisheries, to the extent practicable.

[12] ORSANCO's tabulated fish community data is available online at: http://www.orsanco.org/data/fish-population/.

11.6.2 Task 2 – Collector's Permit

AEPGR's consultant will obtain any necessary collector / survey permits that may be required to conduct the fisheries sampling work and will not begin fieldwork prior to receiving the necessary permits.

11.6.3 Task 3 – Tailwater Fishery Survey

11.6.3.1 Habitat Characterization

AEPGR is proposing to conduct an electrofishing and trawl-netting fishery survey in the tailwater area downstream to OHRM 239. During the surveys, AEPGR will characterize the macrohabitat at sampling locations within the tailwater study area. AEPGR will utilize ORSANCO's method for classifying electrofishing habitats (ORSANCO 2017), and the Ohio Environmental Protection Agency's (Ohio EPA) Qualitative Habitat Evaluation Index (QHEI) for characterizing trawling habitats (Ohio EPA 2006)[13].

11.6.3.2 Boat Electrofishing

AEPGR will conduct boat electrofishing at three, 0.5-kilometer-long sampling locations within the study area downstream from the Racine Locks and Dam. One sampling season will be conducted in mid/late summer (July or August). Specific sampling dates within this timeframe will be determined based on factors including (but not limited to) river flows, weather conditions, water temperatures, and safety of field staff and the general public. Surveys will be conducted along the shoreline at night, beginning just after dusk. Night electrofishing is conducted to take advantage of increased foraging activity and diurnal movements of fishes that occur along the shoreline in the evening hours. Fish will be netted and placed in a live well for processing.

11.6.3.3 Trawling

AEPGR will conduct daytime trawl net sampling at three locations within the study reach downstream from the Racine Locks and Dam. One sampling season will be conducted in mid/late summer (July or August). Specific sampling dates within this timeframe will be determined based on factors including (but not limited to) river flows, weather conditions, water temperatures, and safety of field staff and the general public. Surveys will be conducted using an eight foot mini-Missouri trawl net for sampling small-bodied benthic fish (Herzog et al. 2009)), or equivalent netting. Trawling will be conducted in a downstream direction with the boat powered in reverse (i.e., bow upstream), with each trawl haul lasting approximately three minutes (Herzog et al. 2009). AEPGR anticipates

[13] Consistent with recent fish sampling conducted in support of licensing the RC Byrd Project, AEPGR is proposing two methods of characterizing habitat (EA Engineering, Science, and Technology, Inc. [EA] 2011). ORSANCO's habitat characterization methods have been developed specifically for electrofishing.

conducting three trawls at each sampling location. Fish will be placed in a live well for processing.

11.6.3.4 Supporting Data

Supporting data will be collected at each sampling site (regardless of gear type) including:

- Location (GPS)
- Sampling gear type
- Macrohabitat type
- Representative photographs
- Time and date
- General descriptions of depth
- Cover type and estimated percentage of cover
- River conditions and weather

In addition to this supporting data, AEPGR will collect discrete water quality measurements of temperature, DO, pH, and specific conductance at each sampling location using an appropriate instrument calibrated per the manufacturer's instructions. A secchi disk reading will be taken at each site at the time of sampling.

11.6.3.5 Fish Processing

Catch-per-unit of effort (CPUE) will be recorded for all sites/gear types used. All fish collected will be identified to species, measured, weighed and examined for abnormalities. Photo vouchers will be taken of all species in the field, and those that cannot be identified to species will be preserved and identified in a laboratory setting based on any sampling permit specifications. In the event more than 30 individuals of the same species are collected at a given site, those excess fish will be only counted. Minnows and small juvenile fish that cannot be readily identified in the field will be preserved and identified in a laboratory. All other fish will be returned to the place of capture after processing.

11.7 Analysis and Reporting

Results of this study will be summarized in the final study report. The report will summarize the analysis of existing fisheries data, as well as describe the overall results of fish sampling conducted in support of Project relicensing, including occurrence, composition, relative abundances, game species condition, distribution, and habitat use. The report will include details of all sampling efforts, *in situ* water quality conditions, and general habitat characteristics from each sampling site. AEPGR will include tabular data summarizing length, weight, and size class for fish collected at each sampling location.

AEPGR anticipates that the Fisheries Survey study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

11.8 Schedule and Level of Effort

AEPGR anticipates that this study will be completed in July or August 2019. The study report will be prepared and provided to the applicable parties in conjunction with the ISR that will be distributed to stakeholders, and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The estimated level of effort for this study is approximately 400 hours. AEPGR estimates that this study will cost approximately $50,000 to complete.

11.9 Discussion of Alternative Approaches

The study requests from the USFWS and WVDNR recommended that AEPGR conduct fish surveys in the vicinity of the Project using a range of gear types including electrofishing equipment, seine nets, gill nets, trap sets, and eel pots, traps, or ladders. The requestors also recommended that AEPGR conduct three seasons of fish surveys (spring, summer, and fall).

AEPGR has proposed to conduct sampling downstream from the Project, but believes that the existing wealth of fisheries information – supplemented by the data synthesized and collected through AEPGR's proposed Fisheries Study that targets the tailwater area – is sufficient to inform the environmental analysis of Project effects and the development of license requirements. As described above, eight fisheries surveys have been conducted in the Racine and RC Byrd pools since 2010. These studies have resulted in the collection and measurement of thousands of individual fish. Over 11,500 fish have been captured and recorded by ORSANCO's 2010 and 2015 fish surveys in the Racine Pool alone. This is a substantial database, and AEPGR does not believe that additional information is needed. While the USFWS correctly states that sampling upstream from the Racine Project has not been conducted within 1.5 miles of the dam, AEPGR notes that there is no evidence to suggest that the fish community is substantively different within the 1.5-mile-long river reach between RM 236, where ORSANCO conducted sampling in 2015, and the dam.

The USFWS has indicated that the tailwaters downstream from the Racine Dam provides important habitat for darter species. The ODNR collected four darter species via trawl net sampling at a location 0.6 miles downstream from the dam in 2012. Three of the species collected in 2012 (channel darter, river darter, and Tippecanoe darter) are listed as threatened species in Ohio. A review of ORSANCO's Ohio River main stem fish population database indicates that those species have not been observed in recent years in either the Racine or RC Byrd pools. AEPGR recognizes that there has only been limited sampling in the tailwater habitat and that benthic trawling has been demonstrated as an effective technique to capture small-bodied benthic fish such as darters (Herzog et al. 2009; Koryak et al. 2009). Accordingly, AEPGR has proposed to conduct a tailwater fishery survey using a combination of electrofishing and trawling to characterize fish species in that reach of the river. AEPGR believes that the proposed methods and gear types are sufficient to sample the tailwaters below the Racine Dam, as they have shown to be effective at other, similar locations (Herzog et al. 2009; Koryak et al. 2009). Accordingly, AEPGR is not proposing to incorporate the array of gear types and methods proposed by the requestors.

With respect to the American eel, AEPGR notes that American eel have been documented in the Ohio River upstream to Pittsburgh and they have been documented in ORSANCO's Ohio River main stem fish population database. For the reasons described in Section 3.2.1 of this PSP, AEPGR is not proposing to conduct a Fish Protection and Upstream and Downstream Passage Study at this time. However, AEPGR is proposing to complete an Entrainment Evaluation in support of Project relicensing. Because they have been documented in the main stem of the Ohio River and included in ORSANCO's Ohio River main stem fish population database, AEPGR intends to include American eel in the Entrainment Evaluation. Additional, targeted eel sampling is not necessary, as existing information from previous fisheries surveys is sufficient for an Entrainment Analysis.

Similarly, AEPGR does not believe that it is necessary to conduct three seasons of surveys to characterize the fisheries upstream and downstream from the Project. Fish surveys conducted in support of licensing the RC Byrd Project demonstrated that the total number of species collected during surveys in June, August, and September of 2010 was very similar (N=39, 42, and 43, respectively) (EA 2011). Higher catch rates observed in August and October primarily reflected recruitment of young-of-year (YOY) fish, not an increase in species. AEPGR's proposed Entrainment Evaluation takes into account the life history of fish species known to inhabit the Racine and RC Byrd pools, as well as the seasonal differences in recruitment.

The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

12 Fish Entrainment and Impingement Study

12.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of entrainment and impingement mortality on resident fish populations.

In Section 6.2.3 of the PAD, AEPGR proposed to conduct a desktop Fish Entrainment and Impingement Study to assess potential Project effects on fish mortality and injury using existing literature and site-specific information. On October 30, 2018, USFWS and WVDNR formally requested this study. ODNR also expressed support for conducting a desktop Fish Entrainment and Impingement Study.

12.2 Goals and Objectives

The goals and objectives of the Fish Entrainment and Impingement Study are to:

- Describe the physical characteristics of the powerhouse and intake structures, including location, dimensions, turbine specifications, trashrack spacing, and field collection of intake velocities that could influence entrainment.
- Describe the fish community and compile a target species list for entrainment analysis.
- Utilize intake velocities, trashrack spacing, target fish swim speeds, and other Project specifications to conduct a desktop impingement assessment.
- Conduct a desktop analysis that incorporates the impingement assessment, Project specifications, and hydrology to quantify turbine entrainment and mortality at the Project.

12.3 Study Area

The study area for the Fish Entrainment and Impingement Study includes the FERC Project boundary.

12.4 Background and Existing Information

Existing relevant and reasonably available information regarding the fish community in the Project vicinity was summarized in Section 5.4 of the PAD (AEPGR 2018). The Ohio River supports several popular sport fish species, including Sauger (*Sander canadensis*), Walleye (*S. vitreus*), Channel Catfish (*Ictalurus punctatus*) and Flathead Catfish (*Pylodictis olivaris*), temperate basses (Striped [*Morone saxatilis*], White [*M. chrysops*], and hybrid basses [*M. saxatilis* x *M. chrysops*]), black basses (Largemouth [*Micropterus salmoides*], Smallmouth [*M. dolomieu*], and Spotted [*M. punctulatus*] basses), White

Crappie (*Pomoxis annularis*) and Black Crappie (*P. nigromaculatus*), and Freshwater Drum (*Aplodinotus grunniens*) (ODNR 2003; FERC 2015).

Previous studies of entrainment were conducted at the Racine Project and summarized in a 1987 multi-volume report, entitled *Fish Passage Studies at the Racine and New Martinsville Hydroelectric Projects* (Wapora, Inc. 1987). The studies included (1) hydroacoustic monitoring of the water passages of the turbines for fish passage; (2) monitoring of sound generated by the turbine-generator units and water velocities in the forebay and tailrace; (3) sampling of indigenous fish populations in both the Racine and Hannibal pools; and (4) use of a recovery net in the Racine Project tailrace to estimate fish passage through the turbine and to evaluate survival of fish passing through the turbine (Wapora, Inc. 1987).

12.5 Project Nexus

Downstream fish passage through hydroelectric dam intakes and turbines may cause injury or mortality by impingement against trashracks or entrainment through a turbine as a result of project operations. Entrainment injuries and mortalities can result from fish coming into contact with the turbine blades or other mechanical components and/or pressure changes and cavitation.

12.6 Methodology

A desktop evaluation of the potential for fish impingement, entrainment, and turbine mortality will be performed based on the objectives described in Section 12.2. This evaluation will utilize the wealth of existing fish community information, fisheries data collected downstream of the Project as part of the Fisheries Survey, hydrology data, and structural/operational characteristics of the Project to quantify turbine entrainment and mortality for select species. The only potential field component would be to collect intake velocities at the Project depending on the feasibility and safety considerations.

12.6.1 Task 1 – Formation of Study Working Group

AEPGR will coordinate with representatives from USFWS, WVDNR, ODNR, and other stakeholders who express an interest in participating in this study at the PSP meeting and through subsequent comments filed on the PSP or the RSP. Interested parties will also communicate prior to commencement of the other tasks listed below to identify target fish species and refine protocols specific to this study, if additional protocols are needed.

12.6.2 Task 2 – Describe the Physical Characteristics and Water Chemistry Characteristics of the Project that may influence Fish-related Turbine Entrainment, Impingement, and Survival

Physical and operational data for the Project including pool surface area, volume, average depth, and retention time will be obtained. Maps and available drawings of the dam and powerhouse may be reviewed to gather information related to total head, intake depth and size, the number, type, orientation, trashrack clear spacing, and other relevant powerhouse/turbine specification necessary to perform a desktop fish entrainment and survival study. Many of these physical and operational data are summarized in the PAD, although further review of Project drawings may be necessary.

Water quality profile data collected as part of the Water Quality Study, will be utilized to describe forebay water quality conditions (stratification) and potential influence on fish entrainment.

12.6.3 Task 3 – Intake Velocity Data Collection

As feasible, AEPGR will measure or calculate the average approach velocity 1-foot in front of the existing trashrack structure. Measurements will be collected using an Acoustic Doppler Current Profiler (ADCP) or similar technology. In the event that approach velocity measurements are not possible due to river flow conditions or for safety-related concerns, AEPGR will calculate approach velocities. Results of this task will aid in the assessment of the potential for turbine entrainment or fish avoidance.

12.6.4 Task 4 – Describe the Species Composition of the Existing Fish Community and Select a Subset of these Species for the Entrainment Assessment

Results of the Fisheries Survey and other existing fisheries information (Wapora 1987, ORSANCO 2017) will be used to describe the fish community that may be susceptible to turbine entrainment. This is expected to include information related to spatial and temporal characteristics, life histories, swimming speeds, and avoidance behavior of target fish species larval, juvenile, and adult life stages. A target species list will be compiled for the entrainment assessment to include those species of management concern (game; forage; rare, threatened, and endangered [RTE]), as well as other “non-game” species to appropriately represent the various guilds and life histories in the Project area. The susceptibility of these species to entrainment based on varying life stage periodicities, abundance at the Project, and potential “cold stress” related entrainment will be included.

12.6.5 Task 5 – Assess the Potential for Trashrack Exclusion and/or Impingement of the Target Species

Information gathered as part of Tasks 2 through 4 will be used to assess the potential for trashrack exclusion and vulnerability to impingement/entrainment. This will incorporate the trashrack clear spacing, intake velocities, swimming speeds, and body scaling factors. Body scaling factors (documented body width to body length proportions) will be calculated from empirical data to determine minimum lengths of target species physically excluded from the trashrack spacing. Such exclusions will be factored into the individual entrainment and mortality estimates.

12.6.6 Task 6 – Determine Monthly Turbine Entrainment Rates from Existing Empirical Data and Utilize these Rates to Estimate Monthly Turbine Entrainment for the Target Species using Existing Hydrology and Project Operations

A literature review of turbine entrainment field studies conducted at other hydroelectric projects will be performed to compile entrainment rates for target species. The primary sources of turbine entrainment information may include, but does not have to be limited to, the comprehensive Turbine Entrainment and Survival Database Field Tests prepared by the EPRI (EPRI 1997). For comparing entrainment potential between studied facilities and the Project, the EPRI database includes test data from 43 hydroelectric sites that used full-flow tailrace netting techniques to estimate the number, species, and sizes of fish entrained. Other principal sources of entrainment data include Stone & Webster Environmental Services (1992) and FERC (1995). Monthly entrainment rates will be determined for each of the target species, or surrogate/guild representatives available in the literature. Monthly entrainment estimates for each target species will be calculated using the entrainment rates, hydrological, and operational information. Monthly flow duration curves for a representative dry, average, and wet water year will be utilized, in addition to operational parameters to provide the estimated average and potential range of entrainment. Target fish species abundance data may be incorporated into the entrainment estimates to account for local fish community makeup in relation to the entrainment rates determined from the literature.

12.6.7 Task 7 – Calculate Turbine Mortality for the Range of Target Species' Sizes Expected to Become Entrained and Apply this to the Monthly Entrainment Estimates

A literature review of turbine mortality field studies conducted at other hydroelectric projects will be performed to compile fish survival rates applicable to the Project. The primary sources of turbine survival information may include, but does not have to be limited to, the comprehensive Turbine Entrainment and Survival Database Field Tests prepared by EPRI (EPRI 1997).

In addition to the literature review, a blade strike analysis will be performed to calculate turbine mortality rates at the Project. It has been suggested that the majority of fish mortalities at low head dams (<100 ft) are caused by fish striking a blade or other component of the turbine unit. Estimates of survival for each target species based on the blade strike analysis and literature review findings will be developed, and these survival estimates will be applied to the entrainment estimates for overall Project assessments.

12.7 Analysis and Reporting

Results of this study will be summarized in the final study report. AEPGR anticipates that the Fish Entrainment and Impingement Study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

12.8 Schedule and Level of Effort

AEPGR anticipates that this study will be completed by November 2019. The study report will be prepared and provided to the applicable parties in conjunction with the ISR that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The estimated level of effort for this study is approximately 250 hours. AEPGR estimates that this study will cost approximately $45,000 to complete.

12.9 Discussion of Alternative Approaches

The study requests from the USFWS and WVDNR recommended that AEPGR conduct in-field studies to verify the results of the desktop Entrainment and Impingement Study. AEPGR is not proposing to conduct any in-field sampling as part of this study.

Desktop entrainment and impingement studies are consistent with generally accepted practices in the scientific community. The Commission did not require in-field sampling to verify the results of desktop entrainment and impingement studies conducted in support of recent (since 2010) licensing and relicensing proceedings for other hydroelectric projects at USACE facilities along the Ohio River, including the Markland Hydroelectric Project (FERC No. 2211), RC Byrd Project, Braddock Locks and Dam Hydroelectric Project (FERC No. 13739), Emsworth Locks and Dam Hydroelectric Project (FERC No. 13757) (Emsworth Project), Emsworth Back Channel Hydroelectric Project (FERC No. 13761) (Emsworth Back Channel project), Montgomery Locks and Dam Hydroelectric

Project (FERC No. 13768) (Montgomery Project), Newburgh Lock and Dam Hydroelectric project (FERC No. 12962), or the Uniontown Lock and Dam Hydroelectric Project (FERC No. 12958). In all these proceedings, FERC concluded that a desktop entrainment and impingement analysis was sufficient to assess the potential impingement, entrainment and mortality of fish and to develop license conditions. The requestors have not demonstrated why conditions at the Racine Project are substantively different from these recently licensed or relicensed projects to warrant in-field sampling or why a desktop entrainment study is insufficient to meet information needs.

AEPGR notes that recent studies of fish impingement, entrainment, and mortality at hydropower facilities along the Ohio River have demonstrated that the operation of large bulb-type turbines with Kaplan runners, consistent with the turbines at the Racine Project, have little to no appreciable effect on fish populations. As an example, FERC recently analyzed the effects of impingement, entrainment, and turbine mortality on fish at the RC Byrd Project, which is under construction downstream from the Racine Project. The RC Byrd Project will utilize large, bulb turbines with adjustable Kaplan runners similar to the Racine Project. FERC's 2015 EA of the RC Byrd Project's effects on impingement, entrainment, and turbine mortality concluded that:

[i]n summary, most fish would not be susceptible to impingement on the intake screens due to the relatively large spacing between bars, but most small and medium size fish would be susceptible to entrainment through the project turbine…Fish entrained into the turbine units would have a low probability of blade strike. The survival rate for most small and medium size fish likely to be entrained would be high. The majority of the fish impacted by the turbines would likely consist of young fish of highly prolific species that have the ability to compensate for losses. Therefore, the estimated entrainment and mortality would only minimally effect fish populations in the project vicinity (FERC 2015).

FERC concluded similarly in analyzing the effects of the Montgomery Project, Emsworth Project, and Emsworth Back Channel Project. In its June 2016 multi-project EA, the Commission concluded that:

[b]ased on the applicants' calculated intake velocities, trashrack bar spacing, and results of the desktop entrainment mortality study, it appears that potential effects of impingement and entrainment would be minor (i.e., no impingement mortality and approximately 5 percent entrainment mortality rate). While only a desktop study was conducted, the applicants relied on well-known field studies (EPRI, 1997) and information on blade strike probability (Franke et al., 1997) for Kaplan turbines. Considering the expected low rates of impingement and entrainment mortality, and the relatively high fecundity of most warmwater fish species that would be entrained (e.g., gizzard shad, minnows, sunfish), the projects would not likely affect the composition of the existing fish community or fish species populations. As such, [in-field] entrainment studies at each project would likely only confirm that large Kaplan turbines at relatively low-head projects achieve low entrainment mortality rates (FERC 2016).

In-field sampling would significantly increase the cost of this study, pose significant challenges (e.g., nets being placed in high velocity, high volume conditions), and it has

not been demonstrated why the proposed alternative would not be sufficient to meet the stated information needs. The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

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13 Eastern Spadefoot Habitat Suitability Study

13.1 Study Requests

The Commission's August 21, 2018 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of continued project operation on the state-listed endangered Eastern spadefoot toad (*Scaphiopus holbrookii*).

In Section 6.2.4.2 AEPGR proposed to consult with ODNR to determine if a habitat suitability study was appropriate to determine if suitable Eastern spadefoot toad habitat exists within the Project area. On October 29, 2018, ODNR formally requested an Eastern Spadefoot Toad Habitat Suitability Study.

13.2 Goals and Objectives

The goals and objectives of the study are to:

- Determine if Eastern spadefoot toad habitat exists within the Project area and if so, determine if those areas are being used by the Eastern spadefoot toad through a presence/absence field survey.

13.3 Study Area

The study area for the Study includes the FERC Project boundary.

13.4 Background and Existing Information

The ODOW has multiple records within 3,000 feet of the Project site for the Eastern spadefoot toad. This species is found in areas of sandy soils that are associated with river valleys. Breeding habitats may include flooded agricultural fields or other water-holding depressions. In Table 5.5-2 in Section 5.5.2.3 of the PAD, the Eastern spadefoot is a species listed as potentially occurring in the Project vicinity.

13.5 Project Nexus

The habitat study would help inform the probability of the presence or absence of the Eastern spadefoot toad and determine the need for a presence/absence survey to determine if specimens are present within the Project area.

13.6 Methodology

13.6.1 Task 1 – Habitat Assessment and Agency Consultation

AEPGR will conduct a habitat assessment for the Eastern spadefoot toad within the Project boundary. Soils data, topographic maps, aerial photographs and other available and relevant information will be examined, in conjunction with a field visit, to determine if suitable habitat indicators are present (such as sandy soils and flood-prone areas) for the Eastern spadefoot toad. Upon completion of the habitat assessment, AEPGR will consult with ODNR and other resource agencies to determine if a field survey is necessary.

13.6.2 Task 2 – Eastern Spadefoot Toad Survey

AEPGR will conduct field studies if suitable habitat is present and recommended by ODNR based on the results of Task 1. Suitable habitat areas within the Project boundary will be identified in Task 1, and only those areas will be surveyed. The survey protocols will be developed in consultation with ODOW and will be performed by a qualified biologist.

13.7 Analysis and Reporting

Results of this study will be summarized in the final study report. AEPGR anticipates that the Eastern Spadefoot Habitat Suitability Study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

13.8 Schedule and Level of Effort

AEPGR anticipates that the habitat assessment portion of this this study will be completed by October 2019. The study report will be prepared and provided to the applicable parties in conjunction with the ISR that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The estimated level of effort for this study is approximately 150 hours. AEPGR estimates that this study will cost approximately $20,000 to complete.

13.9 Discussion of Alternative Approaches

The proposed methods for this study are consistent with accepted professional practices. The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

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Appendix A. Comments and Study Requests

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426
October 26, 2018

OFFICE OF ENERGY PROJECTS

Project No. 2570-032
Racine Hydroelectric Project
AEP Generation Resources Inc.

Mr. Jonathan Magalski
AEP Generation Resources Inc.
1 Riverside Plaza
Columbus, OH 43215

Reference: Comments on the Pre-Application Document and Requests for Additional Information

Dear Mr. Magalski:

After reviewing the Pre-Application Document (PAD) for the Racine Hydroelectric Project, and participating in the September 26 and 27, 2018 scoping meetings, and the September 26, 2018 environmental site review, we have determined that additional information is needed to adequately assess potential project effects on environmental resources. We provide comments on the PAD and our additional information requests in Schedule A. We also recommend that you consider our comments on your preliminary study plan for recreational and cultural resources, which are enclosed in Schedule B. Please file your responses to Schedules A and B with your proposed study plan that is due by December 14, 2018.

Please include a master schedule in your proposed study plan that includes the steps for conducting each proposed study (i.e., data collection, data analysis, consultation, and report preparation), the distribution of progress reports, the filing date of the initial study report, and the date of the initial study report meeting. Finally, if you are likely to propose any plans for protection, mitigation, or enhancement measures, drafts of those plans should be filed, if possible, with the study report.

Staff may determine a need for additional studies or information upon receipt and review of scoping comments and study requests from other entities due October 30, 2018, and your proposed study plan. As necessary, we will request additional information, studies, and/or provide additional input on proposed or requested studies after you file your proposed study plan.

If you have any questions, please contact Jay Summers at (202) 502-8764, or via e-mail at jay.summers@ferc.gov.

Sincerely,

Janet Hutzel, Chief
Midwest Branch
Division of Hydropower Licensing

Enclosures: Schedule A
Schedule B

Schedule A

Comments on the Pre-Application Document (PAD) and Additional Information

Aquatic Resources

1. Section 5.3.2, *Flows*, of the PAD presents the daily flow data and section 5.3.3, *Flow Duration Curves*, presents the flow duration curves for the project. In section 5.3.3, *Flow Duration Curves*, of the PAD, you state that the flow data provided was obtained from the U.S. Geological Survey (USGS) gage on the Ohio River at Greenup dam (gage no. 03216600) using 1987 through 2016 as the period of record. Please describe how the USGS data was adjusted to reflect the difference in drainage areas between the project and Greenup dam.

2. In section 5.3.7, *Existing Water Quality Data*, of the PAD, you state that in 1987, a dissolved oxygen study was conducted to evaluate the effects of a recently installed air injection system at the project on downstream dissolved oxygen levels (AEP Service Corporation and Ohio Power Company, 1988). Please file a copy of this report.

Developmental Resources

3. Item 7, on page 2 of the notice of intent, provides an installed capacity of 24 megawatts (MW) for the project. Section 1, *Introduction and Background*, of the PAD provides a project capacity of 47.5 MW. In section 4.3.6, *Turbines and Generators*, table 4.3-1 of the PAD, you state that each of the project's two turbine-generator units have a rated capacity of 24 MW. Please provide the installed capacity of the project and, if it is not 48 MW, please explain how this capacity is calculated.

4. In section 4.3.6, *Turbines and Generators*, table 4.3-1, of the PAD, you state that each turbine has a rated capacity of 24,000 kilowatts (kW) and a rated horsepower (hp) of 29,502.5. However, a turbine with a rated horsepower of 29,502.5 corresponds to a rated capacity of 22,128 kW. Please provide a rated turbine horsepower and a rated generator capacity consistent with 18 CFR 11.1(i) of the Commission's regulations.

5. In section 4.3.7, *Transmission*, of the PAD, you state that the project's transmission line is not included in the current license[1] and is not considered part of the project. In an August 10, 2018, filing, you clarified that transmission facilities are included in the current project license and that these facilities should have been included as existing project facilities in the PAD. You identified these facilities to include the 9 kilovolt (kV) generator leads, the 9,169 kV, 50,000 kilovolt-amperes (kVA) step-up transformer, and an approximately 475-foot-long, 69 kV line and appurtenances to

[1] *Ohio Power Company*, 50 F.P.C. 2020 (1973).

connect to the 69 kV bus at Racine. Please clarify whether the 475-foot-long transmission line is above ground or underground.

6. The primary transmission line terminates at the interconnection with the grid. Please provide the owner of the interconnection and their relationship to AEP Generation Resources Inc. (AEP Generation).

7. In section 4.4, *Project Operations*, of the PAD, you state that the U.S. Army Corps of Engineers provides advance notification to AEP Generation of any changes in discharge that may include ice passage and trash passage. However, section 4.4 does not describe how the project is operated under cold-weather conditions or how the trash rack is operated during its cleaning. Please describe how the project is operated under cold weather conditions, how the trash racks are cleaned, and what is done with the debris removed from the trash rack.

8. In section 4.4.2, *Dependable Capacity*, of the PAD, you state that the dependable capacity was determined as the amount of load that can be carried under adverse hydrologic conditions during a period of peak demand. Please provide the flow associated with adverse hydrologic condition used to estimate a dependable capacity of 46 MW.

9. Section 5.6(d)(2)(iii) of the Commission's regulations requires, in part, that a PAD contain a detailed description of all existing and proposed project facilities, including information on the physical composition, dimensions, and general configuration of any dams, spillway, penstocks, powerhouses, tailraces, and other structures proposed to be included as part of the project. Sections 4.3.5, *Powerhouse and Intake*, and 5.4, *Fish and Aquatic Resources*, of the PAD, reference the project's trashracks and tailrace, respectively. However, information on the composition, dimensions, and general configuration of these structures are not provided in the PAD. Therefore, please provide a detailed description of the tailrace structure, including its location, dimensions, and construction materials, and the trashracks, including its dimensions and bar spacing.

10. Section 5.6(d)(2)(v)(A) of the Commission's regulations requires that a PAD contain a complete description of the current license requirements, including any amendments to the license made during the license term. Section 4.5.1, *Current License Requirements*, of the PAD, appears to be missing license articles, or does not provide information on amendments to the license since it was issued in 1973. For example, section 4.5.1 does not include Article 49 of the current license, which requires the licensee to install facilities for the admission of air into the draft tubes, and during power generation, operate such facilities whenever dissolved oxygen concentrations in the water below the dam is below 5.0 milligrams per liter (mg/1). Article 49 also requires that dissolved oxygen concentrations downstream of the dam be continuously monitored. Please provide a complete description of license requirements and amendments for the project that meets the requirements of the Commission's regulations.

11. Exhibit G, sheet 1 of 2 shows the project boundary and principal project works, which includes an area of 28.3 acres. Please explain the project use of the area southwest of the storage building and to the northeast of the public parking area shown on Exhibit G, sheet 1 of 2.

12. Exhibit F, does not show the functional replacement dam. Please provide a revised Exhibit F that shows the as-built information for the functional replacement dam.

Schedule B

Comments on Preliminary Study Plans

Based on our review of your preliminary study plans outlined in your Pre-Application Document (PAD), we request the following modifications. Please address our requests in your proposed study plan.

Recreation and Land Use

Recreation Inventory and Planning Assessment

In section 6.2 of the PAD, *Project Effects, Studies Needed, and Summary of Relevant Issues for the Project Relicensing,* you propose to conduct a Recreation Assessment. However, you do not provide information on how recreation would be measured or what would be assessed (e.g., condition of existing sites, current and future recreation use, facility capacity, etc). Also, although the PAD provides a discussion of existing recreation facilities and sites within and adjacent to the project boundary, it does not include a detailed description of the condition of each recreation site and facility. It is also unclear how much use each site and facility receives. Anticdotal observations submitted to AEP Generation Resources Inc. (AEP Generation) as part of its PAD questionnaire, suggest that at times there are 20 to 30 individuals using the fishing pier. However, the 2014 Form-80 submitted with the PAD estimates the capacity utilization of the fishing pier at 12 percent. It is unclear if use of the fishing pier has increased since the 2014 study or if the 12 percent capacity utilization remains an accurate assessment of capacity utilization. Understanding the condition of the existing project recreation sites and facilities, the amount of current and projected future use, and how these sites and facilities are managed is essential in determining the adequacy of project recreation facilities to meet current and future recreation needs; and therefore, is relevant to the Commission's public interest determination.

In the absence of recreational use data and facility conditions, we cannot determine that the existing information is adequate for us to assess the adequacy of existing recreation facilities to meet current and future demand. So that we may fully understand and evaluate the effects of continued project operation and maintenance on recreation use, please include the following in your study proposal for recreation resources:

1. determine the current and projected capacity at each recreation site and/or facility using spot counts and traffic counters; and
2. conduct a facilities inventory.

Spot Counts

Spot counts should be conducted on four days per month which should include two randomly selected weekdays and two randomly selected weekend days. If a month contains a three-day holiday weekend, one day per holiday weekend should be included in addition to the standard survey days. The spot counts represent short-term counts (approximately 5 minutes per site) and should record the number of vehicles parked at a site/facility and the number of users observed. This information should be statistically analyzed to develop the recreational use figures for the project. Final recreation use for the recreation facilities and sites within the project should be summarized by season and activity type for each site.

Traffic Counters

A traffic counter should be installed at the entrance to the recreation parking area during the recreation season to collect site visitation data.

Facility Inventory

The inventory of project recreation facilities and sites should include the following:

1. the location and map of facilities in relation to the project boundary;
2. the types and number of amenities provided at each site and facility;
3. the condition of the facility/amenities;
4. the entities responsible for the operation and maintenance of each facility;
5. hours/seasons of operation;
6. accompanying photographs, including the fishing pier and the walkway/stairs to the fishing pier;
7. the number of days per month the fishing pier is underwater, indicating if rainfall is at, above, or below the average yearly rainfall;
8. an estimate of the number of days per month the fishing pier was underwater in the past five years, indicating if those years had rainfall at, above, or below the average yearly rainfall.
9. the condition and location of lighting at the facilities; and
10. an inventory of all recreation or public safety related signage at the facilities, including photographs of all signage.

Cultural Resources

Cultural Resources Inventory Plan

In section 6.2.8, *Cultural and Tribal Resources*, of the PAD, AEP Generation proposes to assess the potential for the project to affect identified historic and

archaeological resources through a Phase I investigation, site file search, and/or an evaluation of project facilities. The PAD provides limited information on known archaeological and historic resources within the project vicinity.

In addition, while there is a general description of the Area of Potential Effects (APE), there is no map depicting the APE. This map information is necessary for us to determine the effects of project operation on historic properties. Therefore, a Phase I archaeological survey of the APE should be conducted. Also, as part of AEP Generation's proposed study, and prior to any surveys being conducted, you should consult with the Ohio State Historic Preservation Officer (Ohio SHPO), West Virginia State Historic Preservation Officer (West Virginia SHPO), and federally-recognized Tribes who have an active interest in the project, and any interested parties.

Please include the following in the study proposal for cultural resources:

1. a defined APE for the project that would include all lands and waters enclosed by the project boundary and any other lands or properties outside the project boundary where project operation may affect historic properties. Also include: (a) a detailed map showing all aspects of the APE in relation to the project boundary;[2] (b) a background section on previous work in and around the APE; and (c) a cultural history of the research area;
2. survey methodology, including: (a) areas to survey for archaeological and/or historic resources relative to the defined APE;[3] and (b) an evaluation of cultural resources, including known archaeological sites within the APE and the project itself, for National Register-eligibility; and (c) site- or resource-specific descriptions of existing and potential project-related effects on historic properties;
3. survey results and concurrence from the Ohio and West Virginia SHPOs, any interested federally-recognized Tribes, and any interested parties on the results of the survey; and
4. a record of consultation with the Ohio and West Virginia SHPOs, interested federally-recognized Tribes, and other interested parties regarding the proposed study, results and APE, and related concurrence letters.

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[2] The APE should be developed after consultation with the Ohio and West Virginia SHPOs, federally-recognized Tribes who have an active interest in the project, and any interested parties. Once you have defined your APE, please send your APE definition and APE map to the Ohio and West Virginia SHPOs and seek their concurrence.

[3] Lands that are highly disturbed are less likely to contain cultural resources, and may not need to be surveyed.

In the event that any historic properties would be adversely affected by project operation or maintenance, AEP Generation would need to develop a draft Historic Properties Management Plan (HPMP) to avoid, lessen, or mitigate for any project-related adverse effect on National Register-eligible properties. A draft HPMP should be developed after consultation with the Ohio and West Virginia SHPOs, the federally-recognized Tribes who have an active interest in the project, and interested parties, and filed with your Preliminary Licensing Proposal (or draft license application).

The draft HPMP should, at a minimum, address the following elements:

1. identification of the APE for the project and inclusion of a map or maps that clearly show the APE in relation to the existing and proposed project boundary;
2. completion, if necessary, of identification of historic properties within the project's APE; continued use and maintenance of historic properties;
3. treatment of historic properties threatened by project-induced shoreline erosion, other project-related ground-disturbing activities, and vandalism;
4. consideration and implementation of appropriate treatment that would minimize or mitigate unavoidable adverse effects on historic properties;
5. treatment and disposition of human remains that may be discovered, taking into account any applicable State laws and the Advisory Council's "Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects," February 23, 2007 and the Native American Graves Protection and Repatriation Act (25 U.S.C. section 3001);
6. discovery of previously unidentified properties during project operation;
7. public interpretation of the historic and archaeological properties at the project;
8. a list of activities (i.e., routine repair, maintenance, and replacement in kind at the project) not requiring consultation with the Ohio and West Virginia SHPOs because these activities would have little or no potential effect on historic properties;
9. a procedure to address effects on historic properties in the event of a project emergency; and
10. a review of the HPMP by the applicant, the Ohio and West Virginia SHPOs, and consulting parties to ensure that the information continues to assist the applicant in managing historic properties and updating the HPMP based on agency and tribal consultations.

Ohio Department of Natural Resources

JOHN R. KASICH, GOVERNOR JAMES ZEHRINGER, DIRECTOR

Ohio Division of Wildlife
Michael R. Miller, Chief
2045 Morse Road, Bldg. G
Columbus, OH 43229-6693
Phone: (614) 265-6300

Electronic File October 25, 2018

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Project: Racine Hydroelectric Project No. P-2570-032 Pre-application document

Location: The proposed relicensing project is located on the Ohio River at river mile 237.5 about 4 miles upstream of the Town of Racine, in Meigs County, Ohio, at the U.S. Army Corps of Engineers Racine Locks and Dam.

Dear Secretary Bose:

The Ohio Department of Natural Resources (ODNR), Division of Wildlife (DOW) has completed a review of the above referenced project scoping document. These comments have been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the National Environmental Policy Act, the Coastal Zone Management Act, Ohio Revised Code and other applicable laws and regulations. These comments are also based on ODNR's experience as the state natural resource management agency and do not supersede or replace the regulatory authority of any local, state or federal agency nor relieve the applicant of the obligation to comply with any local, state or federal laws or regulations.

Recreation and Land Use

The applicant proposes to evaluate the need for improvements to existing recreational facilities in the tailrace area of the project by conducting a recreational assessment of the project to evaluate recreational opportunities and potential improvements to the project boundary. We support the applicants plan of conducting a study of anglers to determine angler opinions and ideas on facility improvements at the Racine Tailwater Fishing Access. This survey could be accomplished in several ways including on-site interviews with angers using the facility, post card survey and on-line surveys.

The DOW feels that the existing angler access facilities at the Racine Hydroelectric Project are inadequate for anglers and requests the following improvements be made to the area:

- Extend the existing fishing access walkway upstream to a point as close as possible to the dam bulkhead (current fenced in area). Also, provide a foot access point from that end (upstream end of existing walkway) of the walkway to the top of the bank that ties in with the existing parking lot.
- Extend the existing walkway downstream to a point close to the end of the existing rock protection on the bank to increase safe shoreline fishing access for anglers.
- The construction of a fishing pier or platform that would meet Americans with Disabilities Act (ADA) guidelines and be accessible from the existing parking lot or a new one developed downstream specifically for disabled anglers.
- Place rock vane structures along the shoreline that extend out into the water from shore that would create habitat complexity and provide current breaks that would provide cover for fish from strong current. These structures would also concentrate fish and potentially increase angler success and opportunities.

The DOW requests that the applicant submit a Recreational Development Plan for both the existing and enhanced or new recreational facilities. This plan should include, but not be limited to, parking, fishing platforms/piers, concrete and grouted pathways to shore fishing areas and platforms, restrooms, and ADA access to facilities where practical. The plan should contain information gathered from the recreational assessment and a survey of anglers for facility improvements. The DOW and West Virginia Department of Natural Resources (WVDNR) should also be consulted on the design, location and types of recreational facilities.

The DOW has existing angler survey reports from the most recent surveys in 2012 and 2017. Anglers were interviewed and counted at 117 different access sites to estimate angler effort, catch, and harvest. One of these survey locations was at the Racine Lock and Dam tailwater. Survey questions provided insight regarding angler demographics and use of the Ohio River fisheries. These reports are available for the applicant if needed.

Fish and Wildlife

The DOW recommends that impacts to streams, wetlands and other water resources be avoided and minimized to the fullest extent possible, and that Best Management Practices be utilized to minimize erosion and sedimentation.

The project is within the range of the Indiana bat (*Myotis sodalis*), a state endangered and federally endangered species. The following species of trees have relatively high value as potential Indiana bat roost trees to include: shagbark hickory (*Carya ovata*), shellbark hickory (*Carya laciniosa*), bitternut hickory (*Carya cordiformis*), black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), white ash (*Fraxinus americana*), shingle oak (*Quercus*

imbricaria), northern red oak (*Quercus rubra*), slippery elm (*Ulmus rubra*), American elm (*Ulmus americana*), eastern cottonwood (*Populus deltoides*), silver maple (*Acer saccharinum*), sassafras (*Sassafras albidum*), post oak (*Quercus stellata*), and white oak (*Quercus alba*). Indiana bat roost trees consists of trees that include dead and dying trees with exfoliating bark, crevices, or cavities in upland areas or riparian corridors and living trees with exfoliating bark, cavities, or hollow areas formed from broken branches or tops. However, Indiana bats are also dependent on the forest structure surrounding roost trees. If suitable habitat occurs within the project area, the DOW recommends trees be conserved. If suitable habitat occurs within the project area and trees must be cut, the DOW recommends cutting occur between October 1 and March 31. If suitable trees must be cut during the summer months, the DOW recommends a net survey be conducted between June 1 and August 15, prior to any cutting. Net surveys should incorporate either nine net nights per square 0.5 kilometer of project area, or four net nights per kilometer for linear projects. If no tree removal is proposed, this project is not likely to impact this species.

Mussels

The project is within the range of the sheepnose (*Plethobasus cyphyus*), a state endangered and federally endangered mussel, the fanshell (*Cyprogenia stegaria*), a state endangered and federally endangered mussel, the pink mucket (*Lampsilis orbiculata*), a state endangered and federally endangered mussel, the snuffbox (*Epioblasma triquetra*), a state endangered and federally endangered mussel, the washboard (*Megalonaias nervosa*), a state endangered mussel, the butterfly (*Ellipsaria lineolata*), a state endangered mussel, the elephant-ear (*Elliptio crassidens*), a state endangered mussel, the long-solid (*Fusconaia maculata maculata*), a state endangered mussel, the Ohio pigtoe (*Pleurobema cordatum*), a state endangered mussel, the pyramid pigtoe (*Pleurobema rubrum*), a state endangered mussel, the monkeyface (*Quadrula metanevra*), a state endangered mussel, the wartyback (*Quadrula nodulata*), a state endangered mussel, the black sandshell (*Ligumia recta*), a state threatened mussel, the threehorn wartyback (*Obliquaria reflexa*), a state threatened mussel, and the fawnsfoot (*Truncilla donaciformis*), a state threatened mussel.

This project must not have an impact on freshwater native mussels within the project area. This applies to both listed and non-listed species. Communication with the WVDNR and the US Fish and Wildlife Service (USFWS) indicates these agencies, along with the DOW are requesting a mussel survey be conducted in the project area. The DOW concurs with the WVDNR and the USFWS that a mussel survey be conducted in accordance with the West Virginia Mussel Survey Protocol. The survey plan and design must be submitted to and be approved by the WVDNR and USFWS; and be conducted by a qualified surveyor.

Fish

The project is within the range of the western banded killifish (*Fundulus diaphanus menona*), a state endangered fish, the goldeye (*Hiodon alosoides*), a state endangered fish, the speckled chub (*Macrhybopsis aestivalis*), a state endangered fish, the paddlefish (*Polyodon spathula*) a state threatened fish, the river darter (*Percina shumardi*), a state threatened fish, and the channel darter (*Percina copelandi*), a state threatened fish. The DOW recommends no in-water work in the Ohio River from March 15 through June 30 to reduce impacts to indigenous aquatic species and their habitat.

Hydropower plant operations pose a threat to fishes of the Ohio River fishes, in particular larger fish species that have a greater chance of turbine strike and mortality. Muskellenge (*Esox masquinonge*), walleye (*Sander vitreus*), sauger (*Sander canadensis*), hybrid striped bass (*Morone chrysops x Morone saxatilis*) , white bass (*Morone chrysops*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*) , spotted bass (*Micropterus punctulatus*), flathead catfish (*Pylodictis olivaris*), blue catfish (*Ictalurus furcatus*) and channel catfish (*Ictalurus punctatus*) are all species that are at risk for strike if they enter the hydro plant. These fish are all important sportfish for Ohio River anglers and those fishing in the tailwater. These fish are also hosts for certain species of mussels that are found in the Ohio River. The DOW is concerned that larger trash rack sizes would allow more of these fish to pass into the hydro plant and have a greater impact on these fish species.

Entrainment Study

The DOW supports the applicants proposal for a water quality and desktop fish entrainment study. The plan and survey design must be submitted to and be approved by the DOW and WVDNR and be conducted by a qualified surveyor.

Trash Rack Opening Size

There is no mention of the trash rack opening size in section *4.3.5 Powerhouse and Intake* of the scoping document for the project. During the field review of the project it was pointed out that the size is 6 inches, but it is not known if that is the opening size or measurement from center to center of the bars on the trash rack. If the existing opening is 6", this size seems excessive and would allow for larger and therefore a greater number of fish and diversity of fish species to enter the intake both at high flow and low flow conditions. This opening size is on the upper limits of what is typically used on other hydroelectric facilities. If the licensee cannot alter this design, the licensee shall mitigate the effects of increased fish loss through habitat enhancements in the tailwater and/or recreational facilities.

Terrestrial

Spadefoot Toad: The DOW has multiple records within 3000 feet of the project site for the eastern spadefoot toad (*Scaphiopus holbrookii*), a state endangered species. This species is found in areas of sandy or loamy soils that are associated with river valleys. Breeding habitats may include flooded agricultural fields or other water holding depressions. The DOW recommends that a habitat suitability survey be conducted by a DOW approved herpetologist to determine if suitable eastern spadefoot toad habitat exists within the project area. If suitable habitat is found to exist, the DOW recommends that a presence/absence survey be conducted by the approved herpetologist. DOW approved herpetologist prepared reports can be submitted to Nathan Reardon, DOW Compliance Coordinator at Nathan.reardon@dnr.state.oh.us.

Spadefoot Toad Habitat Survey Study Request

1. Describe the goals and objectives of each study proposal and the information to be obtained: Goal: *To determine if eastern spadefoot toad habitat exists within the project area and if so, determine if those areas are being used by the eastern spadefoot toad through a presence/absence survey. If it is determined that the eastern spadefoot toad is present within the area to be impacted by construction and/or operations, an avoidance/minimization plan should be developed and implemented by the approved herpetologist. Thus, providing protection for the eastern spadefoot toad, a state endangered species.*
2. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied: *The DOW mission is to conserve and improve fish and wildlife resources and their habitat for sustainable use and appreciation by all. It is given the authority to conserve and protect wildlife and their habitat under the authority Ohio Revised Code, chapters 1531 and 1533. The eastern spadefoot toad is listed as a state endangered species by the DOW.*
3. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study: *The ODNR-DOW is a state resource agency.*
4. Describe existing information concerning the subject of the study proposal, and the need for additional information: *The DOW has multiple records of spadefoot toad within 3000 feet of the project area. It is unknown at this time if suitable habitat exists within the project area. Part of this area is being protected under a conservation easement by the Meigs Soil and Water Conservation district.*
5. Explain any nexus between project operation and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements: *It is unknown how*

the relicensing of the hydro project would affect the existing habitat within the project area, if at all. However, it can be assumed that if new construction or operations activities would occur with the relicensing, there could be potential effects if habitats are present within the current project area boundaries. The habitat survey would help inform the probability of the absence or presence of the eastern spadefoot toad and determine the need for a presence/absence survey to determine if specimens are present within the project area.

6. Explain how any proposed study methodology (including and preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with general accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge: *The survey methodology will be determined by the approved herpetologist depending on site and project characteristics. The DOW can provide a list of approved herpetologists that are qualified to perform the habitat study and presence/ absence study, if needed.*
7. Describe considerations of level of effort and cost, as applicable, and why proposed alternative studies would not be sufficient to meet the stated information needs: *AEP Generation Resources has listed in Section 5.0 Proposed Studies of the scoping document an eastern spadefoot habitat suitability study in their initial proposal list. The applicant proposes to consult with the DOW to determine the need for an eastern spadefoot habitat survey within the project area. Because of the reasons and concerns stated above, the DOW recommends that a habitat survey be conducted.*

Due to the potential of impacts to federally listed species, as well as to state listed species, we recommend that this project also be coordinated with the US Fish & Wildlife Service.

The DOW appreciates the opportunity to provide these comments. Please contact Nathan Reardon, ODNR – Division of Wildlife Compliance Coordinator at (614) 265-6741 or nathan.reardon@dnr.state.oh.us if you have questions about these comments or need additional information.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

OCT 2 9 2018

REPLY TO THE ATTENTION OF:

Jay Summers
Federal Energy Regulatory Commission
888 First Street, NE
Washington, District of Columbia 20426

Via electronic filing and hard copy delivery

RE: Comments on Scoping Document 1 and Pre-Application Document: Racine Hydroelectric Project Relicensing – Meigs County, Ohio (Project P-2570-032)

Dear Mr. Summers:

The U.S. Environmental Protection Agency has reviewed the Federal Energy Regulatory Commission's (FERC) August 27, 2018, Federal Register (FR) Notice of Intent (NOI) advising that an Environmental Assessment (EA) will be prepared for the Racine Hydroelectric Project (Project). American Electric Power (AEP) Generation Resources (hereafter: AEPGR) is the non-federal representative. AEPGR has submitted to FERC both a Notice of Intent to file an application for a new license and a Pre-Application Document (PAD) for the Project, which is located on the Ohio River near the Town of Racine, Meigs County, Ohio. The filing of the PAD and the associated Notice of Intent by AEPGR marks the formal start of the licensing process for the Project. Via the FR NOI, FERC is soliciting comments on the PAD and on Scoping Document 1 (SD1), which was prepared by FERC staff. This letter provides EPA's scoping comments on the PAD and SD1, pursuant to NEPA, the Council on Environmental Quality's NEPA Implementing Regulations (40 CFR 1500-1508), and Section 309 of the Clean Air Act.

AEPGR, a unit of AEP, is the Licensee, owner, and operator of the run-of-river, 47.5 megawatt Racine Hydroelectric Project (Project), located at river mile 237.5 on the Ohio River. The Project is located at the U.S. Army Corps of Engineers (USACE) Racine Locks and Dam, and occupies 23 acres of Federal land administered by USACE. The features associated with the FERC-licensed Project include the water-retaining integral powerhouse[1]/intake structure and a cellular cofferdam non-overflow section that connects the powerhouse to the right abutment (looking downstream). The remainder of the development is owned, operated, and maintained by USACE and is not part of the FERC-licensed Project. USACE facilities include a short gravity section between the powerhouse and spillway, a 1,717-foot long spillway, and the two lock structures at the left end of the spillway (looking downstream) as well as the left abutment. Similarly, the reservoir formed by the Racine Locks and Dam is not a FERC-licensed facility and is not a component of the Racine Project.

Construction of USACE's Racine Locks and Dam began in 1966. The locks went into service in 1969 and are a part of the Ohio River Navigation Dam System. The Ohio River Navigation Dam System is a series of 20 USACE locks and dams located along the 981-mile-long Ohio River mainstem and its

[1] The powerhouse, constructed in 1982 of reinforced concrete over bedrock, is a water-retaining structure approximately 132 feet long and 210 feet wide.

associated tributaries, spanning across six states from Pennsylvania to Illinois. Eleven of the 20 USACE locks and dams, one of which is the Racine Project, have FERC-licensed hydroelectric facilities associated with them.

The Racine Project hydroelectric facilities were constructed in 1983 by the Ohio Power Company (a subsidiary of AEP) as an extension to the existing USACE Dam. The Project's current license was issued by FERC on December 27, 1973 for a term of 50 years, and is currently operated as a run-of-river hydroelectric generating facility in accordance with a February 25, 1983, operating agreement with the USACE. Based on the 1973 FERC license, the primary compliance requirements associated with the operation of the Project are to provide a minimum flow of 6,300 cubic feet/second immediately below the Racine Dam and operate the Project in a run-of-river mode in cooperation with the USACE.

Through the application for relicensing, AEPGR is not proposing any new Project facilities or upgrades or changes to Project operations. Based on the information provided in the FR NOI, the PAD, and SD1, EPA offers the following comments, enclosed, for consideration when preparing the EA for the proposed project. While the Project itself is located on the Ohio side of the Ohio River (EPA Region 5 jurisdiction), due to the project's proximity to West Virginia (EPA Region 3 jurisdiction), our comments have been coordinated with the EPA Region 3 NEPA program.

We look forward to working with you and reviewing future NEPA documents prepared for this project as it is developed. We are available to discuss the contents of this letter at your convenience, should you desire. If you have any questions about this letter, please contact the lead NEPA reviewer, Liz Pelloso, at 312-886-7425 or via email at pelloso.elizabeth@epa.gov.

Sincerely,

Kenneth A. Westlake, Chief
NEPA Implementation Section
Office of Enforcement and Compliance Assurance

Enclosure: EPA comment letter dated December 21, 2016

cc (with enclosure, via email):
Angie Boyer, USFWS-Columbus
John Schmidt, USFWS-Elkins, WV
Rick McCorkle, USFWS-State College, PA
Sherry Adams, USACE-Huntington
Harry Kallipolitis, Ohio EPA
Maggie Selbe, Ohio EPA
Mia Kannik, Ohio DNR
Mike Greenlee, Ohio DNR
John Kessler, Ohio DNR
Laura Cooper, West Virginia DEP
Jacob Harrell, West Virginia DNR
Janet Clayton, West Virginia DNR
Sam Dinkins, ORSANCO
Jon Magalski, AEP
Liz Parcell, AEP

EPA's Detailed Comments: Racine Hydropower Project Relicensing
Scoping/Early Coordination (pre-EA)
Ohio River, Meigs County, Ohio

October 29, 2018

RECREATION AND LAND USE

- The Racine Project provides one recreational facility as required under the current FERC license. The recreation area is located downstream from the Project's powerhouse along the right shoreline at the Project's tailrace and includes a picnic area, parking lot, fishing pier, and an Americans with Disabilities Act (ADA) accessible portable toilet. No boating access is provided, and boating activities are not allowed near the locks and dam or in the tailrace of the Project. AEPGR intends to evaluate the need for any improvements to the existing recreational facilities and plans to conduct a recreational assessment of the Project and assess recreational opportunities and potential improvements. The scope of this study would be limited to the area within the FERC-approved Project Boundary.

  In early coordination comments to FERC, the Ohio Department of Natural Resources (ODNR) noted that Ohio River Angler Survey data is available from the DNR - Division of Wildlife.

  Additionally, safety concerns were raised by users of the recreational facilities, with comments submitted via email directly to AEPGR representatives in August 2017 (Appendix B-54). These concerns and suggestions included:
  - Extending the (existing) fishing walkway upstream to the newly installed chain link fence[1];
  - Constructing a second set of steps or concrete path from the top of the hill down along the chain link fence to the fishing walkway's upstream end;
  - Constructing a second concrete path down the riprap along the newly installed chain link fence to provide additional river access[2];
  - Installing another flood light on the powerhouse building that would shine down on the upper end of the fishing walkway[3];
  - Replacing burnt out dawn-to-dusk lights in the parking lot; and

[1] Users noted that at times, because of the water currents, the best fishing is as close to the powerhouse as one can get, which is upstream of the walkway, so anglers walk the riprap to get to those better spots. Walking the riprap is dangerous, especially when it is wet, but the anglers will do it to get to the better spots. Extending the concrete walkway upstream to the newly installed chain link fence would make access to that area much easier and safer.
[2] Again, users noted that anglers will walk the level path at the top of the hill along the switchyard fence and then climb down the riprap to get to better fishing spots. Whenever the existing concrete walkway is covered during higher water, which is many days throughout the year, this is the only way for anglers to access the river. A concrete path down the riprap along the newly installed chain link fence would make that access much safer. Users also note that other hydro plants on the Ohio River have concrete paths (not steps) to get to fishing access areas, because they provide stable access even when it is wet. A path in this location could reduce falls and injuries on the riprap and greatly enhance fishing access.
[3] Users note that the upstream end of the walkway is dark at night, even when parking lot floodlights are illuminated, and that anglers fish year-round, day and night.

- Replacing the burnt-out floodlight that illuminates the ~70 concrete steps that provide access to the river and fishing walkway. Because the walkway is uneven in places, it is a safety/tripping hazard when the floodlight is out;

Recommendation: As part of relicensing, AEPGR should consider these specific requests and safety concerns raised by anglers, discuss how renovations to degraded recreational facilities will be undertaken, and provide a maintenance schedule for all facilities. Current conditions of all recreational facilities, and proposed requirements/upgrades/modification under the new license should be discussed in the forthcoming EA.

FISH ENTRAINMENT AND IMPACTS TO BIOLOGICAL RESOURCES

- Previous regional studies were undertaken and described in FERC's September 1988 Final Environmental Impact Statement (FEIS) for Hydropower Development in the Upper Ohio River Basin (FERC Docket EL85-19-114). The purpose of the FEIS was to evaluate operational alternatives and the potential environmental impacts of installation of up to 19 hydropower projects in the upper Ohio River Basin (all at existing dams on the Allegheny, Monongahela, Tygart, Muskingum, and Ohio Rivers). In our comment letter on the FEIS, EPA expressed concern for the protection of species in the river systems if turbines for hydropower were added to structures.

  As part of the FEIS (under Section 5.4.2 - Basin-Wide Recommendations), FERC recommended a number of actions and mitigation measures that were to be used as the basis for specific license articles for Ohio River basin projects to be licensed by FERC. EPA provided comments on both the FEIS, and again in a comment letter dated December 21, 2016[4] (enclosed). Currently, many of the projects that were evaluated under the 1988 FEIS are at various stages of license application review.

  Recommendations: The forthcoming EA should provide information and details on how FERC plans to incorporate the FERC staff actions and mitigation measures that were detailed in the 1988 FEIS for this Project. Additionally, FERC should review both the recommendations and commitments made regarding the 1988 FEIS and in EPA's comment letter dated December 21, 2016. Our previous recommendations, as they pertain to the Racine Project, are reiterated as follows:

  - Dissolved Oxygen (DO) - All hydroelectric projects should maintain DO concentrations at or above 6.5mg/liter. The 1988 FEIS concluded that lowering DO level to the state standard of 5.0mg/liter would significantly affect aquatic life. Further, the USACE (Pittsburgh District) noted that they would require that hydropower projects maintain existing DO conditions and the non-degradation standard would be at least 6.5mg/l;

[4] This comment letter pertained to "Proposed hydropower development in the Upper Ohio River Basin including but not limited to FERC Project Numbers (13755-002, 13757-002, 13761-002, 13768-002, 13753-002, 13762-002, 13771-002, 13763, 13766, 13767)".

- Fish Entrainment, Impingement and Bypass Measures - AEPGR, after consultation with the Ohio Department of Natural Resources (ODNR), the West Virginia Department of Natural Resources (WV DNR) and the U.S. Fish and Wildlife Service (USFWS), and within 12 months following issuance of the license, should file for FERC approval of 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 recommended studies.

- Fish Entrainment Studies - AEPGR should, after consultation with ODNR, WV DNR, and USFWS, 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 the FERC license, AEPGR staff 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, AEPGR should file a copy of the study plan and a schedule for filing the results of the study with FERC for review and approval, along with comments from the above agencies on the adequacy of the study and the schedule. FERC would reserve the right to require modification to the plan and its schedule. The results of the study should be submitted to FERC according to the approved schedule along with any comments from the resource agencies consulted 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 the Project, AEPGR should submit a schedule to FERC 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 resource agencies involved/consulted.

- Fish Passage Measures - AEPGR, after consultation with the ODNR, WV DNR, and USFWS, should 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[5]. 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 a license, the project proponent(s) would 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(ies). Within 12 months of the issuance of a license, the project proponent(s) should file a copy of the plan for operation and management of the bioengineering test facility and a schedule for implementing the plan with FERC for approval, along with comments from the

[5] EPA previously recommended that a facility should be established at one (or a few) of the projects on the upper Ohio River system, to be selected after consultation among project developers, resource agencies, and FERC staff, and after review of estimates of annual fish passage at representative sites.

resource agencies on the adequacy of the plan and schedule. FERC 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 annually to both FERC and the resource agencies listed above beginning 12 months from the FERC's approval of the plan, along with comments from the resource 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, the project proponent should include, for FERC 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 resource 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 provided to all resource agencies consulted. A summary of results and recommendations for implementation should be provided to FERC and the resource agencies at no less than two-year intervals.

- Fish Resource Monitoring - AEPGR should, after consultation with ODNR, WV DNR, and USFWS, develop a plan to monitor fish resources in the vicinity of the 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, AEPGR should file a monitoring plan with FERC for approval, along with comments from the resource agencies on the adequacy of the plan. FERC would reserve the right to require modification of the plan. Within six months of FERC approval, the monitoring plan should be implemented and continue for no less than five years after project operation commences. The results of the monitoring should be provided to the resource agencies and filed with FERC on an annual basis.

  At the end of five years AEPGR should file a final report with FERC on the results of the monitoring, to include a recommendation on the adequacy of the monitoring data, in order 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 resource agencies should be included in the final report. If results of the monitoring indicate that fishery resources are being adversely affected by hydropower operation, AEPGR should include, for FERC approval: 1) recommendations to minimize these effects through either changes in the measures established in their mitigation plan or changes in project structures or operation; 2) a schedule for implementing the changes; and 3) comments from the resource agencies on the recommendations and schedule. FERC would reserve the right to modify the recommendations or the schedule.

- The PAD states that AEPGR proposes to perform a desktop reverification Entrainment/Impingement Study to assess potential Project effects on fish mortality and injury using existing literature and site-specific information. AEPGR intends to consult with

interested stakeholders to establish appropriate methodology to identify fish species that are potentially subject to impingement and entrainment, and then assess the likelihood of mortality based on the design parameters of the Project with respect to intake profiles and approach velocities. AEPGR is not proposing to conduct fish or mussel surveys at the Project.

Recommendation: FERC and AEPGR should consult with ODNR, WV DNR, and USFWS to determine the need for and scope of fisheries-related studies that may be required before relicensing occurs. The forthcoming EA should include correspondence with the state DNRs and USFWS, as appropriate, regarding effects of turbine entrainment on fish populations in the Project footprint. If either state DNRs and/or USFWS recommend modifications based on entrainment issues, the Draft EA should discuss and study modifications to be included as a condition of the relicense. We recommend the EA describe the context and intensity of impacts to fish species from impingement, entrainment, and turbine-induced fish mortality, and consider whether measures are available and warranted to minimize impacts. Consider the potential for implementation of best practices, such as optimizing spacing between bars in trash racks, if they are not already present at the Project. WV DNR noted that fish entrainment/turbine-induced mortality is an issue at the Project site.

In early coordination comments to FERC, the WV DNR noted that information regarding water quality, fish surveys, lock and dam studies, mussel surveys and populations, and recreational use can be made available through WV DNR by contacting the appropriate district office (PAD Appendix B-50).

- The fresh water aquatic communities in the Racine Pool (upstream from the Racine Lock and Dam) and the R. C. Byrd Pool (downstream of the Racine Lock) are relatively diverse communities and should be protected to the extent practicable. According to the WV DNR malacologist[6], the potential exists (based on habitat and other factors) that at least four federally listed freshwater mussels exist in the Racine and R.C. Byrd navigational pools of the Ohio River. These include the Pink Mucket (*Lampsilis abrupta*), Fanshell (*Cyprogenia stegaria*), Sheepnose (*Plethobasus cyphyus*), and Snuffbox (*Epioblasma triquetra*). This information is supported by the USFWS[7] statement that at least two federally-endangered mussels (Pink Mucket and Fanshell) occur within the Racine, R. C. Byrd, and other pools in the area.

  Section 6.2.3.1 of the PAD states that both USFWS and WV DNR have noted that rare/threatened/endangered mussels may potentially occur in the Project vicinity. Section 5.4.7 of the PAD discusses historic and more recent sampling of unionid mussels in the Racine Pool. The most recent mussel surveys identified in the PAD were from 2005. More recent sampling of mussels was undertaken by USACE in 2010 and in 2015[8] in planning for

[6] Personal communication between Frank Borsuk (USEPA) and Janet Clayton (WV DNR) on October 22, 2018
[7] See: https://www.fws.gov/refuge/Ohio_River_Islands/what_we_do/science.html
[8] See USACE's application to Ohio EPA for Section 401 Water Quality Certification: https://tinyurl.com/Racine401

dredging of the Federal navigation channel in the vicinity of the Project[9]. This recent sampling, and the results of this sampling and potential implications to existing mussel beds, was not accounted for or discussed in the PAD.

Recommendations: FERC should review the recent USACE unionid mussel surveys and determine, in consultation with the resource agencies, how to ensure that impacts to mussel beds are avoided. The forthcoming EA should discuss mussel resources and potential implications or impacts to mussels should FERC grant a license to AEPGR.

- Page 5-25 of the PAD states, *"ORSANCO [Ohio River Valley Water Sanitation Commission] also reports that a more recent shift in the [Racine Project] fish community may be occurring due to the introduction of an invasive aquatic weed, hydrilla (Hydrilla verticillata), possibly leading to a decline in pelagic piscivores and increasing detritivores and invertivores."* ORSANCO has conducted fish surveys in the Racine and R.C. Byrd pools since the 1990s. Section 5.0 of SD1 identifies two aquatic resource studies to be undertaken by AEPGR (water quality study of dissolved oxygen and water temperature, and a desktop fish entrainment/impingement study). No other fish resource studies, or monitoring, are proposed.

  Recommendations: The ORSANCO fish survey data should be considered in AEPGR and FERC's assessment of impacts to fish communities. In addition to the ORSANCO fish community data, AEPGR and/or FERC should contact the Ohio River fisheries biologist for the State of West Virginia, State of Ohio and the Ohio River Fisheries Management Team to incorporate their recommendations. The results of this fish data and these consultations should help FERC and AEPGR determine if more expansive fishery studies are warranted.

CUMULATIVE IMPACTS

- Section 4.1.1 of SD1 identifies water quality and fishery resources as resources that could be cumulatively affected by the continued operation and maintenance of the project in combination with other activities in the Ohio River Basin, including navigation, hydropower, and other land and water development activities.

  Recommendation: In addition to water quality and fishery resources, cumulative impacts to mussel species, mussel beds, and the specific host fish that carry mussel glochidia, should also be studied. This should be discussed in the forthcoming EA.

[9] To avoid impacting freshwater mussel resources, mussel surveys are conducted by USACE at proposed dredge and disposal areas prior to project activities. Semi-qualitative mussel surveys are performed at each selected disposal area to determine the presence or absence of freshwater mussels. These surveys are in accordance with the Ohio Mussel Survey Protocol (April 2016). Several sampling locations were identified upstream of the Project.

CLIMATE ADAPTATION

- SD1 states that FERC may issue licenses for terms ranging from 30 to 50 years for non-federal hydroelectric projects. The National Climate Assessment[10] finds that in the Midwest, extreme heat, heavy downpours, and flooding will affect infrastructure.

  Recommendation: FERC should consider the current condition and expected integrity of the project's physical infrastructure over the life of the new license. The forthcoming EA should include a discussion of reasonably foreseeable effects that changes in the climate may have on the proposed project and the project area, including its long-term infrastructure. This could help inform the development of measures to improve the resilience of the proposed project. If projected changes could notably exacerbate the environmental impacts of the project, EPA recommends these impacts also be considered as part of the NEPA analysis.

[10] The U.S. Global Change Research Program's National Climate Assessment is available at: https://www.globalchange.gov/browse/reports

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

OCT 2 1 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street NE, Room 1A
Washington, DC 20426

Subject: Proposed hydropower development in the Upper Ohio River Basin including but not limit to FERC Project Numbers (13755-002, 13757-002, 13761-002, 13768-002, 13753-002, 13762-002, 13771-002, 13763, 13766, 13767)

Dear Secretary Bose:

In September 1988, the Federal Energy Regulatory Commission (FERC) published a Final Environmental Impact Statement (FEIS) on the Hydropower Development in the Upper Ohio River Basin (FERC Docket No. EL85-19-114), in accordance with the National Environmental Policy Act (NEPA). The purpose of the FEIS was to evaluate operational alternatives and the potential environmental impacts of up to 19 hydropower projects in the upper Ohio River Basin (all are existing dams on the Allegheny, Monongahela, Tygart, Muskingum, and Ohio Rivers). The dams are operated by the U.S. Army Corps of Engineers (Corps) with the exception of Muskingum Lock and Dam (L&D No. 3), which is operated by the Ohio Division of Parks and Recreation. The FERC's evaluation also included an analysis of both hydroelectric and non-hydroelectric alternatives. The U.S. Environmental Protection Agency (EPA) commented on the EIS, expressing concern for the protection of species in the river systems if turbines for hydropower were added to structures.

As the result of the FEIS environmental analysis, the FERC staff recommended Alternative 4 as its preferred alternative for development of hydropower projects in the upper Ohio River Basin. As stated in the FEIS, 16 hydropower projects would be constructed and operated with staff's recommended mitigation 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 dissolved oxygen (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 protection of wetlands and fish habitat provided by Alternative 4 is important for maintaining the overall biological integrity of the basin.

As part of the FEIS (under Section 5.4.2 Basin-Wide Recommendations), FERC staff recommended a number of actions and mitigation measures that were to be used as the basis for specific license articles for any project licensed by the Commission. Those specific actions and mitigations measures include but not limited to the following:

1. **Dissolved Oxygen (DO)** - All hydroelectric projects maintain DO concentrations at or above 6.5mg/l. The 1988 FEIS concluded that lowering DO level to the state standard of 5.0mg/l would significantly affect aquatic life. Further, the Corps (Pittsburgh District) will require that hydropower projects maintain existing DO conditions and the non-degradation standard would be at least 6.5mg/l.

2. **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.

3. **Fish Entrainment, Impingement and Bypass Measures** - 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 recommended studies.

4. **Fish Entrainment Studies** - 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.

5. **Fish Passage Measures** - 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 two-year intervals.

6. **Fish Resource Monitoring** - 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 six months of Commission approval, the monitoring plan should be implemented and continue for no less than five 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 five 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. Currently many of these projects that were evaluated under the 1988 FEIS are at various stages of license application review. EPA would like to get clarification on how FERC plans to incorporate the FERC staff actions and mitigation measures that were detailed 1988 FEIS into these projects.

7. **Effects on Aquatic on Aquatic Habitat and Life**. The 1988 FEIS recommended that Allegheny L&D No. 7, Montgomery L&D, and Muskingum L&D No. 3 be excluded from hydropower development because it was determined that it would result in significant adverse impacts to fish habitat, recreation, and wetlands, even with implementation of spill requirements (turbine bypass flow). The protection of wetlands and fish habitat provided by this recommendation was considered "*...important for maintaining the overall biological integrity of the basin*".

   The Montgomery Embayment Area in the Montgomery Pool was identified as having "*...the most ecologically significant area* [U.S. Fish and Wildlife Service Resource Category 1] *in the PA portion of the Ohio River in the form of an embayment just upstream of the dam... Its shallow water areas and wetlands provide excellent spawning and feeding areas and cover for many fish species.*" and it was "*...believed to be important because of the relative rarity of this habitat in the Ohio River mainstem.*" (FERC, 1988). The 1988 FEIS concluded that the recreational enhancements proposed for Montgomery L&D could not compensate for losses of this important habitat.

As you may be aware, EPA as well as the Corps (Pittsburgh District), and a number of other federal and state resource agencies have concerns with the potential impacts on the upper Ohio River Basin as the result of the construction of these hydroelectric facilities. The Corps is currently leading an effort to develop system-wide operating procedures incorporating adaptive management measures to be protective of the aquatic resource. Issues such as DO, entrainment, hydroelectric exclusions and protection of endangered species using updated information is important to current licensing decisions. EPA strongly recommends that FERC consider the Corps effort and the staff recommendations identified in the 1988 FEIS in the licensing of these hydroelectric facilities.

Thank you for your consideration of this matter. If you have any questions, please contact Mr. Kevin Magerr, PE at (215) 814-5724.

Sincerely,

Barbara Rudnick
NEPA Team Leader
Office of Environmental Programs

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pennsylvania Field Office
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October 30, 2018

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First St., N.E., Room 1A
Washington, DC 20426

RE: Racine Hydroelectric Project (FERC #2570)
Review of Pre-Application Document and Scoping Document 1, and Study Requests

Dear Ms. Bose:

The U.S. Fish and Wildlife Service (Service) has reviewed the August 21, 2018 "NOTICE OF INTENT TO FILE LICENSE APPLICATION, FILING OF PRE-APPLICATION DOCUMENT (PAD), COMMENCEMENT OF PRE-FILING PROCESS, AND SCOPING; REQUEST FOR COMMENTS ON THE PAD AND SCOPING DOCUMENT, AND IDENTIFICATION OF ISSUES AND ASSOCIATED STUDY REQUESTS" for the Racine Hydroelectric Project (FERC No. 2570) (Project). The Project is located on the Ohio River at the Racine Locks and Dam (L&D) at river mile 237.5 in Meigs County, Ohio. The features associated with the Federal Energy Regulatory Commission (FERC)-licensed Project include the water-retaining integral powerhouse/intake structure and a cellular cofferdam non-overflow section connecting the powerhouse to the right abutment (looking downstream). There are 23 acres of Federal land within the FERC Project boundary.

Comments on Scoping Document 1

Page 7, Section 3.1.1, Existing Project Facilities, last paragraph: The bar-spacing on the steel trash racks is not specified. This information is important for evaluating fish entrainment and impingement potential. The Service is also interested in what the intake velocity is within 1 foot of the trash racks.

The Service would also appreciate more details pertaining to the two horizontal bulb turbines, such as runner diameter, rated speed (rpm), and number of blades/buckets.

Section 3.2.2, Proposed Environmental Measures, page 9, Aquatic Resources: Depending on results of requested studies (as noted below), the Service may be recommending additional Protection, Mitigation and Enhancement (PM&E) measures.

Section 4.1.1, page 13: The Service agrees that water quality and fisheries resources should be evaluated in terms of potential cumulative effects of the project in combination with other activities in the Ohio River Basin (e.g., other existing or proposed hydropower projects).

Section 4.2.4, Threatened and Endangered Species: The Service concurs with this list of federally listed threatened and endangered species as potentially occurring in the vicinity of the Project.

Section 5, Proposed Studies, Table 1: Regarding the proposed desktop fish entrainment/impingement study, the Service believes that no reliable in-field entrainment survival study has been conducted at hydropower projects on the Ohio River. Previous studies were flawed and were not accepted by the resource agencies (see FERC Accession #20170602-5024(32196011)), nor were they accepted by FERC at the time of FERC's 1988 Final Environmental Impact Statement (FEIS; see Section 6 suggested references, below).

The Service will be requesting a freshwater mussel survey to be conducted by a qualified/approved surveyor, and will also be requesting fisheries surveys, including more targeted American eel (*Anguilla rostrata*) surveys. The Service does not intend to request bat surveys unless there are proposed activities that may require tree/forest removal.

Section 6.0, request for information and studies; suggested references:

Federal Energy Regulatory Commission, Office of Hydropower Licensing. 1988. Hydroelectric Development in the Upper Ohio River Basin, FERC Docket No. EL85-19-114, Ohio, Pennsylvania, West Virginia, FINAL Environmental Impact Statement. FERC/FEIS-0051.

20171003-5127(32433546) – USFWS letter to FERC regarding status of American eel in the Ohio River Basin, October 3, 2017.

20170602-5024(32196011) – USFWS letter to FERC regarding deletion of in-field entrainment study requirements for other licensees and potential for cumulative impacts to fisheries from multiple hydropower projects in the Ohio River Basin, June 1, 2017.

9.0 Comprehensive Plans; The Service will consider filing the following plan for FERC's consideration as a comprehensive plan:

Stark, J. 2013. The Ohio River Basin Fish Habitat Partnership: Strategic Plan. Produced by The Nature Conservancy in Ohio (with funding from USFWS Cooperative Grant #301818J224)

Ohio Division of Wildlife. 2015. Ohio's State Wildlife Action Plan. Columbus, Ohio, USA.

Comments on the PAD

Page 1, Distribution List: Note that "Ms. Lindy Nelson" should be "Mr. Lindy Nelson."

Page 1 of the NOI, (5), "Constantine" should be "Racine."

Page 2 of the NOI, (6), Project Location, should be Meigs County, "Ohio."

Page 2 of the NOI, (7), Project's installed capacity should be "47.5 megawatts (MW)."

Section 4.3.5, Powerhouse and Intake: This section stated on page 4-6 that there are two 21.75–foot-wide by 60-foot-high intake openings for each of the two generating units (four openings total). Each intake opening has a set of steel trash racks. No details are provided regarding the trash racks, such as clear spacing between the bars or the orientation. This information should be provided in the PAD. Based on the site visit conducted on September 26, 2018, the trash racks are oriented vertically with a bar spacing of what appears to be between 4 and 5 inches. This spacing will not prohibit fish from entering the intake and turbines. To protect fish from entering the intake, the Service's standards for water intake racks call for a 0.75 inch clear spacing and an approach velocity not exceeding 2 feet per second measured at a distance of 1 foot upstream of the trash rack. Downstream fish passage options at the Racine L&D are currently limited to passage through the lock, an option that is not consistently available, or through dam gates. If spillage through dam gates is reduced or eliminated as a result of operation of the Project, a large percentage of fish attempting to move downstream past the Project may become entrained in the powerhouse turbines. Therefore, we recommend that consideration be given to providing a downstream bypass.

The use of horizontal bars on the trash racks has also been shown to exclude more fish than those with vertical bars having the same spacing, and impinged fish are also better able to escape trash racks with horizontal bars because their side-to-side movements are not restricted as they would be when impinged between vertical bars. There are also examples of trash racks with rounded bars which allow for tighter spacing with much less associated head loss. Sloped racks have demonstrated success in protecting fish from entrainment, particularly American eels. The Service recommends an entrainment study to assess impacts of entrainment on fish in the river (see Study Requests below).

Section 4.4 Project Operations: This section stated on page 4-8 the approximate flow range for the Project is from 4,000 cubic feet per second (cfs), the minimum turbine discharge, to about 150,000 cfs (flow at which units are shut down due to loss of operating head). River flows from approximately 4,000 cfs to 31,300 cfs (hydroelectric plant discharge capacity) normally will be passed through the turbines but may be passed through both plant and dam in a coordinated effort, if required. During periods where all flow is passing through the turbines, the Service is concerned that fish will not have a viable route to move downstream. The Service requests a fish passage study to evaluate the potential for fish passage both upstream and downstream at different flow regimes (see Study Requests below).

It appears that there are periods of time where all flow passes through the turbines with no spillage through the dam. Depending on the stratification of the pool and the position of the intake, the Service is concerned that the water passing through the turbines and discharging downstream could result in low dissolved oxygen (DO) levels in the river downstream of the Project. The Service recommends that this issue be further evaluated as part of the water quality monitoring study including how operations can be modified to enhance oxygen levels downstream. If there is a negative effect on DO during these periods, minimum spillage flows through the dam would be recommended in order to continue to provide aeration and thereby maintain DO levels that support fish populations and other aquatic life. In addition, minimum year-round flows through the dam gates are needed to continue to provide shallow-fast habitat conditions for species associated with dam tailwater habitats (e.g., darters), considering the relative rarity of shallow-fast habitats in the Ohio River navigation system. As the Commission stated in its 1988 FEIS, "habitat for shallow, swift-water species no longer exists except at the tailwaters of dams" (FERC 1988).

Section 5.3.6, Federally Approved Water Quality Standards: This section stated on page 5-12 that although there are some slight differences in the wording between the DO criteria among Ohio River Valley Water Sanitation Commission (ORSANCO), Ohio EPA, and the WVDEP, the required values are the same for each entity. According to the current license, the average DO concentration shall be at least 5.0 milligrams per liter (mg/L) for each calendar day; the minimum concentration shall not be less than 4.0 mg/L; and from April 15 to June 15, a minimum concentration of 5.0 mg/L shall be maintained at all times.

Regarding the ORSANCO water quality criteria for the protection of warm water aquatic life, it is the Service's position that the DO criteria as stated in the paragraph above are not fully supportive of optimal growth conditions for many fish and other aquatic species. A literature review by Chamberlain et al. (1980) found that largemouth bass experienced reduced larval growth at 6 mg/L (temperature: 20-23 degrees C), and juvenile swimming speed was reduced at DO concentrations of < 5.0-6.0 mg/L (temperature = 25 degrees C). Carlson and Siefert (1974) concluded that DO concentrations up to 6.3 mg/L reduced the growth of early stages of the largemouth bass by 10 to 20 percent. Stewart et al. (1967) observed reduced growth of juvenile largemouth bass at 5.9 mg/L and lower concentrations, with significant growth reductions at concentrations below 5.5 mg/L.

In general, prolonged exposure to 4 mg/L causes acute mortality in many invertebrates and non-salmonid fish embryos (Gray et al. 2002). Severe production impairment of early-life-stage non-salmonid species occurs when oxygen falls below 4.5 mg/L (EPA 1986). The Habitat Suitability Index Model for largemouth bass considers a DO concentration of 5-8 mg/L as providing a suitability of 80 percent during midsummer within pools or littoral areas, and a concentration > 8 mg/L as being optimal (suitability rating of 100 percent) (Stuber et al. 1982). Optimal DO concentration for walleye spawning and embryo development is ≥ 6.5 mg/L (McMahon et al. 1984). Therefore, the optimal DO growth range is more likely ≥ 6.5 mg/L for target fish species.

Section 5.3.7.1, Designated Use Attainment: This section stated on page 5-17, DO criteria were not met on approximately 3 percent of the days between 2010 and 2014. The Service is

concerned these low DO events could have a detrimental impact on aquatic resources in the river. The Licensee should develop a plan to reduce the number of days where DO concentrations do not exceed minimum levels so that the river downstream of the project better supports aquatic life.

Section 5.4.2, Existing Fish and Aquatic Resources: This section stated on page 5-21 that the American eel, a catadromous species, has been documented in the Ohio River and tributaries, including in the RC Byrd Pool, just downstream of this project in 2015. American eels are likely more abundant in the Ohio River in the vicinity of this Project than what was found in these surveys. Electrofishing surveys of navigation pools may fail to detect eels that may congregate at the base of dams. Correspondence from an ORSANCO biologist indicated that American eel is among those species that are probably underrepresented in surveys (J. Thomas, personal communication).

Historically, the American eel was much more abundant in the Ohio River, but a variety of factors, including water pollution and construction of locks and dams, contributed to its decline and present-day rarity in the Ohio River. Some eels still manage to migrate upstream, and have even been documented as far upstream as above Lock and Dam 9 on the Allegheny River, upstream of East Brady (PFBC 2012).

In its 1988 FEIS for proposed hydroelectric development in the upper Ohio River basin, the FERC stated that migratory eels have recolonized the study area, and their downstream adult spawning migrations may cause them to pass through turbines (FERC 1988). The Atlantic States Marine Fisheries Commission identifies mortality caused by hydropower turbines during the downstream migration of adult eels as one of the impacts affecting the American eel's population (ASMFC 2000). The American eel is particularly susceptible to turbine entrainment mortality due to its elongated body shape.

The Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Plan for American Eel (ASMFC 2000) contains the following goal:

> Protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic States and jurisdictions, and contribute to the viability of the American eel spawning population.

As stated in the Goals of this Plan, the purpose of this management effort is to reverse any local or regional declines in abundance and institute consistent fishery-independent and dependent monitoring programs throughout the management unit. Among the primary objectives of the Plan are to protect and enhance American eel abundance in all watersheds where eel now occur, and, where practical, to restore American eel to those waters where they had historical abundance. Early accounts regarding eel abundance in the Ohio River Basin are not readily available, but during the period 1920-50, the eel was "rather numerous" in the Ohio River as far upstream as Marietta, in the lower Scioto River, and especially in the Muskingum River upstream as far as Zanesville (Trautman 1981).

The American eel is also a host for several freshwater mussel species that are found in the Ohio

River, including species that are listed as threatened or endangered in Ohio, or imperiled or vulnerable in West Virginia. These species include: washboard (*Megalonaias nervosa*), Ohio Endangered and West Viriginia Imperiled (S2); black sandshell (*Ligumia recta*), Ohio Threatened and West Virginia Vulnerable (S3); flutedshell (*Lasmigona costata*), West Virginia Vulnerable (S3); mucket (*Actinonaias ligamentina*), West Virginia Vulnerable (S3); and spike (*Elliptio dilatata*), West Virginia Vulnerable (S3).

The skipjack herring (*Alosa chrysochloris*), a facultative anadromous species which migrates long distances to preferred upstream spawning habitats, has also been documented in increasing numbers in the Ohio River. As indicated in Table 1, below, the skipjack herring is the host for the imperiled elephant-ear mussel (*Elliptio crassidens*).

The Service also has concerns about potential impingement and entrainment of fish species which serve as hosts for freshwater mussels, including federally listed endangered species known to occur in the Ohio River. Table 1 includes a list of selected fish species documented upstream and/or downstream of Racine L&D, and the imperiled, critically imperiled and federally listed or Ohio listed threatened and endangered freshwater mussel species they host.

Table 1. Selected Fish Species Documented in the Ohio River*, and the Imperiled (S2)**, Critically Imperiled (S1)**, Federally Listed Endangered (FE), Ohio Endangered (OE) and Ohio Threatened (OT) Freshwater Mussels They Host.

Host Fish Common Name	Host Fish Scientific Name	Mussel Species Common Name	Mussel Species Scientific Name	Mussel Status
American Eel	*Anguilla rostrata*	Washboard	*Megalonaias nervosa*	OE, S2
		Black Sandshell	*Ligumia recta*	OT
Freshwater Drum	*Aplodinotus grunniens*	Deertoe	*Truncilla truncata*	S2
		Butterfly	*Ellipsaria lineolata*	OE, S2
		Fawnsfoot	*Truncilla donaciformis*	OT, S1
Sauger	*Sander canadensis*	Sheepnose	*Plethobasus cyphyus*	FE, OE
		Fawnsfoot	*Truncilla donaciformis*	OT, S1
		Deertoe	*Truncilla truncata*	S2
		Monkeyface	*Quadrula metanevra*	OE, S2
		Pocketbook	*Lampsilis ovata*	OE
Skipjack Herring	*Alosa chrysochloris*	Elephant-ear	*Elliptio crassidens*	OE, S2
		Washboard	*Megalonaias nervosa*	OE, S2
Logperch	*Percina caprodes*	Fanshell	*Cyprogenia stegaria*	FE, OE
		Clubshell	*Pleurobema clava*	FE, OE
Banded Darter	*Etheostoma zonale*	Fanshell	*Cyprogenia stegaria*	FE, OE

		Northern Riffleshell	*Epioblasma torulosa rangiana*	FE, OE
Greenside Darter	*Etheostoma blennioides*	Fanshell	*Cyprogenia stegaria*	FE, OE
Bluebreast Darter	*Etheostoma camurum*	Northern Riffleshell	*Epioblasma torulosa rangiana*	FE, OE
Bluntnose Minnow	*Pimephales notatus*	Round Pigtoe	*Pleurobema sintoxia*	S2
Bluegill	*Lepomis macrochirus*	Round Pigtoe	*Pleurobema sintoxia*	S2
		Monkeyface	*Quadrula metanevra*	OE, S2
		Pocketbook	*Lampsilis ovata*	OE
Spotfin Shiner	*Cyprinella spiloptera*	Round Pigtoe	*Pleurobema sintoxia*	S2
Creek Chub	*Semotilus atromaculatus*	Ohio Pigtoe	*Pleurobema cordatum*	OE, S2
Rock Bass	*Ambloplites rupestris*	Purple Cat's Paw Pearlymussel	*Epioblasma obliquata obliquata*	FE
Smallmouth Bass	*Micropterus dolomieu*	Pocketbook	*Lampsilis ovata*	OE
Spotted Bass	*Micropterus punctulatus*	Pocketbook	*Lampsilis ovata*	OE
Largemouth Bass	*Micropterus salmoides*	Pocketbook	*Lampsilis ovata*	OE
White Crappie	*Pomoxis annularis*	Pocketbook	*Lampsilis ovata*	OE
Greenside Darter	*Etheostoma blennioides*	Purple Cat's Paw Pearlymussel	*Epioblasma obliquata obliquata*	FE, OE
Logperch	*Percina caprodes*	Purple Cat's Paw Pearlymussel	*Epioblasma obliquata obliquata*	FE, OE
Yellow Perch	*Perca flavescens*	Pocketbook	*Lampsilis ovata*	OE

*ORSANCO Ohio River Main-stem Fish Population Data – 2010-2016; 2003-2014
**2014 Status Rankings provided by Janet Clayton, WVDNR

This section further stated the Ohio River also supports rare species such as the bluebreast darter (*Etheostoma camurum*) and Tippecanoe darter (*Etheostoma tippecanoe*). Both species have been documented within the Racine Project tailrace habitat (Honick et al. 2017). The Service is concerned how operations may affect these rare fish species in the tailrace.

Section 5.4.6, Benthic Macroinvertebrates Habitat and Life-History Information, page 5-26: The sections of the Ohio River surveyed in 2015 are not identified. Did these surveys include the Racine and RC Byrd pools?

Section 5.4.7, Freshwater Mussels: This section stated on page 5-27 that historic sampling in 2000 of mussels in the Racine Pool showed the presence of up to 31 species of mussels, with

evidence of mussel recruitment. The RC Byrd Pool was historically sampled less, with only 23 percent of the total area sampled and only 50 percent of that area containing up to 22 species of mussels. More recent surveys at the Great Bend Site (RM 221.5-224.5) and Mountaineer Plant (RM 242-243.4) in 2005 found lower density and diversity of mussels. No live or dead individuals of federally-protected species were collected at either the Great Bend Site or the Mountaineer Plant site.

As noted above, the 2000 surveys were limited in scope and were also conducted over 18 years ago. The Great Bend site and Mountaineer Plant site are located 13 and 4.5 miles from this Project, respectively, and were surveyed 13 year ago.

The Service recently obtained results of mussel surveys conducted in 2010 and 2015 in support of the U.S. Army Corps of Engineers (Corps) Navigation Dredge Program for the Corps' Huntington District which includes the Racine Locks and Dam (McClane Environmental Services 2010; Lewis Environmental Consulting 2015). Results of these surveys showed a mussel concentration area approximately 1200 m downstream of the Racine powerhouse, near the right descending bank.

The 2015 report also cited surveys conducted in 2001 and 2005 in support of its conclusion that this mussel concentration has been steadily increasing in density and species diversity across the four surveys. The dominant species in this mussel concentration is the black sandshell, which is threatened in Ohio and rare (S3) in West Virginia. Also present are the threehorn wartyback mussel (*Obliquaria reflexa*), listed as threatened in Ohio and rare in West Virginia, the monkeyface mussel (*Quadrula metanevra*), listed as endangered in Ohio and very rare (S2) in West Virginia, and the Ohio pigtoe (*Pleurobema cordatum*), also endangered in Ohio and very rare in West Virginia. Although no federally listed threatened or endangered species were found, the survey did not include a qualitative component as is currently required by the 2018 West Virginia Mussel Survey Protocols. While a species richness curve was provided, it was based only on semi-quantitative transect data. Additional qualitative sampling within the higher concentration areas, conforming to the WV protocols, is needed to build upon the species richness curve. In addition, the 100-m transect spacing was only adequate for a scoping study and did not adhere to the WV protocols for determining whether federally listed species are present. Results from the two most downstream transects in the 2015 survey meet the diversity trigger for requiring a Phase 2 survey, and federally listed species have been documented in areas with lower diversity and density. Therefore, the Service requests a new mussel survey, following the WV protocols (see Study Request below).

Table 5.5-1, page 5-30: The incorrect Latin name is given for the Eastern Harvest Mouse. The Latin name in the table is that of the Eastern Gray Squirrel, which is missing from the table. The correct Latin name for this mouse is *Reithrodontomys humulis.*

Section 5.5.2.2, Avifauna: This section stated according to correspondence with the Service, bald eagles have been documented upstream and downstream of the Project. The bald eagle was removed from the Federal Endangered Species List on August 8, 2007, and is no longer protected under Section 7 of the ESA; however, bald eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d). If bald eagles are present within or near the

Project area, we recommend that you follow the Service's Bald Eagle Management Guidelines prior to commencement of work. These guidelines, as well as additional eagle information, are available on the Service's website.[1] To assist you in making a decision regarding potential impacts to bald eagles, a screening form can also be found on the Service's website.[2]

Section 5.7.1, Federally Listed Threatened, Endangered, and Candidate Species: This section stated on page 5-38 that AEP Generation Resources Inc. (AEPGR) conducted a review of federally listed threatened, endangered, and candidate species using USFWS' Information for Planning and Consultation (IPaC) online system on August 14, 2017. A total of seven threatened, endangered, or candidate species have the potential to occur within the Project Boundary including four mussels (fanshell [*Cyprogenia stegaria*], pink mucket [*Lampsilis abrupta*], sheepnose [*Plethobasus cyphyus*], and snuffbox mussel [*Epioblasma triquetra*]), two mammals (Indiana bat [*Myotis sodalis*] and northern long-eared bat [*Myotis septentrionalis*]) and one flowering plant (running buffalo clover [*Trifolium stoloniferum*]). AEPGR should clarify what Project Boundary was used in IPaC to define the action area and determine what listed species may be affected. Because operations can affect aquatic resources in the river both upstream and downstream, the action area should have included a larger portion of the river than what is depicted in Figure 5.6-1. The Service generally recommends 200 meters upstream and 800 meters downstream be identified as the action area for purposes of identifying threatened and endangered species in the area of a project. In addition, it has been over 1 year since the official species list was identified. Therefore, the Service recommends that IPaC online system be rerun for the larger action area to ensure all potential listed species that could be impacted by this project have been identified.

Section 6.2.2.2 Proposed Studies: This section proposes on page 6-2 to conduct seasonal temperature and DO studies to confirm compliance with water quality standards. The Service supports this recommendation and would like to work with the Licensee to develop the work plan for the monitoring that addresses our concerns with the low DO occurrences in the river in the vicinity of this Project.

Section 6.2.3.2, Proposed Studies: This section proposes on page 6-4 to perform a desktop reverification entrainment/impingement study to assess potential project impact on fish mortality and injury using existing literature and site-specific information. The study would assess the likelihood of mortality based on the design parameters of the project with respect to intake profiles and approach velocities. This type of study may be appropriate for resident/non-migratory fish. However, for migratory species which would be attracted to the water intakes as a means to migrate downstream (e.g., American eels), approach velocities and swimming speeds are not an important consideration. The most reliable method for keeping these species out of the water intake are trash racks with small enough spacing between the bars to exclude fish from the powerhouse. In the case of the American eel, the trash rack clear bar spacing needs to be 0.75 inches wide to prevent eel entrainment and mortality. The Service recommends an entrainment study to assess impacts of entrainment on fish in the river (see Study Requests below).

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[1] http://www.fws.gov/northeast/EcologicalServices/eagle.html

[2] http://www.fws.gov/northeast/EcologicalServices/eagleguidelines/constructionnesting.html

Section 6.2.3.2 Proposed Studies: This section stated on page 6-4 that fish and mussel surveys are not proposed for this project. The Service does not support this position. Fish and mussel surveys in close vicinity of the project have either not been performed or are out of date. The Service recommends updated fish and mussel surveys be performed to better understand resources in the vicinity of the Project and understand what species may be affected by the operations of this project.

Section 6.2.4.1 Potential Issues: This section stated on page 6-4 the majority of the land within the project boundary is mowed, maintained, and enclosed by fencing. Therefore, the continued operation and maintenance of the project associated with power generation, including the existing recreation site, is not anticipated to have significant cumulative impacts to terrestrial wildlife or botanical resources. This section further stated the federally endangered Indiana bat and federally threatened northern long-eared bat may occur in the Project vicinity. However no impacts to foraging bats are anticipated from continued project operation. The Service supports this position. However, should any removal of trees greater than 3 inches dbh need to occur within the project boundary in the future, potential impacts to these species would need to be addressed. Impacts can be avoided by only removing trees between October 1 and March 31.

Running buffalo clover could also occur in the project vicinity. Any change in use or management of the upland areas within the project boundary would need to assess potential impacts to this species.

Literature Cited:

Atlantic States Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American Eel. *Fishery Management Report No. 36 of the Atlantic States Marine Fisheries Commission.* 93 pages. (Accepted by FERC as a Comprehensive Plan).

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Study Requests

The Service requests that the Licensee conduct the following studies.

I. Fish Surveys

We do not agree with the Licensee's conclusion that no fish surveys are needed. Fish surveys are needed to get an assessment of fish populations in the vicinity of the project. A variety of sampling gear, including gill nets, trap nets, seines, and electroshocking should be used as appropriate for site conditions. The survey should cover at least three seasons (spring, summer, and fall), and all four seasons if possible. The study should be done for 1 full year, with provision for a second year of study if data collected are inadequate based on review by the Service and other resource agencies. Information to be collected should include species, size, age, sex, and condition, as well as movement patterns and habitat utilization. Standard water quality data (i.e., water temperature, DO, pH, and conductivity) should be collected in conjunction with these surveys. These studies should focus on general fishery resources, and should include the dam tailrace area, to the extent this can be accomplished in a safe manner.

We also request that this study include American eel-targeted surveys, focused on detecting adult silver eels moving downstream in the fall, and yellow (juvenile) eels moving upstream during the spring, when water temperature reaches about 15 degrees Celsius (59 degrees Fahrenheit), as well as during the summer and fall, until water temperatures decline to about 10 degrees Celsius (50 degrees Fahrenheit). Upstream-migrating eels are attracted to areas immediately below dams where there is a detectable flow that is not too fast, and they are more likely to be collected during increasing flows. We recommend a combination of methods, including both daytime and night-time electrofishing in targeted areas near the dam, to the extent it can be done safely. It is important to use an appropriate setting when electrofishing for eels, as this approach is known to injure eels, or miss them altogether.

We also recommend the use of eel traps, eel pots, or a small strategically-placed eel ramp terminating in a bucket. This approach may be quite effective inside a lock chamber, if possible. Night-time red-light surveys might be considered if there are shallow areas with low turbidity; otherwise this approach is not recommended.

1. *Goals and Objectives*

The goals and objectives of this study are to provide information on the existing fishery resources in the vicinity of the Project, both upstream and downstream of the dam, including dam tailwaters, to aid in the determination of what the Project impacts may be and to establish a baseline for future assessments. The information to be obtained should include both the temporal and spatial aspects of species distribution; age, size, sex, and condition data; habitat utilization; and fish movement patterns.

2. *Resource Management Goals*

Resource management goals include: (1) protecting the existing warmwater fishery, including species associated with dam tailwaters; (2) where justified, providing fish passage to diadromous fish species (e.g., American eel) in order to aid in restoration of these species to the Ohio River; and (3) ensuring protection of species which are known or potential hosts for the glochidia (larva) of freshwater mussel species of concern, and possibly developing passage measures for these species, as well.

3. *Public Interest*

The requestor is a resource agency.

4. *Existing Information*

Although the Racine Pool was surveyed by ORSANCO in early September of 2015 on the left descending bank, the survey above the dam was done by electrofishing. This upstream survey was closest to the Project and was at RM 236, 1.5 miles upstream from the Project. A trawl survey of the RC Byrd Pool at RM 238.1 in early October of 2012 by ODNR conducted at mid-channel was the closest downstream survey location, 0.6 miles downstream from the Project.

Four darter species were among the species collected, emphasizing the importance of the dam tailwater to darter species. Three of the collected darter species, channel darter, river darter and Tippecanoe darter are Ohio listed threatened species. The ORSANCO also did a downstream survey in late July of 2013 by electrofishing at RM 238.7 on the right descending bank, 1.2 miles downstream of the Project. Other recent surveys of both the Racine and RC Byrd Pools are documented in the ORSANCO database, but all are farther from the Project than those described above.

5. *Nexus to Project Operations and Effects*

The Racine L & D serves as a partial barrier to upstream and downstream fish migration, and the existing hydropower may reduce upstream migration due to fish being attracted to the powerhouse discharge and reduction or elimination of flows through the dam gates. The Project may also reduce survival of downstream migrants due to turbine entrainment. In addition, the Project may redirect flow and change flow patterns, impact channel morphology and substrates (e.g., spawning gravels) in downstream areas, and impact habitats in the impoundment above the dam.

6. *Methodology Consistent with Accepted Practice*

The recommended study uses standard scientific collecting techniques used in most hydropower licensing activities.

7. *Level of Effort, Cost, and Why Alternative Studies Will Not Suffice*

The level of effort would involve one field crew sampling on a seasonal basis. The study would last for 1-2 years. The actual cost is unknown and would depend upon the gear types used, number of sampling locations, local labor costs, and the ability to combine multiple studies (e.g., fisheries and water quality) into one task. Recent upstream surveys in the vicinity of the proposed Project used only one method, electrofishing, and there was no survey effort less than 1.5 miles upstream of the Project. All recent surveys in the vicinity of the Project were performed in mid-summer to early fall. No recent spring surveys have been conducted. More spring survey work, preferably earlier in the season, is needed, and should employ methodologies other than or in addition to electrofishing. The recent downstream surveys (late-July and early October), were electrofishing and trawl surveys, respectively. Mid-summer survey efforts using other methods are needed, including surveys conducted as close as possible, without compromising safety, to the dam. An American eel-targeted survey effort during the spring, summer and fall is also needed (see above recommended methods). There are no recent records for any such efforts. The existing data and literature are inadequate to fully address Project impacts, and there are no alternatives to conducting standard fishery surveys. However, the Licensee has flexibility to design the most cost-effective way to acquire the necessary data.

II. <u>Fish Protection and Upstream and Downstream Passage Studies</u>

The operation of the turbines at this Project likely reduces attraction of upstream and downstream migrants to lock chambers, and reduced spillage flows with diversion of most or all

of the flow through the powerhouse will reduce survival rates for fish moving downstream past the Project. Fish moving downstream will be subjected to potential mortality from impingement and entrainment. Many hydroelectric project licenses have incorporated trash racks with 1-inch clear bar spacing to physically exclude most adult fish from the turbines, alternate downstream passage routes, and other features (e.g., reduced approach velocities, adequate plunge pools, etc.) to encourage safe downstream fish passage. In the context of multiple, stacked hydropower projects, cumulative entrainment impacts are likely. The Licensee has not proposed any measures to ensure safe, timely and effective upstream and downstream fish passage. Therefore, we request that upstream and downstream passage studies be undertaken.

These studies should include a literature search of available passage designs for the species of concern (including American eel), as well as information on the relative effectiveness of each design. Existing facilities at other dams should be investigated. Careful attention should be paid to attraction flows, guidance mechanisms, and velocities. If the Licensee agrees to provide an alternate downstream bypass, the fish moving downriver must be diverted away from the turbines and guided to the downstream passage facility, and adequate attraction and conveyance flows must be provided. A passage facility should not create a bottleneck that would delay downstream movement or expose the fish to excessive predation. Any passage facilities should be designed to prevent blockage from ice and debris, and should be as maintenance-free as is feasible. They must also be able to operate under all flow conditions experienced in the Ohio River. If the Licensee does not provide alternate upstream and downstream passage facilities, then studies should focus on relative use of lock chambers, versus spillage flows (if provided for downstream passage) and passage through the powerhouse (downstream), as well as attraction to the powerhouse discharge (upstream).

In addition to literature review and on-site investigations of existing facilities, the Licensee should collect site-specific data from the Project to aid in the design of protection and passage facilities. This information should include flows, velocities, water depths, and substrates.

The Licensee should also collect information on the passage requirements of the fish species found in the Ohio River. This information should include swimming speeds (including burst speeds), where in the water column these fish are likely to be moving, different forms of attractants or repellents (e.g., sound, light, etc.) that may help guide each species, etc.

1. *Goals and Objectives*

The goals and objectives of this study are to provide information on potential fish passage and protection structures, or other measures that could be utilized at this Project. The information obtained will allow the Service's fishway engineers to evaluate the potential effectiveness of various options.

2. *Resource Management Goals*

Resource management goals include providing passage to migratory fish species (e.g., smallmouth bass, largemouth bass, sauger, walleye, skipjack herring, American eel) and fish species which serve as glochidial hosts to freshwater mussels found in the Project area (e.g., see

Table 1, above), in order to prevent negative impacts to recovering fish and mussel populations from the proposed Project and to aid in the continued recovery of these populations in the Ohio River.

3. *Public Interest*

The requestor is a resource agency.

4. *Existing Information*

The PAD provides very little information regarding passage alternatives. For an example of an inexpensive downstream bypass option for American eel, see Haro (2016).

5. *Nexus to Project Operations and Effects*

The Project causes changes in routes of passage (e.g., possible reduction in use of lock chambers; reduced downstream passage through dam gates; downstream diversion through powerhouse; upstream attraction to powerhouse discharge). The turbines will entrain fish, resulting in some immediate mortality, as well as latent mortality and cumulative mortality from multiple, stacked hydropower projects.

6. *Methodology Consistent with Accepted Practice*

The recommended study uses standard literature reviews and site-specific data collection techniques common to most hydropower licensing activities.

7. *Level of Effort, Cost, and Why Alternative Studies Will Not Suffice*

The level of effort would involve moderate literature review, discussions with fishway engineers, and site-specific data collection. The study could be completed in less than 1 year, but may require more time to design effective facilities. The actual cost is unknown and would depend upon the number of alternatives examined. The existing information in the PAD is inadequate to allow a thorough examination of alternatives; however, most of the information needed should be available in the existing literature.

Literature Cited:

Haro, A., B. Watten, J. Noreika. 2016. Passage of downstream migrant American eels through an airlift-assisted deep bypass. Ecological Engineering 91 (2016) 545-552.

III. Mussel Surveys

We do not agree with the Licensee's conclusion that no mussel surveys are needed. Results from a 2015 survey did not satisfy the West Virginia Mussel Survey Protocols, but met the diversity trigger for requiring a Phase 2 survey. All previous surveys are considered out of date.

Therefore, a new mussel survey is needed in order to determine whether any federally listed endangered freshwater mussel species are present within the potentially affected area, and to determine the potential for operation of the Project to adversely affect any mussel species that may be present. We recommend that a mussel survey be conducted within all suitable habitat identified in the potentially affected area, extending as far downstream as hydraulic modeling indicates potential velocity effects or, in the absence of modeling, a minimum of 1.6 km (1 mi) downstream of turbine discharge. The survey should follow the West Virginia Mussel Survey Protocols[3] which also include a list of qualified surveyors. This list may not include all individuals qualified or authorized to survey for these species. If you select someone not on the pre-approved surveyor list, provide the proposed surveyor's qualifications and proposed survey design to the Service's Pennsylvania Field Office[4] for review and approval prior to initiating the survey. Send copies of all survey results to this office or inform this office if a survey will not be conducted.

1. *Goals and Objectives*

The goals and objectives of this study are to provide information on occurrences and distributions of freshwater mussels and their habitats, to establish a baseline from which to measure increases or decreases in mussel populations over time, to assess the potential for the Project to adversely affect federally listed endangered mussel species or other mussel species of concern, and to develop protection and mitigation measures for these species if a determination is made that such measures are necessary and appropriate.

2. *Resource Management Goals*

To restore and protect viable populations of freshwater mussels, including federally listed endangered species and other species of conservation concern.

3. *Public Interest*

The requestor is a resource agency.

4. *Existing Information*

We are not aware of any recent, systematic mussel surveys that follow the currently accepted survey protocols, in the vicinity of the Racine L&D. The 2015 survey in support of Corps navigation channel dredging cited surveys conducted in 2001 and 2005 in support of its conclusion that a mussel concentration downstream of the Project has been steadily increasing in density and species diversity. Although no federally listed threatened or endangered species were found, the survey did not include a qualitative component as is currently required by the 2018 West Virginia Mussel Survey Protocols. While a species richness curve was provided, it was based only on semi-quantitative transect data. Additional qualitative sampling within the

[3] http://www.wvdnr.gov/Mussels/Main.shtm

[4] https://www.fws.gov/northeast/pafo/connect.html

higher concentration areas, conforming to the WV protocols, is needed to build upon the species richness curve. In addition, the 100-m transect spacing was only adequate for a scoping study and did not adhere to the WV protocols for determining whether federally listed species are present. Results from the two most downstream transects in the 2015 survey meet the diversity trigger for requiring a Phase 2 survey. Therefore, a new survey is needed in order to assess the potential for the Project to affect mussel communities, and to establish a baseline for future determinations of any effects of the Project on mussel communities.

5. *Nexus to Project Operations and Effects*

Freshwater mussel populations are likely to be impacted by the Project, both directly (scouring, sedimentation, changes in flow distribution) and indirectly (reduced upstream and downstream movements of host fish species, and possible entrainment impacts to host species).

6. *Methodology Consistent with Accepted Practice*

Survey methodology should follow the West Virginia Mussel Survey Protocols: http://www.wvdnr.gov/Mussels/Main.shtm.

7. *Level of Effort, Cost, and Why Alternative Studies Will Not Suffice*

The level of effort would be moderate. At a minimum, the river channel and banks downstream of the Project should be surveyed, extending downstream beyond the influence (e.g., sedimentation) of the Project. A few to several person-days would be required. Costs would be minimal to moderate, depending on the number of person-days needed to thoroughly survey the area, and quantitative and qualitative methods used. There are no known alternative approaches to determining presence, distribution and abundance of freshwater mussels.

IV. Entrainment and Impingement Study

The Licensee proposes to perform a desktop reverification Entrainment/Impingement Study to assess potential Project effects on fish mortality and injury using existing literature and site-specific information. The Licensee intends to consult with interested stakeholders to establish appropriate methodology to identify fish species that are potentially subjected to impingement and entrainment, and then assess the likelihood of mortality based on the design parameters of the Project with respect to intake profiles and approach velocities.

With regards to consideration of approach velocities, it should be noted that this aspect of the study may include a bias in that it considers species- and life-stage-specific swim speeds and associated ability to escape the intake flow velocities into the powerhouse. Not considered are those fish that are volitionally moving downstream, including out-migrating American eels which may be attracted to the powerhouse intake flow and voluntarily enter the turbines when there is no alternative route of passage (e.g., when all flow is diverted through the powerhouse), or if the flow into the powerhouse is more attractive than flow through dam Tainter gates. In addition, recent Ohio River desktop entrainment studies (e.g., HDR 2013) have limited the range

of fish lengths in their model predictions based on a misconception that the American eel is not present in the Ohio River. Therefore, the modeled fish length range should capture that of a silver (adult) eel.

At the September 27, 2018 scoping meeting, the Service stated that an in-field entrainment study would likely be requested because it is our opinion that there has never been an acceptable in-field entrainment study conducted at any of the hydropower projects on the Ohio River, as discussed in FERC's 1988 FEIS for Hydroelectric development in the Upper Ohio River Basin (FERC 1988). In the FEIS, FERC stated that the results of studies of turbine-induced fish mortality are highly varied, and they concluded that "all entrainment field studies to date are deemed incomplete and inconclusive for answering impact questions on the upper Ohio River system quantitatively, despite extensive effort." The FERC further stated that no reliable, quantitative estimate of passage rates for sites on the upper Ohio River system is presently available, and in the absence of well-defined fish passage rates at existing projects, monitoring at new projects will be necessary to determine these rates.

The Service is not aware of any recent in-field turbine mortality studies on the Ohio River, and we agree that results of such studies where they have been conducted are highly variable. Of the turbine-induced fish mortality studies reviewed (FERC 1988), including studies at the Racine (WAPORA, Inc. 1987) and Greenup (Olson and Kuehl 1988; Olson et al. 1987) projects, only the Columbia River studies used a technique (mark and recapture at downstream dams) that adequately accounted for long-term survival. Lack of winter sampling in the Racine and Greenup studies was a major drawback to concluding little overall game fish entrainment (FERC 1988). Although few game fish were affected, based on these incomplete studies, many juvenile gizzard shad and freshwater drum were entrained, a small percentage of which were killed by turbines, while mortality rates were high for any large game fish entrained in the turbines (FERC 1988).

We understand that a comprehensive in-field entrainment study is potentially cost-prohibitive. Therefore, we are not opposed to the Licensee's proposal to conduct a desktop reverification Entrainment/Impingement Study, but we recommend some type of in-field assessment to verify the results of the desktop study. In addition to the Licensee's intention to consult with interested stakeholders to establish appropriate methodology to identify fish species that are potentially subjected to impingement and entrainment, we ask that this consultation also include consideration of some type of field verification. We would also like to discuss the proposed approach to the desktop study. The Electric Power Research Institute (EPRI) database has become the standard for desktop analyses, but the resource agencies do not have a high degree of confidence in the studies included in this database because it does not include results from any comparable hydropower projects (e.g., run-of-river project at a lock-and-dam project on the Ohio River). Therefore, we request that consideration be given to other, potentially more reliable sources.

1. *Goals and Objectives*

The goals and objectives of this study are to provide information on survival rates of all species and life stages of fish that may be impinged on powerhouse intake trash racks or entrained in

powerhouse turbines, and develop estimates of annual mortality rates for all species and life stages. Estimates should also consider indirect, latent mortality of injured fish that are subjected to predation (e.g., due to disorientation or loss of equilibrium), disease (e.g., as a result of cavitation injuries) or physiological stress.

2. *Resource Management Goals*

To protect native fish populations and ensure that entrainment and impingement impacts are not resulting in population-level effects to species of conservation concern (e.g., American eel, paddlefish). Conclusions regarding potential population-level effects should consider the cumulative effects of multiple, stacked hydropower project on the Ohio River and its major tributaries (e.g., Allegheny River and Monongahela River).

3. *Public Interest*

The requestor is a resource agency.

4. *Existing Information*

The only Ohio River in-field entrainment studies that the Service is aware of, those at the Racine (WAPORA, Inc. 1987) and Greenup (Olson and Kuehl 1988; Olson et al. 1987) projects, did not adequately account for long-term survival. In addition, lack of winter sampling in these studies was a major drawback to concluding little overall gamefish entrainment (FERC 1988). Although few game fish were affected, based on these incomplete studies, mortality rates were high for any large game fish entrained in the turbines (FERC 1988). In addition, recent desktop studies (e.g., HDR 2013) did not evaluate survival rates for adult American eels.

5. *Nexus to Project Operations and Effects*

Operations of the Project result in injury and mortality of a percentage of fish that are impinged on powerhouse intake trash racks or entrained in Project turbines.

6. *Methodology Consistent with Accepted Practice*

The recommended study uses standard methodologies used in many hydropower licensing activities.

7. *Level of Effort, Cost, and Why Alternative Studies Will Not Suffice*

The level of effort and cost are to be determined during the study plan development phase. The Service is interested in working with the Licensee, FERC and the other resource agencies to develop a study plan that will address resource agency concerns. As to why alternatives will not suffice, please see criterion number 4, above.

Literature Cited:

HDR – Henningson, Durham & Richardson. 2013. FLA Volume II, Appendix C-3, Fish Entrainment Study Report. Ohio River Projects Fish Entrainment and Movement Study Prepared for Free Flow Power Corporation, Boston, Massachusetts.

Olson, F.W., and E.S. Kuehl. 1988. Fisheries Resource Studies, Vanceburg Hydroelectric Generating Station No. 1 (FERC Project No. 2614). Volume 2. Survival of sauger passing through bulb turbines and tainter gates at Greenup Dam, Ohio River. CH2M Hill and Biosonics. Report for the City of Vanceburg, Kentucky.

Olson, F.W., J.F. Palmisano, G.E. Johnson, and W.R. Ross. 1987. Fish population and entrainment studies for the Vanceburg Hydroelectric Generating Station No. 1. CH2M Hill, Inc. and Biosonics, Inc.

WAPORA, Inc. 1987. Fish passage studies at the Racine and New Martinsville hydroelectric projects. 4 vols. Cincinnati, Ohio.

WAPORA, Inc. 1987. Fish passage studies at the Racine and New Martinsville hydroelectric projects. Report for City of New Martinsville and Ohio Power Company, New Martinsville, West Virginia. 3 vols.

V. Water Quality

The Service supports the Licensee's proposal to conduct a seasonal temperature and DO study at the Project and would like to work with the Licensee to develop the work plan for the monitoring that addresses our concerns with the low DO occurrences in the river in the vicinity of this Project. We recommend hourly data collection from May 1 to October 15 when there is the greatest potential for high temperatures and low DO concentrations. In addition, we recommend that the study be conducted over a 2-year period to increase the likelihood of conducting the monitoring effort under conditions that are typical for that time of year.

VI. Recreational Access

The Service supports the Licensee's proposal to evaluate the need for any improvements to the existing recreational facilities in the tailrace area of the Project, and their plan to conduct a recreational assessment which should include a quantitative assessment of usage and angler interviews. The proposed study should also evaluate options for modifying the existing angler access facility, or developing additional angler access facilities that are compliant with the standards established under the Americans with Disabilities Act (ADA).

The Service recommends that the Draft Study Plan developed by the Licensee incorporate all of the above-listed studies. The study proposals incorporated into the Draft Study Plan should be as detailed as possible so that all parties know exactly what is being agreed to when the study plan is approved.

Thank you for the opportunity to comment on this PAD and the opportunity to provide study requests. If you have any questions regarding this matter, please contact Richard McCorkle of my staff at 814-206-7470.

Sincerely,

Sonja Jahrsdoerfer

Sonja Jahrsdoerfer
Project Leader

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Jim Justice
Governor

Stephen S. McDaniel
Director

October 30, 2018

Electronic file

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

RE: Racine Hydroelectric Project (FERC no. 2570) Pre-Application Document, Scoping Document 1 and Study Requests

Dear Secretary Bose:

Thank you for allowing the West Virginia Division of Natural Resources, Wildlife Resources Section (WRS) the opportunity to provide comments with regards to the referenced Pre-Application Document (PAD) for the proposed Racine Hydroelectric Project (Racine), FERC No. 2570. AEP Generation Resources, Inc. (applicant) has chosen to use the Integrated Licensing Process in preparing for a new license. The current license expires on November 30, 2023. The applicant submitted the referenced PAD in accordance with FERC regulation and within the established timeframe of between May 30, 2018 and November 30, 2018.

The Racine Project is an established hydroelectric project located on the Ohio river at river mile 237.5 in association with the Racine Locks and Dam and has a total installed capacity of 24MW. The comments below are being provided pursuant to 18 C.F.R §4.38(b)(5).

Trashracks

As per section 4.3.5 Powerhouse and Intake, the Racine project is described as having a set of steel trashracks installed at each intake opening. Trash racks installed at the facility appear, based on a preliminary site visit, to be of approximately 5-inch spacings. Such large trash rack spacing allows for the movement of larger fish that would be more susceptible to blade strikes and turbine-induced mortality to enter the intake structures and pass through the turbines. In an effort to reduce fish mortality, the WRS would request that the trash rack spacing not exceed 3 inches and have an approach velocity of no more than 2.0 fps. The WRS further recommends angled trash racks be employed as a means to further reduce entrainment.

Fish Passage

Hydropower projects pose a particular risk to fish passage (i.e. passage through turbines) and an additional impediment to fish passage. Project operations may also attract fish moving downstream to pass through the turbines creating an increased risk for mortality. It is the flowing water through the Project that initially attracts the migrating fish. It should be noted that, with regards to the Racine Project, there are additional avenues for fish passage available through the lock system and also through spill over. These additional avenues may not be available fish passage at all times, which may leave passage through the turbines as the only viable option for downstream migrating fish. To minimize the potential hazards for the downstream movement of fish, the WRS would request that a bypass system be installed whereby the fish moving downstream may be redirected into a bypass channel, thus avoiding the turbines. Similarly, the WRS requests maintaining a minimum flow over the dam structures to further help facilitate the downstream passage of fish.

Upstream mitigation is limited through the lock chamber structure and is dependent on boat traffic through the lock chamber. The lock is operated irregular intervals and when the lock chambers are not being operated, upstream migration is not possible. This makes the lock chambers an efficient means for facilitate the passage of fish upstream. Therefore, the WRS further requests that a bypass channel, for use when the locks are not being utilized, be installed thus facilitating upstream movement of fish.

Fish Entrainment/Impingement

As per state rule §47-5A-6, reimbursement for the incidental loss of fish due to project operation will be required. Therefore, the WRS would request that a comprehensive desktop entrainment study be utilized to determine the likely number of fish, fish species, and size classes to become entrained and experience mortality as a result of the Project's operation. Further, the WRS would request in-field verification of the resulting desktop entrainment analysis.

Ohio River Fisheries

Improvements to water quality have allowed the Ohio River the ability to support a more robust fish population and community. Even still, the fishery is continually subjected to a barrage of risks and challenges, including barriers to migration and hydropower operations, which may work to further undermine the optimal success of the fishery.

With regards to hydropower operation, a great number of fish have the risk of entering the turbines and suffering blade strike and mortality. Larger fish that enter the turbine pose a greater risk for blade strike and mortality than smaller fish. Of particular concern are paddlefish (*Polyodon spathula*), walleye (*Sander vitreus*), sauger (*Sander canadensis*), largemouth and smallmouth basses (*Micropterus sp.*), muskellunge (*Esox masquinonge*), and blue catfish (*Ictalurus furcatus*). The majority of these fish species are prime gamefish sought by anglers, while the paddlefish is a species of great importance to the overall ecological integrity of the fishery. The WRS is concerned that continued operation of the Racine Project with larger trash rack sizes than the size recommended will have a continued negative impact on the larger fish species. The WRS is also concerned that the lack of additional fish passages being offered as alternatives to the powerhouse, means that more fish moving downstream will continue to be attracted to the powerhouse flows and suffer an increased chance of mortality as a result.

The American eel (*Anguilla rostrata)* is also known to occur throughout the Ohio River. Eels have been observed as far upstream as above the Morgantown Lock and Dam on the Monongahela River. Although the American eel is not a federally or state listed species, it still represents a species of concern due to a significant decline of its populations within the Ohio River since the early 1900's. The actual numbers of American eel within the Ohio River are entirely suppositional considering the relative difficulty in effectively sampling for this species. The WRS, therefore, would request a more targeted sampling for American eels be conducted and, should the populations be observed in relative abundance in or near the Project area, measures should be taken at the Racine Project to further minimize impacts to the American eel, such as modifying operations through periodic shutdowns during downstream migration or through the utilization of bypass channels.

Ohio River fish species also serve as host species for the glochidia of freshwater mussel species. Some fish, for example sauger, are host to multiple mussel species including threatened and endangered mussels. Sauger, found within the project vicinity, is host to Sheepnose (*Plethobasus cyphyus* - S2), Fawnsfoot (*Truncilla donaciformis* - S1), Deertoe (*Truncilla truncate* - S2), Monkeyface (*Quadrula metanevra* - S2), and Pocketbook (*Lampsilis ovata* - S3) mussels. The WRS is concerned that impacts to the Racine fishery may result in further impacts to mussel populations.

Ohio River Freshwater Mussels

A 2015 survey by the Army Corps of Engineers at the project, conducted as a follow-up survey to previously conducted surveys in 2010 and 2005, indicated that mussel populations have been established downstream of the project, in direct contradiction with the applicant's assertion in the PAD that mussels had not been located in the project area. Of the seven species collected in the 2015 survey, one is a WV rare species: Monkeyface (*Theliderma metanevra* – S2). Additionally, there may also be reason to believe that other species of concern may have the potential to occur within the area of the Racine Project. These would include the Fanshell (*Cyprogenia stegaria* - S1), Sheepnose (S2), Pink Mucket (*Lampsilis abrupta* - S1), and Northern Riffleshell (*Epioblasma torulosa rangiana* - S1). These species have been collected in other pools on the Ohio.

The WRS is concerned about the potential for further impacts to the mussel communities with respect to disruptions in habitat and entrainment of fish host species. Changes in flow velocity and direction as a result of project operation may create unintended disruptions of mussel habitat downstream of the project. Further, entrainment of fish host species may have a detrimental impact on the mussel community within the vicinity of the project. The WRS would require that a mussel survey be conducted utilizing the current West Virginia Mussel Survey Protocol.

Cumulative Impacts of Projects on the Ohio River

The WRS is concerned about cumulative impacts of hydroelectric projects on the fishery with the construction and operation of a series of hydroelectric projects throughout the Ohio River and its major tributaries, including the Allegheny River and Monongahela River. Including the Racine Project, there are ten hydropower projects operating on the Ohio River currently with an additional 10 projects in various stages of the licensing/construction process. Additionally, there are a number of projects that have been proposed or are currently operating on the major tributaries of the Ohio River. The cumulative impact of all of these projects operating on the Ohio River may adversely impact the fishery, particularly those fish species that may migrate long distances and the mussel populations that may depend on certain fish species. Therefore, the WRS would request that the cumulative impacts of these projects operating on the Ohio River be considered when going through the licensing process of Racine.

Existing Water Quality Data

It is the policy of the state of West Virginia that water should be maintained in a manner that does not allow for the degradation of the water quality. It is understood that the project operation will utilize water at great depth within the water column to generate power. This water typically has a lower dissolved oxygen (DO) concentration than water found nearer to the surface. Thus, the WRS has concerns that the potential use of low DO water for power generation and the subsequent discharge of the low DO water downstream of the project facility may result in a degradation of water quality.

The WRS has further concerns about the water quality data that has been collected at the Racine Project over the years it has been in operation. Of particular concern is the low DO levels that persist at the Project throughout the Summer months. While these levels have not yet dropped below the 4.0mg/L instantaneous threshold, the levels have been below 5.0mg/L periodically throughout the sampling season, which is cause for concern. While the WRS applauds the attempts to maintain levels within compliance (the average DO concentration cannot be less than 5.0mg/L per calendar day and cannot be less than 4.0mg/L at any given time), the WRS feels that additional methods may be deployed to avoid and mitigate for any future low readings and therefore recommends that the Project take a more proactive approach to correcting water quality deficiencies in an effort to ensure adherence to anti-degradation policy and to resolve issues before they get to levels of concern. A buoy placed upstream of the intake with several DO probes positioned throughout the water column would be able to note stratification of the pool and may be able to relay the information quickly to the plant operator to

make operational modifications before the situation reaches the critical point. Further, air may be injected into the water to saturate it with oxygen before entering the tailrace.

The WRS is in support of the applicant's proposal to conduct a water quality study targeting water entering the Project and exiting the facility. The WRS further contends that water quality monitoring should continue in perpetuity to address concerns with the low DO readings (<5.0mg/L) that have been recorded at the Project. The WRS recommends that data be collected on an hourly and daily basis from May 1 to October 15 of each year to focus the data collection within a period by which DO concentrations are expected to be at their lowest and temperature is expected to be at its highest.

State 401 Water Quality Certification

Section 401(a)(1) of the federal Clean Water Act, 33 U.S.C. § 1341(a)(1) provides that any applicant of a federal license or permit must obtain a state certification from the appropriate state certifying agency. This certification is to ensure that any activity conducted under the license are to be in compliance with all applicable provisions of the Clean Water Act. The Racine Project is unique in that, in being located on the Ohio, it must obtain a 401 certificate from both administering states, Ohio and West Virginia. The state of WV will have one year to act on a received 401 application from the date the applicant has been informed by the state of West Virginia that their application is deemed complete.

Recreation and Land Use

The greater part of the Racine Hydroelectric Project associated infrastructure is located within the Ohio state boundaries. Nevertheless, this is an area frequented by West Virginia residents in large part due to license reciprocity wherein West Virginia residents may fish along the Ohio side of the Ohio River, including on the banks, and vice-versa. As is such, the WRS has a vested interest in the Racine Project's Recreational Plan within the project boundary.

Currently, the recreation area on the Ohio side consists of a parking lot, restroom facilities, field with picnic tables, and a steep set of stairs leading to a small angler path. The WRS feels that these current recreation amenities are inadequate in fully addressing recreation within the area and may exclude people with disabilities from engaging in activities within the area. Therefore, the WRS requests that improvements be made to the area to address any deficiencies to recreation. The WRS further recommends that an American Disabilities Act (ADA) compliant walkway be constructed to access the angler path. The WRS further recommends that the angler walkway be extended approximately 140m downstream to access more of the bank. To improve fishing opportunities, the WRS recommends that rock vane structures (approximately 5) be installed on the right descending bank at periodic intervals as a means to break up the increased velocities in the tailrace and should be installed only if a mussel survey and flow study deem their installation to be of little to no negative impact. Rock vanes should be installed at a suitable distance to allow for effective flow diversion and for the continued sampling of the pool. The WRS further recommends that a fishing platform, or pier, be constructed and extend out for

between 10 and 20 meters into the river channel to more immediately access the optimal fishing area within the tailrace.

Study Requests

The WRS is in support of the studies proposed by AEP for the Racine Hydroelectric Project as identified within the PAD. Of the five studies proposed, four are applicable to the goals and mission of the WRS. These include a water quality study, fish entrainment/impingement study, eastern spadefoot habitat suitability study, and recreational resources study. Additional studies not previously included within the PAD are being requested by the WRS. The WRS makes these requests in support of currently proposed studies, to correct deficiencies in data and to offer a greater level of detail where needed. The WRS further requests the opportunity to review any study plans associated with this project. The request format is in accordance with that described in 18 CFR § 5.9 (b).

Study Request 1: Water Quality Monitoring

Goals and Objectives:

The goal of water quality monitoring is to ensure the Project's compliance with state water quality standards and to provide early detection for potential deviations in water quality measurements (i.e. DO levels approaching 5.0mg/L) and to provide for the mechanisms to correct these deviations.

Resource Management Goals:

The WRS is charged with the protection and management of all wildlife within West Virginia. The WRS is fully cognizant of the need to have water quality data as a tool to more adequately manage its fisheries and to make sound decisions to promote and regulate the health of the fisheries.

Existing Information:

DO monitoring has been conducted on a yearly basis. The most recent DO report indicated several events where the DO concentrations dropped below 5.0mg/L.

Nexus Between Project Operation:

Impacts on downstream water quality could have potentially adverse effects on the fishery. These impacts would be a direct result of the project's utilization of water with low DO concentrations for power generation. More "head" is created by using water at this depth, thus generating more power. DO typically decreases as depth increases and previous water quality data has demonstrated the utilization of water with low DO concentrations by this project. There is concern that continually allowing low DO concentrations to artificially be transported to the

surface thereby lowering the DO throughout the water column will result in a negative impact to the fishery.

Study Methodology:

The methodology should employ the deployment of no less than two data collection devices positioned in at least the upstream intake and within the tailrace. DO and temperature measurements should be recorded every 15 minutes and have the ability to be relayed to a plant operator at the project. Additionally, probes should be maintained and calibrated on a routine basis to address potential fouling of data and other malfeasances with the probe's operation.

Level of Effort and Cost:

The cost of conducting an ongoing and continual water quality monitoring program with a focus on two parameters (DO and temperature) is reasonable and attainable. An ongoing study would require limited scientific equipment (i.e. a water quality probe capable of recording readings at regular intervals and with a minimum of one month of data storage) and limited effort (calibration/maintenance of instruments and retrieval of data). Continual monitoring efforts of the requested parameters are being conducted at other facilities throughout the state of West Virginia and these can be used as estimates for total cost and effort.

Study Request 2: Mussel Survey

Goals and Objectives:

The goal of a mussel survey is to fully and completely assess the mussel populations; determine the presence of rare, threatened, and endangered species; provide information on the occurrence and distribution of mussels; and to establish current and baseline conditions of mussels within 1500 meters upstream and downstream of the project.

Resource Management Goals:

The WRS is charged with the protection and management of all wildlife within West Virginia. This includes populations of mussels on the Ohio River. The goal of this study, from a resource management perspective, is to determine what impacts, if any, the Project's continued operations may have on established or likely to establish populations of mussels.

Existing Information:

The most recent mussel survey conducted within the project area was executed by the Army Corps of Engineers (COE) in 2015 as part of their analysis of steering flows/flushing flows. The primary goal of the COE study was to indicate presence/absence. As such, while the COE study was conducted consistent with their study goals and approved collection permit, it was not

conducted consistent with the protocols approved by the WVDNR and is thusly incompatible with achieving the goals as proposed by the WRS mussel survey. Furthermore, results from the COE study met the diversity/concentration requirements that would further necessitate a Phase 2 survey, thus reinforcing the need for further mussel surveys of the area.

The applicant provided information on two additional studies as justification for the exclusion of mussel surveys during the relicensing. These studies were conducted in areas incomparable with the project area and utilizing protocol inconsistent with the WVDNR protocol. The WRS finds these studies to likewise be inefficient, incompatible, and deficient in assessing the mussel community within the project area and immediate vicinity.

Nexus Between Project Operation:

Project operations have the potential to directly impact mussel communities by altering flow velocity regimes, scouring potentially suitable habitat, redefining sediment transport downstream, displacing mussel beds, disrupting preferred hydraulic conditions during crucial life stages, restricting movement of host fish species and causing turbine mortality to host fish species. These impacts then could further impact the health of the ecosystem.

Study Methodology:

The WRS requires that any mussel survey be conducted in a manner consistent with the guidelines provided by the West Virginia Mussel Survey Protocol which can be found at http://www.wvdnr.org/Mussels/Main.shtm. Prior to survey commencement, the WRS requires that any survey plans and designs be submitted to and approved by the WRS. A scientific collection permit will need to be obtained prior to conducting any survey work. Mussel work should further be completed in coordination with WVDNR, OHDNR, ORSANCO, and the USFWS.

Level of Effort and Cost:

Most consulting firms, universities and state agencies are able to perform mussel surveys at varying costs. Conducting an adequate mussel survey in accordance with the West Virginia Mussel Survey Protocol requires that a surveyor be certified and trained to assess and identify mussels and that they have the necessary expertise to properly handle such a survey. This need for an experienced and knowledgeable surveyor increases the cost of a mussel survey. However, numerous mussel surveys have been conducted in waters throughout West Virginia and the United States and they have been conducted within a level of cost and effort that is both reasonable and prudent. A list of WV approved freshwater mussel surveyors is available through the WVDNR website at http://www.wvdnr.gov/Mussels/MusselSurveyors2018.docx.

Study Request 3: Fish Survey

Goals and Objectives:

The goal of this survey is to provide a comprehensive assessment of fish populations and current information on the occurrence, abundance, and distribution of fish species in and around the Project area; and to provide quality data for use in a desktop entrainment analysis.

Resource Management Goals:

As the state resource agency, the WRS is charged with the protection and management of all wildlife within West Virginia, including the Ohio River fisheries. Operations at the Racine Project may result in impacts to the fish populations. An adequate fish survey would thus be necessary in making the most quality decisions about the management of the fishery within the project area.

Existing Information:

Both the Ohio DNR and WVDNR have conducted numerous fish studies near the Racine project on an annual basis. These studies, however, focus primarily on game fish species and utilize techniques that do not offer a full assessment of the total fish assemblages within the reach.

Nexus Between Project Operation:

The hydropower facility and associated lock and dam structure create a partial, physical barrier to both upstream and downstream movement of fish species. During hydropower operation, flow is directed through the powerhouse. Increased flow through the powerhouse is attractive to many fish moving downstream. In some instances, this may be the only flow available for fish passage. Passing through the powerhouse poses inherent risks towards fish. Many fish become entrained and suffer turbine-induced and latent mortality through blade strikes and pressure changes. In addition, alterations in flow patterns may alter fish behaviors and degrade suitable habitat downstream of the project.

Study Methodology:

Methodology should target the full and complete array of fish species found at the Racine project, including the American eel. This would require various sampling techniques to be incorporated including lock chamber surveys, nighttime electrofishing sampling, fyke netting, etc. The WRS requests that any study design be submitted to the WRS for review and approval.

Level of Effort and Cost:

A qualitative and comprehensive study of the fishery would necessitate a high level of effort by staff experienced in fisheries and with a working knowledge of fish identification. Conducting

research that targets each trophic level and species in the project area would be relatively costly when compared to other recent electrofishing surveys in the area. However, such a comprehensive analysis of the fishery is necessary for making proper management decisions and for the later determination of fish entrainment through the desktop entrainment analysis request in study request #4. Additionally, the WRS welcomes the opportunity to further discuss methodologies and study plans with the applicant.

Study Request 4: Entrainment Study

Goals and Objectives:

The goal of the proposed study is to determine the number of fish by species and size class that are either entrained or impinged, and to estimate the injury and mortality of fish that pass through the turbines during Project operation.

Resource Management Goals:

The WRS is charged with the protection and management of all wildlife within West Virginia, including within the section of Ohio that passes through its borders. As per state rule §47-5A-6, the WRS would require the applicant to compensate the state for any loss of fish.

Existing Information:

To the best of its knowledge, the WRS is not aware of any entrainment studies that have been performed at the Racine Project, or at the very least, no recent entrainment studies (within the last 5 years) have been conducted.

Nexus Between Project Operation:

During operation of the facility, fish of a certain size are able to pass through the trash racks and become entrained through the turbines. As the turbines operate, it is likely that some fish will be struck by the turbine blades while others will succumb to changes in barometric pressures as they pass through the intake. The likelihood of a blade strike and turbine-induced mortality increases as the size of the fish increases. In the event that operation of the turbines results in fish mortality, compensation will be required as replacement for the loss of fish.

Study Methodology:

The methodology employed should include a combination of desktop entrainment and in the field verification. The standard practice has been to utilize the Electric Power Research Institute (EPRI) turbine entrainment and survival database as a model in evaluated the potential of entrainment at a facility. The WRS has had concerns that this particular practice lacks the scientific creditability necessary to make informed decisions about the management of the fishery. Therefore, the WRS requests the opportunity to review any entrainment data considered

for use in the desktop entrainment analysis. Further, the WRS requests that a verification procedure be incorporated as a means to test the veracity and accuracy of the desktop entrainment results. Deploying hydroacoustics sampling techniques may be one way to achieve this goal as a more cost-effective method than deploying nets downstream. Data for any type of analysis should be presented by species and by 2-inch class sizes to remain consistent with general state practices. The WRS is willing to further discuss methodologies with the applicant and would request the opportunity to review any study designs.

Level of Effort and Cost:

The level of effort required to conduct a desktop entrainment analysis is relatively minor and most consulting firms/universities are well equipped to perform such an analysis. Additionally, the cost of a desktop entrainment analysis is much more attainable when compared to the alternative of an in-field entrainment analysis. Incorporating an in-field verification procedure with the analysis will increase the level of effort and cost and would require certain levels of training, expertise, and equipment. Nonetheless, an in-field verification procedure is still attainable and within reasonable limits of effort and cost.

Study Request 5: Upstream/Downstream Fish Passage and Feasibility Study

Goals and Objectives:

The goals of this study are to assess movement of fish through the project area; identify likely routes fish would take under a variety of conditions; and assess the feasibility of incorporating alternative routes or additional fish protection measures.

Existing Information:

To the best of its knowledge, the WRS is unaware of any study on upstream/downstream passage at the Project. Any study that may have been completed is likely dated material and incompatible in reflecting current conditions and population dynamics.

Nexus Between Project Operation:

Dam features, because of their general nature, impede the upstream and downstream movement of fish. The Racine dam is built in conjunction with a lock structure. This lock structure acts as a possible vector for upstream movement, but is only able to provide such movement at inconsistent times that may not align with the needs of an upstream migrating fish. Downstream movement is similarly restricted. Generally, fish have two options afforded to them for downstream movement: over the dam gates during certain flows; and through the project's powerhouse. While in operation, a portion of the river flow is redirected through the powerhouse. In some cases, this flow through the powerhouse may be attractive to fish moving downstream. In passing through the turbines, fish risk being struck be turbine blades and

experiencing either immediate mortality or delayed mortality. Thus, project operation is directly related to fish passage.

Study Methodology:

Methodology would include a literature review of all available options for bypass routes and fish protection measures and an analysis on how such measures could be incorporated into the current project designs. Architectural design and structural engineers would need to be consulted for their expertise in determining feasibility of any new structural component at the project.

Level of Effort and Cost:

A study such as this would most likely take less than a year to complete with minimal effort. Discussions with engineers and reviews of designed structures would be necessary to properly assess the feasibility of any bypass channels or fish protection structures. Additionally, this study could be completed in concert with study request #4 to reduce costs and effort. The WRS is not aware of the cost associated with this study but would assume it to be at a nominal rate.

Study Request 6: Recreational Use Survey

The WRS is requesting that a recreational use study be conducted of the area within the vicinity of the Project.

Goals and Objectives:

The goal of this survey is to asses public use of the area and its facilities and to address any potential areas of improvement/concern with respect to recreational use.

Existing Information:

The WRS is aware of a number of efforts by the Ohio DNR to assess angler use and effort utilizing regular creel surveys. Data collected via these surveys are inherently valuable in managing the resources; however, these particular creel surveys did not assess recreation improvements or the need for improvements to the area.

Nexus Between Project Operation:

Potential impacts to the fishery, aquatic habitats, and water quality may have adverse effects on fishing opportunities and success rates in the tailwaters of the Racine Project and further downstream. Operations at the project directly relate to these concerns.

Study Methodology:

The methodology should employ an experimental design incorporating statistical analysis and a questionnaire comparable with other recreation use studies. Random stratified sampling should be utilized to capture use throughout the study period, including weekends, weekdays, and holidays. The questionnaire should include questions targeting types of use, potential improvements to the recreation, satisfaction of current facilities, and recreational deficiencies impacting the area.

Level of Effort and Cost:

Most consulting firms and universities are fully capable of conducting a recreation use study and further interpreting and analyzing the data. The costs of such a study is variable dependent on contractor used to conduct the study and the level of attention

The WRS appreciates the opportunity to provide comments and to make study requests. If you have any questions regarding this letter, comments made, or these study requests, please contact me by telephone at (304)825-6787, or by email at Jacob.D.Harrell@wv.gov.

Sincerely Yours,

Jacob Harrell
Hydropower Coordination Biologist

Cc: Jonathan Magalski, AEP Generation Resources
Rick MacCorkle, USFWS
John McClosky, USFWS
Michael Greenlee, ODNR
Paul Johanson, WVDNR
Mark Scott, WVDNR
Zack Brown, WVDNR
Jeff Hansbarger, WVDNR
Danny Bennett, WVDNR

Appendix B. 1988 Racine Dissolved Oxygen Study Report

American Electric Po
Service Corporation
1 Riverside Plaza
Columbus, OH 43215
614 223 1000

AEP
AMERICAN ELECTRIC POWER

Mr. Dave Plummer
Environmental Engineer
ORSANCO
5735 Kellogg Ave.
Cincinnati, OH 45228

September 6, 1995

Dear Mr. Plummer:

Per our conversation yesterday, enclosed is a copy the 1988 document entitled "A Report on Ohio River Dissolved Oxygen Studies at Ohio Power Company's Racine Hydroelectric Project" by American Electric Power Service Corporation and Ohio Power Company.

If you have any questions, please feel free to call me at (614) 223-1269.

Sincerely,

Andrew B. Maul

Andrew B. Maul
Environmental Engineering Division

Enclosure

cc (w/o document): A.R. Wood/R.J. Reash/J.C. Hendricks

American Electric Power
Service Corporation
1 Riverside Plaza
Columbus, OH 43215
614 223 1000

Writer's Direct Dial No. 614/223-1638

AEP
AMERICAN ELECTRIC POWER

Ms. Lois D. Cashell
Acting Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

May 19, 1988

Re: Licensed Project No. 2570-Ohio
Ohio Power Company

Dear Ms. Cashell:

Enclosed for filing on behalf of Ohio Power Company are an original and fourteen copies of a document entitled "A Report on Ohio River Dissolved Oxygen Studies at Ohio Power Company's Racine Hydroelectric Project" dated May 1988. This report is in further fulfillment of the requirements of Articles 49 and 50 of the license for the Racine Project. My January 31, 1986 transmittal filed February 4, 1986 contained additional material filed in accordance with the requirements of Articles 49 and 50 of the license for the Racine Project.

Generally, the February 4, 1986 filing described the air injection system installed at the Project and the dissolved oxygen monitoring system and indicated that such systems satisfied the requirements of the Ohio River Valley Water Sanitation Commission (ORSANCO). It also contained observations made regarding the Project's general lack of effect on a number of environmental features including shoreline stability and shoreline commercial and recreation facilities. There was concurrence with the licensee's observations that the Project was not affecting such features and facilities and that no changes in present Project operations were warranted. The February 4, 1986 filing also included a study plan entitled "Program for a Water Quality Study at the Racine Dam on the Ohio River." Letters issued by the Commission on April 3, 1986 and April 17, 1986 indicated that the materials filed were in compliance with Articles 49 and 50.

The attached report is the result of the studies conducted under the plan filed with the Commission February 4, 1986. The plan and schedule were modified somewhat as explained in my detailed letter dated August 31, 1987 which responded to Mr. Springer's July 27, 1987 letter requesting certain modifications in the planned study. As the field study progressed, its objective was refocused to compare the aeration effects produced by the hydro discharges without air injection with aeration effects produced by controlled gate openings in the dam. A draft of this report was furnished to Mr. George Taylor at his request on December 29, 1987. The report was reviewed in draft form by the Huntington District of the Corps of Engineers and by ORSANCO. Copies of their letters of comment, which generally concur with the report, are attached and appropriate responses have been made by revisions to the final report.

Although the air injection system as installed at the Racine Project is not capable of adding measurable amounts of oxygen to water discharges, the study concludes that the turbulence provided by discharges through the hydroelectric turbine provides aeration equal to or greater than aeration provided by turbulence from water released under the dam's tainter gates by the Corps of Engineers when the Project is not operating and before the Project was built.

Review of current water quality data of the Ohio River at Racine indicates that there is little likelihood that levels will go below the water quality standards for dissolved oxygen of 5.0 mg/l daily average. This condition has not occurred within the past two years and is not likely to recur given current requirements for advanced sewage and industrial waste treatment facilities.

In light of all of the above, Licensee believes that it has demonstrated that dissolved oxygen levels are being maintained and will continue to be maintained and that no change in Project operation is warranted.

Sincerely,

Robert W. Harmon

Robert W. Harmon
Counsel for Ohio Power Company

RWH/mac

Enclosures

cc: Alan Vicory, ORSANCO
Michael G. Ferguson, Huntington COE
George Kincaid, Huntington COE

A Report on Ohio River Dissolved Oxygen Studies at Ohio Power Company's Racine Hydroelectric Project

Racine Project No. 2570

by

American Electric Power Service Corporation
and Ohio Power Company

May 1988

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1.0 Executive Summary

This is a report of dissolved oxygen studies conducted at Ohio Power Company's operating Racine Hydroelectric Project by Ohio Power Company and the American Electric Power Service Corporation. Ohio Power Company holds a license issued by the Federal Energy Regulatory Commission which contains an article that required Ohio Power Company to install facilities for the admission of air into the water passage of the Project and to operate such facilities whenever the dissolved oxygen in the river at Racine is below 5.0 mg/L daily average.

The Racine Hydroelectric Project is located at the Ohio end of the Corps of Engineers' Racine Locks and Dam on the Ohio River (River Mile 237.5). The Project includes two 24-megawatt units consisting of two parallel water passages in each of which a horizontal-axis, bulb-type Kaplan turbine is installed. During low flow periods of the Ohio River, usually in August, September, and October, the dissolved oxygen levels in the Ohio River tend to decrease, occasionally falling below the Ohio River Valley Sanitation Commission water quality standard of 5.0 mg/L daily average. Under these conditions the Corps of Engineers previously discharged the available river flow through as few gates as possible as a means of increasing turbulence to improve aeration and increase dissolved oxygen levels in the river.

Now at times, all of the river flow (greater than 4,000 cfs) passes through the hydro turbines, eliminating the Corps of Engineers' means of aeration. Ohio Power Company installed an air injection system to inject air into the water passages at one of three locations as required by the FERC license.

The objective of the dissolved oxygen study conducted was to determine the efficacy of the air injection system at each of the air injection locations as a means of providing aeration to maintain dissolved oxygen concentrations in the river. Ohio Power Company developed a Study Plan in consultation with the Corps of Engineers, the Ohio River Valley Sanitation Commission, and the Federal Energy Regulatory Commission. An initial study of dissolved oxygen upstream and downstream of the dam and the Project was conducted from September 1-4, 1987. Early on in this study it was determined that the air injection system was not capable of providing measurable increases in downstream dissolved oxygen levels. The objective of the study then shifted to determining the impact on dissolved oxygen levels downstream from discharges through the dam only and when discharging all of the river flow through the Project. Again upstream and downstream dissolved oxygen data were collected. The results indicated that the hydro units increased dissolved oxygen levels downstream as much as the dam releases and sometimes more. To further validate this finding, additional testing was performed on September 29-30, 1987. The results of this test work confirmed that the hydro units have a more positive effect on downstream dissolved oxygen levels than the dam releases. Based on this study, Ohio Power Company concludes that, although the design of the air injection system installed is not adequate to significantly increase dissolved oxygen levels downstream, the operation of the Racine Hydroelectric Project itself provides more than sufficient aeration to replace the Corps of Engineers' means of aeration when utilizing all of the river flow.

2.0 Introduction

This report presents the test results of the dissolved oxygen studies conducted at Ohio Power Company's Racine Hydroelectric Project by Ohio Power Company (OPCo) and the American Electric Power Service Corporation (AEPSC) in September 1987. The Racine Hydroelectric Project, owned by OPCo and operated by Appalachian Power Company, is located at the Ohio end of the Army Corps of Engineers' Racine Locks and Dam on the Ohio River at River Mile 237.5.

During low flow periods of the Ohio River, usually in August, September, and October, the dissolved oxygen (DO) levels in the river tend to decrease, occasionally falling below the Ohio River Valley Sanitation Commission (ORSANCO) water quality standard of 5.0 milligrams per liter (mg/L) daily average. Since the water quality monitor has been in operation (late 1985) at Racine, this condition has not occurred. The Corps of Engineers (COE) discharges the available flow through as few gates as possible in an attempt to increase turbulence sufficiently to improve aeration and, thus, increase DO levels in the river. Presently, however, when river flows are less than 31,000 cubic feet per second (cfs) and greater than 4,000 cfs during normal Project operation, all of the river flow passes through the hydro turbines, thereby eliminating the Corps' discharge. In accordance with Article 49 of the Racine Project's Federal Energy Regulatory Commission (FERC) license, OPCo installed an air injection system with injection ports located in the turbine water passages. This system is to be operated whenever the DO concentration in the river upstream of the dam is below 5.0 mg/L daily average.

The objective of this study was to determine the efficacy of the air injection system as a means of providing aeration to maintain DO concentrations in the river. The Study Plan (Appendix 1) was developed in consultation with ORSANCO and the COE (Huntington District and Ohio River Division). Certain modifications to the Study Plan in Appendix I were agreed to with FERC in August of 1987, and the correspondence regarding these changes are contained in Appendix II.

The river conditions specified for this study were:

1) that the dissolved oxygen concentration in the river be 1.5 mg/L below saturation (to allow detection of dissolved oxygen increases resulting from air injection) and that the dissolved oxygen level be near ORSANCO's criteria of 5.0 mg/L, and

2) that the river flows be between 4,000 cfs and 31,000 cfs for two-unit operation and between 4,000 cfs and 16,000 cfs for one-unit operation. These are the ranges in which all river flow (except lockage and leakage) passes through the hydro units.

OPCo was prepared to conduct the study in 1986. However, the DO concentrations in the river rarely dropped below 2.0 mg/L below saturation (Study Plan criteria in 1986) and was never below 2.0 mg/L below saturation for a long enough time to conduct the DO study. Also, both units were out of service in mid-September. In 1987, the conditions in Items 1 and 2 above were first met on August 31. On that date the average DO

concentration obtained from the continuous DO analyzer at Racine was 5.3 mg/L (2.9 mg/L below saturation), and the flow was 14,460 cfs. Although only Unit 1 was operating, the flow criteria for one unit were still met. On this basis, OPCo had its contractor mobilize to begin the study on September 1, 1987. On September 1 the river flow increased to 25,000 cfs, and the DO remained well below saturation. Although the flow criteria for conducting the study were not met, OPCo decided to proceed with the study based on (1) an assumption that the flows would gradually decrease (based on the COE's flow forecasts), (2) the DO concentration required for the study might not consistently occur again (based on historical data), and (3) the information would be most useful to FERC if obtained in 1987. The study was adapted to the conditions encountered and conducted from September 1 through 4.

Additional testing was conducted on September 29 and 30 to verify some of the results obtained during the September 1-4 study period.

The following sections provide a description of the hydro project, a general description of the Racine Dam, test procedures, study conditions, data analysis, and conclusions.

3.0 Racine Hydroelectric Project Description

3.1 Location and Operation

The Racine Hydroelectric Project is located at the COE's Racine Locks and Dam on the Ohio River at River Mile 237.5. The Project is situated on the Ohio side of the river near the towns of Pomeroy and Racine, Ohio, in southeastern Ohio. OPCo, as licensee, owns the facility, and Appalachian Power Company operates it under an agreement with OPCo.

The powerhouse contains two horizontal axis bulb-type Kaplan turbines, each rated at 24,000 kilowatts. These units are specifically designed to operate over a wide range of heads, especially low heads, to maximize use of varying river flows. Head is the difference in height between the water levels upstream and downstream of the dam. The Racine pool upstream of the dam is maintained at a normal pool elevation of 560 ft. above mean sea level (msl), and the Gallipolis pool downstream of the dam is maintained at 538 ft. msl. For the Ohio River to be regulated for navigation and concurrently provide hydroelectric power, OPCo and the COE jointly utilize the river by terms of a formal Operating Agreement. As stated in the Operating Agreement with the COE, during normal operation the Project will generate electricity with one or two of the units 24 hours a day when favorable river conditions exist. The approximate flow range for power generation is 4,000 cfs (minimum turbine discharge) to about 150,000 cfs. River flows from approximately 4,000 cfs to 31,300 cfs (Project discharge capacity) normally will be passed through the turbines but may be passed through both the Project and the dam in a coordinated effort if required. In the event only one unit is operating, the Project flow capacity is reduced to 4,000 - 15,650 cfs. For river flows between 31,300 cfs and 150,000 cfs, discharges will be made through both the dam and the Project. For river flows in excess of 150,000 cfs, the hydroelectric units are shut down due to lack of operating head.

3.2 Description of Air Injection System and DO Monitor

In accordance with Article 49 of the Project's license issued by the Federal Power Commission (now FERC) on December 27, 1973, as amended, OPCo installed an air injection system to add air to the water passages and a water quality monitor to monitor DO concentrations upstream of the dam.

The installed air injection system is tied into the Project's compressed air supply system and is capable of injecting air at any of three points in each of the units' turbine water passage. Injection ports are located at the upstream and downstream bulkheads and the discharge rings of each unit. Although air can be injected at any of these locations, the injection ports at the discharge rings were specifically designed for the purpose of adding DO to the river. The feedline to the discharge rings is equipped with a flow meter to measure the air being added. The air injection ports and the bulkhead slots are primarily designed for clearing the slots of debris.

The Project compressed air supply system consists of two Ingersoll-Rand Model SSR-250H rotary screw air compressors. Each compressor can deliver 250 scfm of air at 125 PSIG discharge pressure and are equipped with 72 hp, 3,600 rpm, 575v motors. The No. 1 compressor is utilized to supply air for the normal project air requirements including the addition of air to the river. The No. 2 compressor is utilized as a stand-by compressor. It was found during this study that up to 220 scfm of air could be added to the turbine water passage with compressor No. 1 before the alarm tripped and the stand-by compressor kicked on. Operation of the standby compressor is for back-up purposes only.

The water quality monitor installed at the Project is a Schneider Model OH-10 robot monitor consisting of parametric systems for the measurement of DO and temperature on an hourly basis. The data storage system maintains 24 hours of data and can be interrogated at any time to retrieve the previous 24 hours of data. Quality assurance measures and maintenance are performed in accordance with the instruction manual for the monitor and are consistent with ORSANCO's quality assurance program. The sample point is located within the water passage upstream of the turbine blades.

3.3 Description of the Racine Dam

The Racine Dam, operated by the Huntington District Army COE, is a non-navigable, high-lift, and gated dam with a top length of 1,173 ft. The dam has eight non-overflow-type tainter gates each with a clear span of 110 ft. between 15-ft. intermediate piers and 16-ft. end piers. Gate 8 is on the Ohio end of the dam, and gate 1 is nearest to the West Virginia end. The dam also consists of two adjacent parallel locks to service river traffic. The upstream pool (Racine Pool) is maintained in accordance with an Operating Agreement between the COE and OPCo at approximately 560.0 ft. msl. The downstream pool (Gallipolis Pool) is maintained by the Gallipolis Locks and Dam at approximately elevation 538.0 ft. msl. Flows are passed through the dam by raising the tainter gates. When not in use, the gates rest on a sill at elevation 528.0 ft. msl, 32 ft. below normal upstream pool. On the downstream side of the gates, the sill slopes to an elevation of 510.0 ft., 28 ft. below normal pool. Releases through the dam are made to maximize the potential for aeration downstream by discharging the

available flow through as few gates as possible. Operation of the tainter gates is sequential beginning with gate 5 passing up to 5 ft. of water and then utilizing gates 3, 7, 4, 6, 2, 8, and 1 in order passing up to 5 ft. of water through each before moving on to the next gate. It was reported by the lockmaster, however, that when the hydro units are not operating, up to 1 ft. of available flow will be passed through gate 8 at all times (until sequential operation of gate 8 required) to provide turbulence for the fishing areas located just downstream of the Project. One foot of water passing through a dam gate is equivalent to approximately 3,000 cfs of river flow.

4.0 Testing Procedures

As previously mentioned, the objective of this study was to determine the efficiency of the air injection system installed as a means of providing aeration to maintain DO in the river. After consultation with ORSANCO and the COE (Huntington District and Ohio River Division), it was mutually agreed that two traverses, one upstream approximately 2500 ft. from the dam and one downstream approximately 3600 ft. from the dam, would be tested for DO and temperature for various modes of operation of the air injection system. Each traverse would consist of five to six sampling points, each spaced approximately 200 ft. apart. Testing at each sampling point would be at depths of 1, 2, 5, 10, 15, 20, and 40 ft. or bottom. As time permitted, OPCo also planned to conduct additional testing at a traverse located 2.5 miles downstream to determine if DO increases were maintained. It was agreed that the traverse locations were tentative and might require changes depending on the results obtained early in the study.

The upstream traverse (Traverse A) was located 2500 ft. upstream of the dam as shown in Figure 1 at the rear of this report. Seven sampling locations were marked, spaced approximately 170 ft. apart. The depth of the river at Traverse A ranged from 22 ft. deep on the Ohio side to 40 ft. deep on the West Virginia side of the river. The first downstream traverse (Traverse B) was located 3600 ft. downstream from the dam. Six sampling points were located on Traverse B approximately 200 ft. apart. Depths ranged from 15 to 20 ft. deep. The second downstream traverse (Traverse C) was located 2.5 miles downstream from the dam. Traverse C consisted of four sampling points spaced approximately 200 ft. apart. Depths at Traverse C ranged from 22 to 30 ft. deep. Traverse C was dropped from the study after the first day since no difference in DO between Traverses B and C was found. A fourth traverse (Traverse RZ) was added to the study on the second day approximately 1400 ft. downstream from the dam near the restricted zone boundary. Traverse RZ was added to determine if there was any localized increase in DO downstream that dissipated before reaching Traverse B and to see if there was any DO difference noted across the traverse due to the dam releases. Traverse RZ was located as close to the dam as possible without being in the restricted zone. Four sampling locations were located equally along the traverse. Depths ranged from 25 to 30 ft. deep. Traverse RZ was tested throughout the remainder of the study.

The testing along the traverse was conducted by two testing crews; one for upstream testing and one for downstream testing. WAPORA, Inc. was hired as a contractor to collect the temperature and DO data. They supplied two boats, an operator for each boat, and a person to operate the DO meter and

record data in each boat. The testing crews, for most of the time, consisted of three persons; two from WAPORA and a third person either from AEPSC or the Huntington District COE to monitor the data collection activities.

Flow pattern studies for the hydro discharge were also conducted by placing orange wooden blocks in the discharge of the hydro unit and observing their travel.

The DO and temperature data were obtained by Yellow Springs Model 57 DO Analyzers. These meters are capable of measuring DO with an accuracy of ±0.1 mg/L. The DO meters (upstream and downstream) were calibrated side by side each morning of the study before field use by chemical DO tests (Hach Winkler Azide Modification Method). The DO meters also were calibrated individually a minimum of two more times during each study day to check on possible calibration drift. This was done by either chemical DO tests or air calibration using the instrument manufacturer's recommended procedure. The accuracy of the chemical DO test is estimated at ±0.1 mg/L DO.

Appendix III contains records of the calibrations performed during this study. The DO values determined by the chemical calibration test are also given in this Appendix. In nearly all cases, the DO meter readings were within 0.2 mg/L DO or less of the calibration value. If necessary, the meter was adjusted to agree with the calibration test value.

The study was planned to be conducted for five days; one day without air injection, three days with air injection at the individual air injection points, and a fifth day with air injection at the most efficient of the three air injection points. The detailed Study Plan is contained in Appendix 1.

The actual study conditions varied significantly from the initial Study Plan for several reasons which will be discussed in detail in Section 5.0. Conduct of the study required close coordination with the Racine Dam Lockmaster whose assistance was critical to the successful completion of the study.

5.0 Study Conditions and Results

5.1 Introduction

This section will discuss the actual study conditions and the results from each day of testing. As mentioned earlier, the study consisted of four days of testing from September 1-4 and then two additional days of testing on September 29 and 30, 1987. The study deviated significantly from the Study Plan due to river conditions encountered and the results obtained as the study progressed. This is discussed in detail in the following sections.

Because of the large amount of data obtained, this report will deal with averages (Grand Averages) across the various depths for a complete transect tested. No consistent differences were apparent across the traverse in any of the transects at individual depths. For the purpose of discussion, in this report the cross section tested at each traverse is considered a

transect. The average values at each depth were then averaged to come up with one value for the period of time the transect was tested. The data for some of the transects showed a significant diurnal effect from top to bottom. The high values, however, usually occurred in the top five feet, and these values were averaged as one depth in order not to skew the profile average.

Another item of relevance is the estimation of what is a statistically significant difference between upstream and downstream Grand Average DO values based on the accuracy of the instrumentation and calibration methods utilized (discussed in Section 4.0).

The uncertainty associated with each individual DO measurement was estimated to be ±0.2 ppm due to analytical accuracy and that this ±0.2 ppm represented a 95% confidence interval about any one measurement. The associated uncertainty calculated for each depth average DO value and then for the Grand Average DO value for a given transect will be much smaller than the original uncertainty of ±0.2 ppm, due to statistical rules for variance calculation.

For each upstream transect, the Grand Average DO value (determined from approximately 50 individual DO values) will have an estimated uncertainty of ±0.03 ppm at the 95% confidence level. For the downstream transects' Grand Averages (determined from 28 individual DO values for RZ and approximately 33 individual DO values for transect B), the associated uncertainty is estimated to be ±0.04 ppm for transect RZ and ±0.03 ppm for transect B.

To determine whether the difference between upstream and downstream Grand Average DO values is significant at the 95% confidence level, this difference must be greater than the sum of the uncertainties about the upstream and downstream Grand Average values. This sum is 0.06-0.07. Thus, a conservative estimate of how large this difference must be in order to be considered significant at the 95% confidence level should be 0.1 ppm DO.

An important consideration in reviewing the data is the lag time between transects tested at each traverse. The lag time is the time it would take water tested at an upstream location to travel to a downstream location. Lag times were estimated for each day based on the total river flow (cfs) and the volume (ft^3) of the river. The lag times were used in comparing the downstream transects tested to upstream transects of water tested to determine increases in DO. The lag time between transects is important when the upstream and downstream DO values do not remain constant during an individual day of testing.

As previously mentioned, the total river flow at the beginning of the test period from September 1-4 exceeded the amount of flow that could be passed by the hydro unit in operation. Only one unit was operating, and the other unit was not returned to service until late September. Although this flow requirement for the study was not being met, it was decided to proceed with the study for the reasons stated in Section 1. In order to minimize any potential aeration from the dam releases, the lockmaster distributed the flow more evenly across the dam to minimize turbulence during the study

when flows were being discharged through both the dam and the hydro units. Total river flow referred to in the following sections excludes lockage and leakage. River traffic and lock releases were monitored throughout the study and had little effect on DO readings. At times, an increase of 0.1 mg/l was noted near the lock chamber due to barge traffic but dissipated within a few minutes.

Another objective of the study (minor) was to determine how well the water quality monitor functioned in measuring upstream DO, and DO readings were collected throughout the study.

The following text discusses the study conditions for each day of testing, the results of each day, and the operation of the water quality monitor. A summary of the raw data collected is contained in Appendix III.

5.2 September 1, 1987 - Background Testing

Testing on September 1 was conducted without any air injection to obtain background data. The total flow of the river was 25,000 cfs; 12,000 cfs through the dam and 13,000 cfs through the hydro unit. The discharge through the dam was distributed evenly through gates 1, 3, 5, and 7, with gate openings of one foot each. One foot of gate opening is equal to approximately 3,000 cfs. No significant surface turbulence was noted at the gate discharges.

Transects were tested at Traverse A (2,500 ft. upstream), Traverse B (3,600 ft. downstream), and Traverse C (2.5 miles downstream).

The average water temperature for the day was 26°C, and at this temperature the DO saturation is 8.2 mg/L.

The DO data collected are summarized in Table 1. Each column represents a transect tested, and the DO values are averages of the various depths tested across the traverse. The DO upstream averaged 5.6 mg/L, and the DO downstream averaged 5.9 mg/L. The upstream average DO variation from top to bottom ranged from 0.4 to 1.0 mg/L. As will be seen later, the river upstream of the dam generally began to stratify about mid-morning for the September 1-4 study period. This stratification was probably due to increasing phytoplankton activity near the river surface. Downstream DO values, however, remained relatively constant. A comparison of upstream and downstream transects taking into account lag times is shown in Table 2. The time for water tested at Traverse A to arrive at Traverse B was one hour and 30 minutes (reflected in Column (C)), and the lag time from Traverse A to Traverse C was three hours and 30 minutes (reflected in Column (G)). Differences in DO between upstream and downstream are shown in Column (F) for transects tested at Traverses A and B and in Column (J) for transects tested at Traverses A and C. These data show that there is an apparent increase in DO downstream of 0.3 mg/L (±0.1). Although not shown on the table, there was no difference noted between transects tested at Traverses B and C.

5.3 September 2, 1987 - Testing with Air Injection

Testing on September 2 began with air being injected in the water passage at the discharge rings at a rate of 200 scfm (normal operation) and later increased to 450 scfm using the stand-by compressor. Air injection began on the evening of September 1. The total river flow ranged from 17,460 cfs to 19,710 cfs; 14,460 cfs was being discharged through the hydro unit, and 3,000 to 5,250 cfs was discharged through gates 5 and 7 of the dam.

Transects were tested at Traverses A, B, and RZ. Testing at Traverse C was discontinued since the previous day's data showed no difference between Traverses B and C. Traverse RZ (1400 ft. downstream) was added to determine if there was any localized increases in DO that dissipated by the time the water reached Traverse B and to see if there was any difference across the river (near the dam) due to the dam releases.

The average river temperature was 25°C, at which DO saturation is 8.4 mg/L. The DO data collected are summarized in Table 3. The average upstream DO was 5.4 mg/L and downstream DO averaged 5.7 mg/L. A comparison of the upstream and downstream transects is presented in Table 4. The time for water tested at Traverse A to arrive at Traverse RZ was two hours (reflected in Column (C)), and the lag time between Traverse A and Traverse B was two hours and 30 minutes (reflected in Column (G)). The differences between Traverses A and RZ transects are shown in Column (F), and the differences between transects tested at Traverses A and B are shown in Column (J). These data indicate a downstream DO increase of 0.2 to 0.3 mg/L (±0.1). A field review showed that there was no measurable increase over the background data obtained on September 1, with air being injected at 200 scfm, and it was decided to increase the air feed to 450 scfm utilizing the stand-by air compressor about mid-day. As can be seen from Table 4, there was still no increase in downstream DO over the background data obtained on September 1. Since this air injection location was expected to be the most efficient, a review of the design of the system was made in the field to determine how much DO could be added to the river. It was tentatively determined that the air injection system was only capable of adding 0.06 mg/L DO (100% transfer) to 15,000 cfs of water passing through the turbines at an air feed of 200 scfm and 0.14 mg/L at an air feed of 450 scfm. This was not significant enough to warrant further testing. Rather than stop the entire study, though, it was decided to continue testing to determine impacts on DO downstream from the dam alone and the hydro unit without air injection.

A flow pattern study was also conducted on September 2. Orange wooden blocks were thrown into the hydro discharge and visually observed from the hydro top deck with the aid of binoculars. Sitings downstream (and out of site from the Hydro Project) were noted by the crew conducting the test work downstream. The pattern of the blocks floating downstream is shown in Figure 2. The flow pattern moves diagonally across the river (westerly) to the end of the lock wall, and then towards the West Virginia shore in a diagonal direction. This pattern is consistent with results of the flow pattern modeling studies conducted by the Alden Research Laboratory for AEPSC and OPCo in the course of designing the Project.

5.4 September 3, 1987 - Testing with Dam Discharge Only and Discharge Through the Dam and the Hydro

Testing on September 3 was conducted, with the total river flow being released through the dam (hydro unit shut down) in the morning and the river flow being discharged through the hydro unit and the dam in the afternoon. The total river flow was 18,000 cfs. From 0741 to 1141, 18,000 cfs was released through the dam; 15,000 cfs (5 ft.) through gate 5 and 3,000 cfs (1 ft.) through gate 8. These discharges through the gates are in accordance with the COE's standard procedure to maximize aeration potential when the hydro units are not operating. After 1141, 15,570 cfs of the river flow was discharged through the hydro unit and 2,250 cfs (.75 ft.) was being released through gate 5 of the dam. It was noted that the surface turbulence caused by the discharge of the hydro was more than that observed from the gate releases when all of the river flow was being discharged through the dam. Transects at Traverses A, RZ, and B were tested.

The DO saturation level was 8.4 mg/L at the average river temperature of 25°C. The DO data are summarized in Table 5. Upstream DO values averaged from 5.6 to 6.0 mg/L and downstream DO values average 5.9 mg/L. Depth variation in DO ranged from 0.1 to 1.2 mg/L upstream, and there was little variation downstream. A comparison of upstream and downstream transects is shown in Table 6, taking into consideration lag times between transects tested. The time for water tested at Traverse A to arrive at Traverse RZ was two hours (reflected in Column (C)) and to arrive at Traverse B, two hours and 40 minutes (reflected in Column (G)). In reviewing the data, though, the lag time between Traverse A and the dam of one hour and 30 minutes, must also be considered to distinguish impact downstream due to discharge through the dam only. Comparison of transects tested upstream before 1015 and tested downstream before 1230 correspond to the operation of the dam only. Column (F) shows the DO difference between transects tested at Traverses A and RZ, and Column (J) shows the downstream DO difference for transects test at Traverses A and B. The data show an apparent downstream increase in DO of 0.2 mg/L (±0.1) when discharging through the dam only, and an increase of 0.2 to 0.3 mg/L (±0.1) when discharging through the dam and the hydro unit. Virtually no difference in DO was noted between transects tested at Traverses RZ and B.

5.5 September 4, 1987 - Testing with Hydro Discharge Only and Air Injection

Testing was continued on September 4 with the total river flow discharging through the hydro since this was the first day that this flow condition had occurred. Also, air was injected at the discharge ring at a rate of 220 scfm to gather more data with air injection in the event the field review of the system design was not correct. Further review, however, indicated the field review was correct.

The total river flow was 15,650 cfs. Transects along Traverses A, RZ, and B were conducted. The average river temperature was 25°C at which DO saturation is 8.4 mg/L. DO data obtained on September 4 are presented in Table 7. The upstream DO ranged from 6.0 to 6.3 mg/L, and the downstream DO ranged from 6.0 to 6.7. The depth variation in DO values upstream from

surface to bottom ranged from 0.2 mg/L in the early morning to 2.4 mg/L in the afternoon. There was no downstream depth variation in DO.

A comparison of upstream and downstream DO concentrations, taking into account lag times, is shown in Table 8. The time for water tested at Traverse A to arrive at Traverse RZ was two hours and 30 minutes (reflected in Column (C)). The lag time between Traverse A and Traverse B was three hours (reflected in Column (G)). The DO difference downstream between transects tested at Traverses A and RZ are shown in Column (F) and the downstream difference between transects tested at Traverses A and B are shown in Column (J). These data show an apparent increase in DO downstream in the range of 0.3 to 0.6 mg/L (±0.1). Minimal difference was noted in DO data collected at Traverses RZ and B.

A flow pattern study was also conducted and revealed similar results to the study on September 2. The pattern of the blocks flowing downstream is shown in Figure 3.

It was decided to end this initial study after the testing on September 4 and to evaluate the data obtained more thoroughly to determine if any additional testing was appropriate. After a complete review of the data, it was determined that additional testing was needed to further validate the results obtained from the testing conducted when the river flow being discharged through the dam only and when the total river flow was being discharged through the hydro units. This additional testing was conducted on September 29 and 30, 1987.

5.6 September 29, 1987 Testing with Dam Discharge Only

On September 29, additional testing was conducted with the total river flow being discharged through the dam. The river flow was 25,000 cfs; 15,000 cfs (5 ft.) was being discharged through gate five, 7,500 cfs (2.5 ft.) through gate 3, and 3,000 cfs (1 ft.) through gate 8. These gate discharges were in accordance with the COE standard operating procedures for maximizing the potential for aeration.

Transects were tested along Traverses A, RZ, and B. The average river temperature was 20°C, yielding a DO saturation level of 9.2 mg/L. The DO data collected are presented in Table 9. Upstream DO averaged 7.8 mg/L with minimal depth variation. Downstream DO ranged from 7.5 mg/L to 7.7 mg/L, also with little depth variation. The comparison of upstream and downstream DO values is shown in Table 10. The lag time between Traverses A and RZ was one hour and 30 minutes (reflected in Column (C)), and lag time between Traverses A and B was two hours (reflected in Column (G)). These data show a downstream DO difference of -0.20 to 0.1 mg/L (±0.1) from upstream. There was minimal difference between the DO values obtained at Traverses RZ and B.

5.7 September 30, 1987 - Testing with Hydro Discharge Only

Testing on September 30 was conducted with all of the river flow passing through the hydro units (both units operating). The total river flow was 20,000 cfs; approximately 12,000 cfs being discharged through Unit 1, and approximately 8,000 cfs through Unit 2.

Transects were tested at Traverses A, RZ, and B. The average river temperature was 20°C at which DO saturation level was 9.2 mg/L. The DO data are summarized in Table 11. Upstream DO values averaged 7.5 mg/L with minimal variation in depth, while average downstream DO values ranged from 7.3 to 7.9 mg/L. A comparison of upstream and downstream DO values is presented in Table 12 taking into account lag times. The lag time between Traverses A and RZ was two hours (reflected in Column (C)) and between Traverses A and B it was two hours and 30 minutes (reflected in Column (G)). The DO difference between transects tested at Traverses A and RZ is shown in Column (F), and the DO differences between Traverses A and B are shown in Column (J). The DO difference between downstream and upstream ranged from -0.20 to 0.4 mg/L (±0.1). Little difference was noted between Traverses RZ and B.

5.8 Comparison of Water Quality Monitor with Upstream DO Measurements

During the course of this study, DO readings from the water quality monitor were recorded. Data taken when the hydro units were not operating were ignored. Also, data taken September 30 indicated the monitor was not functioning properly, and the data were not used. In comparing the readings from the monitor to the results of the transects tested at Traverse A (considering lag time), DO differences of -0.1 to 0.3 mg/L were found.

6.0 Discussion

The following text discusses and summarizes the results presented in Section 5.0. As discussed in Section 5.0, the air injection system installed is not capable of adding a significant amount of dissolved oxygen to the water passing through the Hydroelectric Project. Therefore, for all the days where the air was being injected during this study, it is assumed that little if any of the DO increases downstream are attributable to the air injection system.

A summary of the impacts to DO levels downstream are summarized in Table 13 for all six days of testing. On September 1 and 2, the river flow was being discharged through both the hydro unit and the dam, and downstream DO increases of 0.2 - 0.3 mg/L (±0.1) were noted. The discharge through the dam was spread across the gates to minimize potential aeration, and the releases virtually provided no turbulence which would be the source of aeration. Therefore, the apparent increase in downstream DO levels is attributed to hydro discharge.

On September 3, the tests were conducted with the total river flow being discharged through the dam in the morning in accordance with the COE's procedure for maximizing aeration potential and then with as much river flow as possible through the hydro in the afternoon with the remainder being discharged through the dam in a fashion to minimize turbulence. The objective of this testing was to determine what impact the dam releases alone had on downstream DO levels and to confirm the positive impacts on downstream DO from the hydro unit observed on the previous two days of testing. Increases of 0.2 mg/L (±0.1) were noted for the discharge through the dam only, and an increase of 0.2 to 0.3 (±0.1) was noted for the discharge through the dam and the hydro. Under these conditions it appears

that the hydro unit had essentially the same overall effect on DO levels downstream as the dam did. It is possible that the dam did add more air to the river than was evident, since it was releasing flow from near the bottom of the river upstream in which a difference of 0.2 mg/L from top to bottom was observed. Still, the overall effect on the river downstream as compared to the hydro unit was about the same.

On September 4, testing was conducted with all of the river flow being discharged through the hydro unit. The resulting downstream DO increase of 0.4 to 0.6 mg/L confirmed that the hydro unit has a positive effect on downstream DO concentrations.

On September 29, additional testing was conducted with the total river flow being discharged through the dam to further validate the results obtained on September 3. A downstream difference of -0.2 to 0.1 (±0.1) mg/L DO was observed. For all practical purposes, the dam had no impact on downstream DO levels. The main differences between conditions on September 3 and 29 were that there was a DO deficit (difference between ambient DO and DO saturation levels) of 2.5 mg/L on September 3 and a DO deficit of 1.4 mg/L on September 29, with average DO values upstream about 1.5 mg/L higher on September 29. The river flow was also 7,000 cfs greater on September 29. The most logical explanation is that the dam is not efficient in increasing DO levels downstream when upstream levels are that close to saturation. Downstream values compared to upstream levels near the river bottom and were about the same.

On September 30, the testing conducted with all of the river flow passing through the hydro units showed downstream DO differences of -0.2 to 0.4 mg/L (±0.1). There is no explanation of the two negative values noted (appear to be outliers); however, the majority of the data showed an increase of 0.2 to 0.4 mg/L (±0.1) downstream. This is fairly consistent with past data obtained. The data obtained on September 4, when all the river flow was discharging through the hydro, showed increases of 0.3 to 0.6 mg/L (±0.1). The DO increases were somewhat lower on September 29, which could be due to the smaller DO deficit.

7.0 Conclusion

Although the air injection system design is not sufficient to increase downstream DO levels, OPCo concludes that the operation of the Racine Hydroelectric Project alone provides an increase in DO downstream equal to and greater than the dam releases alone. When the total river flow is passing through the Racine Hydroelectric Project and the COE's means of aeration by turbulence is lost, the Project provides adequate aeration to maintain downstream DO levels.

8.0 References

- AEPSC, "Report on the Water Quality Studies at the Markland Dam", 1969.

- AEPSC, "Report on Dissolved Oxygen Study at Winfield Dam", 1969.

9.0 Record of Consultation

Ohio Power Company and Appalachian Power Company consulted with ORSANCO and the U.S. Army Corps of Engineers during the development of the Study Plan contained in Appendix I. A record of consultation of the Study Plan is contained therein. The following is a record of the consultation process for the review of this report. Correspondence follows.

Correspondence

- December 18, 1987 letter from M. R. Robida to Michael G. Ferguson of the Corps of Engineers.
- December 18, 1987 letter from M. R. Robida to Alan Vicory of ORSANCO.
- January 21, 1988 letter from Charles E. Vandevelde, Corps of Engineers, to M. R. Robida.
- February 17, 1988 letter from Peter A. Tennant, ORSANCO, to M. R. Robida.
- May 6, 1988 letter from M. R. Robida to Michael G. Ferguson of the Corps of Engineers.

Telecommunication

- January 28, 1988 teleconference between M. R. Robida, T. A. Miskimen, and J. C. Hendricks of AEPSC and Dr. George Kincaid and Vince Marchaise regarding analytical variability and data reporting.

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AMERICAN ELECTRIC POWER

Mr. Michael G. Ferguson, P.E.
District Coordinator for Hydropower Projects
Engineering Division
Project Management Branch
Huntington District Corps of Engineers
502 Eighth Street
Huntington, WV 25701

May 6, 1988

Dear Mr. Ferguson:

Re: Racine Hydroelectric Project, FERC No. 1235
September 1987 Dissolved Oxygen Study

This letter confirms discussions held between representatives of the American Electric Power Service Corporation (AEPSC) and the Huntington District regarding the comments contained in Charles E. Vandevelde's letter to the writer of January 21, 1988 on a draft report of dissolved oxygen studies at Racine. Specifically, a teleconference was held on January 28, 1988 among M. R. Robida, T. A. Miskimen, and J. C. Hendricks of AEPSC and Dr. George Kincaid and Vince Marchaise of the Water Quality Section of the Huntington District. The discussion focused on Comment No. 2 of Mr. Vandevelde's letter regarding the accuracy of the instrumentation as it relates to what could be considered a relative increase in dissolved oxygen downstream of the Racine Hydroelectric Project. The following is what was agreed upon, which is to be incorporated in the final report.

> The uncertainty associated with each individual DO measurement was estimated to be ±0.2 ppm and that this ±0.2 ppm represented a 95% confidence interval about any one measurement. The associated uncertainty calculated for each depth average DO value and then for the Grand Average of all DO data for a given transect will be much smaller than the original uncertainty of ±0.2 ppm, due to statistical rules for variance calculations.

For each upstream transect, the Grand Average DO value (determined from approximately 50 individual DO values) will have an estimated uncertainty of ±0.03 ppm at the 95% confidence level. For the downstream transects' Grand Averages (determined from 28 individual DO values for RZ and approximately 33 individual DO values for transect B), the associated uncertainty is estimated to be ±0.04 ppm for transect RZ and ±0.03 ppm for transect B.

To determine whether the difference between upstream and downstream Grand Average DO values is significant at the 95% confidence level, this difference must be greater than the sum of the uncertainties about the upstream and downstream Grand Average values. This sum is 0.06-0.07. Thus, a conservative estimate of how large this difference must be in order to be considered significant at the 95% confidence level should be 0.1 ppm DO.

We generally agreed with the remainder of the comments contained in Mr. Vandevelde's letter and have addressed them in the final report. We will transmit a final copy of the report to you when it is filed with the Federal Energy Regulatory Commission.

If there are any questions regarding this letter, please call me at (614) 223-1259.

Sincerely,

Michael R Robida

Michael R. Robida
Environmental Engineering Division

MRR/kme

cc: Dr. George Kincaid
Chief, Water Quality Section
Hydrology and Hydraulic Branch

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
502 EIGHTH STREET
HUNTINGTON, WEST VIRGINIA 25701

REPLY TO
ATTENTION OF:

January 21, 1988

Engineering Division
Project Management Branch

SUBJECT: Racine Locks and Dam Hydroelectric Project, FERC Project Number 1235

AEP Service Corporation

JAN 28 1988

ENVIRONMENTAL ENGINEERING DIVISION

Mr. Michael R. Robida
American Electric Power Service Corporation
Environmental Engineering Division
1 Riverside Plaza
Columbus, Ohio 43215

Dear Mr. Robida:

I refer to your letter and report dated December 18, 1987, concerning your dissolved oxygen studies at the Racine Locks and Dam hydroelectric facility.

The report dealing with the dissolved oxygen studies at the project site has been reviewed and the comments are enclosed for your consideration.

Sincerely,

Charles E. Vandevelde
Chief, Engineering Division

Enclosure

Racine Locks and Dam, Ohio River
American Electric Power, FERC No. 2570
Huntington District Corps of Engineers
Comments
13 January 1987

American Electric Power submitted a draft report on 18 December 1987 pertaining to their September 1987 Dissolved Oxygen Studies at the Racine Hydroelectric Project. The Huntington District has reviewed the report and comments are as follows:

1. Page 13, Line 2; There is no indication of significant stratification. The upstream transect (A) shows signs of diurnal fluctuations.

2. Page 14, Line 1; The procedure used cannot measure a change of less than 0.5 mg/l of dissolved oxygen as indicated on pages 15, 16, 18, 20, 22, 23, and 25. The instruments were accurate to ± 0.1 mg/l, the calibration procedure was accurate to ± 0.1 mg/l, and there were two instruments used. This implies an accuracy of no better than 0.4 mg/l can be obtained. Thus a change of 0.5 mg/l is needed before a change in conditions can be claimed.

3. Page 19, Line 17; There was no downstream stratification.

4. Page 21, Line 5; The term stratification implies to the lake conditions. Another term should be referred to since the study was conducted on the Ohio River.

5. Page 24, Line 1-5; This opinion is not supported by data. Additional data will be necessary to support this statement. The positive effect from the hydro unit is minimal.

6. Page 25, Line 1; Negative changes can occur because of instrument or calibration errors. Each was accurate to ± 0.1 mg/l.

7. Table 13; The procedure used is not capable of measuring change of less than 0.5 mg/l.

8. The study has concluded that the air injection system was not capable of providing measurable increases in downstream D.O. levels. Inasmuch as this was to be a major purpose of the study, the report should include detailed explanations as to why the forecasted D.O. increases were not met. The discussion should include prior testing of the subject injection systems with full references as applicable. Inadequacies of the system and the design thereof should be spelled out.

OHIO RIVER VALLEY
WATER SANITATION COMMISSION

49 EAST FOURTH STREET, CINCINNATI, OHIO 45202 (513) 421-1151

THOMAS A. STORCH, PH.D.
CHAIRMAN
ALAN H. VICORY, JR., P.E.
EXECUTIVE DIRECTOR
AND CHIEF ENGINEER

February 17, 1988

Michael J. Robida
Environmental Engineering Division
American Electric Power Service Corporation
1 Riverside Plaza
Columbus, Ohio 43215

Dear Mike:

I have reviewed the draft report on the dissolved oxygen study conducted at the Racine Hydroelectric Project this past September. The report appears to me to provide a thorough analysis of the field monitoring results. I discussed the findings with personnel from the Oak Ridge National Laboratory who are conducting the Environmental Impact Study for the Federal Energy Regulatory Commission; they feel that your results are consistent with their findings.

It appears from your study results that little aeration is provided to the river by the Racine dam under normal operations. The FERC study indicates that traditional dam aeration equations are not valid for Ohio River dams, and that the aeration characteristics vary widely among the dams. This would indicate to me that, while hydropower operations at Racine will have little if any impact on dissolved oxygen levels in the Ohio River below the project, similar studies must still be performed at the other dams where hydropower facilities are to be installed.

I appreciate your patience in awaiting this reply and the overall cooperation of AEP in assuring that hydropower development on the Ohio River proceeds in an environmentally sound manner.

Sincerely,

Pete

Peter A. Tennant
Water Quality Programs Manager

PAT/bh

American Electric Power
Service Corporation
1 Riverside Plaza
Columbus, OH 43215
614 223 1000

AEP
AMERICAN
ELECTRIC
POWER

Mr. Alan Vicory
Executive Director
Ohio River Valley Sanitation Commission
414 Walnut Street
Cincinnati, OH 45202

December 18, 1987

Dear Alan:

Re: Racine Hydroelectric Project
September 1987 Dissolved Oxygen Study

In accordance with our conversation on December 17, this letter transmits a draft report for your review on the dissolved oxygen study conducted at Ohio Power Company's Racine Hydroelectric Project in September of this year. A final report tabulating the raw data (Appendix III) is presently being prepared by our contractor and will be sent to you shortly. A copy of the draft report also has been sent to the Huntington District Corps of Engineers for review.

Please provide us with your comments on this draft report in writing by January 20, 1988. Please call me at (614) 223-1259 with any questions you may have.

Very truly yours,

Michael R Robida

Michael R. Robida
Environmental Engineering Division

MRR/kme

American Electric Power
Service Corporation
1 Riverside Plaza
Columbus, OH 43215
614 223 1000

AMERICAN ELECTRIC POWER

Mr. Michael G. Ferguson, P.E.
District Coordinator for Hydropower Projects
Engineering Division
Project Management Branch
Huntington District Corps of Engineers
502 Eighth Street
Huntington, WV 25701

December 18, 1987

Dear Mr. Ferguson:

Re: Racine Hydroelectric Project
September 1987 Dissolved Oxygen Study

In accordance with our conversation of today, enclosed for your review are three copies of a draft report on the dissolved oxygen study conducted at Ohio Power Company's Racine Hydroelectric Project in September of this year. A final report tabulating the raw data (Appendix III) is presently being prepared by our contractor who collected the data, and it will be sent to you shortly. A copy of the draft report also has been sent to the Ohio River Valley Sanitation Commission for review.

I take this opportunity also to thank the Huntington District Corps of Engineers for the excellent cooperation received during the course of the study from the Racine Dam Lockmaster, and for Dr. George Kincaid's assistance in developing the Study Plan and the participation of his staff in the study itself. This support led to the successful completion of the study.

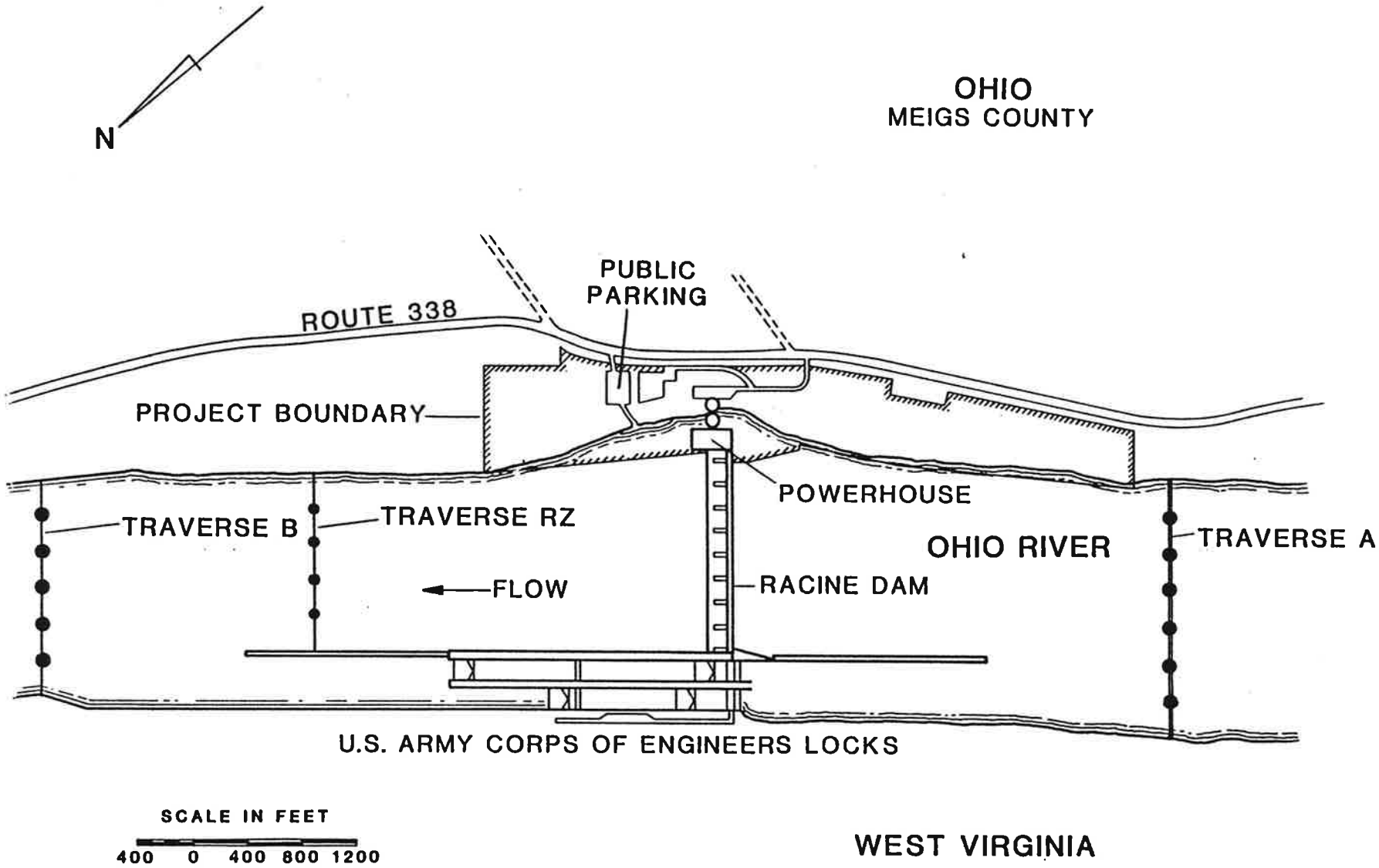
We would appreciate your comments on this draft report by January 20, 1988 since we plan to send a final copy of the report to FERC by the end of January 1988. Please call me at (614) 223-1259 with any questions you may have.

Very truly yours,

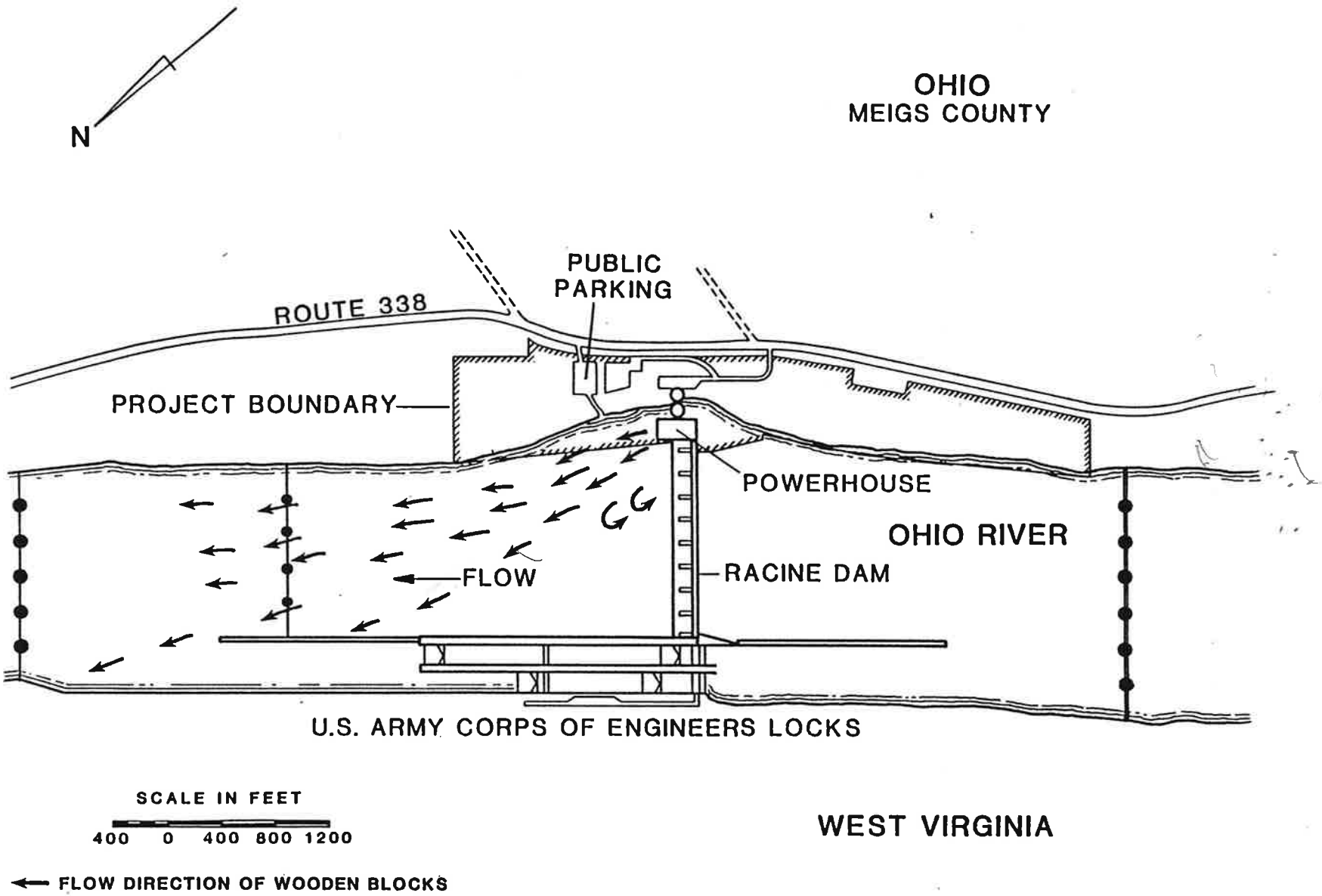
Michael R Robida

Michael R. Robida
Environmental Engineering Division

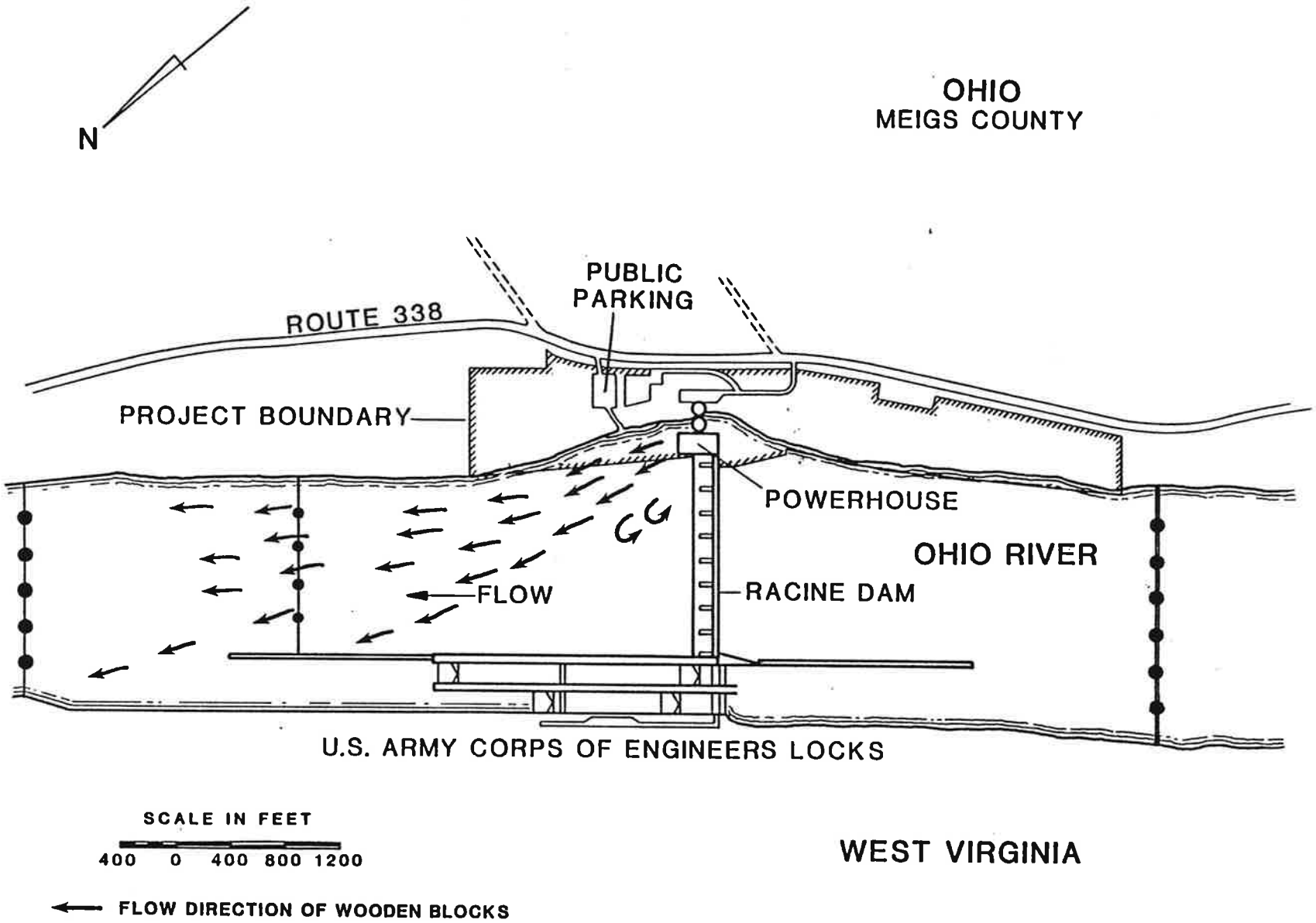
MRR/kme
cc: Dr. George Kincaid
Chief, Water Quality Section
Hydrology and Hydraulic Branch



RACINE DISSOLVED OXYGEN STUDY
TRAVERSE LOCATIONS
FIGURE 1



RACINE DISSOLVED OXYGEN STUDY
FLOW PATTERN STUDY 9-2-87
FIGURE 2



RACINE DISSOLVED OXYGEN STUDY
FLOW PATTERN STUDY 9-4-87
FIGURE 3

Table 1
Summary of Dissolved Oxygen Data (mg/L) for 9-1-87
DO Transects

Traverse A (2500' Upstream)

Depth	Time (1131 - 1207)	(1350 - 1433)	(1445 - 1523)	(1535 - 1614)	(1628 - 1702)
0	6.1	6.0	6.1	6.2	6.3
2	6.0	5.9	6.0	6.1	6.2
5	5.7	5.7	5.8	5.9	5.9
10	5.7	5.6	5.6	5.7	5.7
15	5.6	5.6	5.5	5.6	5.6
20	5.6	5.4	5.4	5.4	5.5
30-40	5.6	5.3	5.3	5.2	5.3
Grand Avg*	5.7	5.6	5.6	5.6	5.6

Traverse B (3600' Downstream)

Depth	Time (1123 - 1146)	(1352 - 1416)	(1427 - 1448)
0	5.9	6.0	6.1
2	5.9	6.0	6.0
5	5.8	6.0	6.0
10	5.8	5.9	6.0
15	5.8	6.0	6.0
20	5.8	6.0	6.0
Grand Avg*	5.8	6.0	6.0

Traverse C (2.5 mi. Downstream)

Depth	Time (1204 - 1221)	(1504 - 1522)	(1528 - 1551)
0	5.9	6.0	6.0
2	5.8	6.0	6.0
5	5.8	6.0	6.0
10	5.8	6.0	6.1
15	5.8	6.0	6.0
20	5.8	6.0	6.0
30	5.8	6.0	6.0
Grand Avg*	5.8	6.0	6.0

* Depth values from 0 - 5 ft. averaged as one depth.

Table 2
Dissolved Oxygen Data (mg/L) for 9-1-87[1]
Transect Comparison with Lag Times

(A) Time of Transect at Traverse A	(B) DO at Traverse A	(C) Time Traverse A Water Arrives at Traverse B	(D) Time of Transect at Traverse B	(E) DO at Traverse B	(F)[2] DO at B Minus DO at A	(G) Time Traverse A Water Arrives at Traverse C	(H) Time of Transect at Traverse C	(I) DO at Traverse C	(J)[2] DO at C Minus DO at A
1131-1207	5.7	1301-1337	1123-1146	5.8	NA	1501-1537	1204-1221	5.8	NA
1350-1433	5.6	1520-1603	1352-1416	6.0	(0.3)	NA	1504-1522	6.0	0.3
1445-1523	5.6	NA	1427-1448	6.0	(0.3)	NA	1528-1551	6.0	0.3
1535-1614	5.6	NA	---	---	---	NA	---	---	---
1628-1702	5.6	NA	---	---	---	NA	---	---	---

(1) DO saturation = 8.2

(2) Includes nearly overlapping transects within 45 minutes. These values are shown in parentheses.

Table 3
Summary of Dissolved Oxygen Data (mg/L) for 9-2-87
DO Transects

Traverse A (2500' Upstream)

Depth	Time (0905 - 0935)	(0946 - 1028)	(1037 - 1104)	(1123 - 1149)	(1410 - 1506)
0	5.5	5.6	5.7	5.7	6.0
2	5.5	5.6	5.6	5.6	6.0
5	5.4	5.5	5.4	5.6	5.9
10	5.4	5.4	5.4	5.5	5.6
15	5.4	5.4	5.3	5.4	5.5
20	5.4	5.4	5.3	5.3	5.4
30-40	5.3	5.3	5.3	5.2	5.2
Grand Avg*	5.4	5.4	5.4	5.4	5.5

Traverse at Restricted Zone Boundary (1400' Downstream)

Depth	Time (1053 - 1108)	(1442 - 1458)
0	5.7	5.7
2	5.7	5.7
5	5.7	5.7
10	5.8	5.7
15	5.8	5.7
20	5.7	5.7
30	5.7	5.7
Grand Avg*	5.7	5.7

Traverse B (3600' Downstream)

Depth	Time (0953 - 1002)	(1032 - 1125)	(1506 - 1535)	(1556 - 1615)	(1618 - 1636)
0	5.7	5.7	5.7	5.7	5.7
2	5.7	5.7	5.7	5.7	5.7
5	5.7	5.7	5.7	5.7	5.7
10	5.7	5.7	5.7	5.7	5.7
15	5.7	5.7	5.6	5.7	5.7
20	5.7	5.7	5.6	5.7	5.7
Grand Avg*	5.7	5.7	5.7	5.7	5.7

* Depth values from 0 - 5 ft. averaged as one depth.

Table 4
Dissolved Oxygen Data (mg/L) for 9-2-87[1]
Transect Comparison with Lag Times

(A) Time of Transect at Traverse A	(B) DO at Traverse A	(C) Time Traverse A Water Arrives at Traverse RZ	(D) Time of Transect at Traverse RZ	(E) DO at Traverse RZ	(F) [2] DO at RZ Minus DO at A	(G) Time Traverse A Water Arrives at Traverse B	(H) Time of Transect at Traverse B	(I) DO at Traverse B	(J) [2] DO at B Minus DO at A
0910-0935	5.4	1110-1135	1053-1108	5.7	(0.3)	1145-1210	0953-1002	5.7	NA
0954-1028	5.4	1154-1228	1442-1458	5.7	NA	1229-1303	1032-1125	5.7	(0.3)
1038-1104	5.4	1238-1304	---	---	---	1313-1339	1506-1535	5.7	(0.3)
1128-1149	5.4	1328-1349	---	---	---	1403-1424	1556-1615	5.7	(0.2)
1411-1506	5.5	NA	---	---	---	1641-1736	1618-1636	5.7	0.2

(1) DO saturation = 8.4

(2) Includes nearly overlapping transects within 45 minutes. These values are shown in parentheses.

Table 7
Summary of Dissolved Oxygen Data (mg/L) for 9-4-87
DO Transects

Traverse A (2500' Upstream)

Depth	Time (0825-0900)	(0905-0950)	(0955-1020)	(1030-1100)	(1115-1145)	(1340-1455)	(1455-1550)
0	6.1	6.1	6.2	6.4	6.6	7.7	8.0
2	6.0	6.1	6.2	6.3	6.5	7.5	8.0
5	6.0	6.1	6.1	6.2	6.2	6.7	7.5
10	6.0	6.0	6.0	6.1	6.0	6.2	6.3
15	6.0	6.0	6.0	6.0	5.9	5.9	6.0
20	6.0	6.0	6.0	6.0	5.9	5.8	5.9
30-40	5.9	5.9	5.9	6.0	5.9	5.7	5.6
Grand Avg*	6.0	6.0	6.0	6.1	6.0	6.2	6.3

Traverse at Restricted Zone Boundary (1400' Downstream)

Depth	Time (0920-0932)	(1012-1023)	(1352-1403)	(1539-1549)
0	6.0	6.3	6.5	6.7
2	6.1	6.3	6.5	6.7
5	6.1	6.3	6.6	6.8
10	6.1	6.3	6.5	6.7
15	6.1	6.3	6.6	6.7
20	6.1	6.3	6.6	6.7
30	6.0	6.2	6.5	6.7
Grand Avg*	6.1	6.3	6.5	6.7

Traverse B (3600' Downstream)

Depth	Time (0855-0912)	(0940-1001)	(1031-1053)	(1108-1126)	(1141-1201)	(1431-1452)	(1456-1520)	(1555-1614)	(16:17-16:35)
0	6.0	6.2	6.4	6.4	6.4	6.7	6.7	6.7	6.8
2	6.0	6.2	6.4	6.4	6.4	6.7	6.7	6.7	6.8
5	6.0	6.2	6.4	6.4	6.5	6.7	6.7	6.7	6.8
10	6.0	6.2	6.4	6.4	6.5	6.6	6.6	6.7	6.7
15	6.0	6.2	6.4	6.4	6.5	6.6	6.6	6.7	6.7
20	6.0	6.1	6.3	6.4	6.5	6.6	6.6	6.7	6.6
Grand Avg*	6.0	6.2	6.4	6.4	6.5	6.6	6.6	6.7	6.7

* Depth values from 0 - 5 ft. averaged as one depth.

Table 6
Dissolved Oxygen Data (mg/L) for 9-3-87[1]
Transect Comparison with Lag Times

(A) Time of Transect at Traverse A	(B) DO at Traverse A	(C) Time Traverse A Water Arrives at Traverse RZ	(D) Time of Transect at Traverse RZ	(E) DO at Traverse RZ	(F) [2] DO at RZ Minus DO at A	(G) Time Traverse A Water Arrives at Traverse B	(H) Time of Transect at Traverse B	(I) DO at Traverse B	(J) [2] DO at B Minus DO at A
0840-0910	5.7	1040-1110	0937-0951	6.0	NA	1120-1150	0906-0929	5.9	NA
0930-1005	5.8	1130-1205	1416-1430	5.9	(0.3)	1210-1245	1005-1041	5.9	(0.2)
1025-1110	5.6	1225-1310	1551-1604	6.0	0.2	1305-1350	1052-1110	5.9	(0.2)
1115-1200	5.6	1315-1400	---	---	---	1355-1440	1441-1456	5.9	(0.3)
1400-1440	5.8	1600-1640	---	---	---	1640-1720	1504-1528	5.9	(0.3)
1445-1530	5.9	1645-1730	---	---	---	1725-1810	1609-1629	6.0	(0.2)
1534-1615	6.0	NA	---	---	---	---	---	---	---

(1) DO saturation = 8.4

(2) Includes nearly overlapping transects within 45 minutes. These values are shown in parentheses.

Table 5
Summary of Dissolved Oxygen Data (mg/L) for 9-3-87
DO Transects

Traverse A (2500' Upstream)

Depth	Time (0840 - 0910)	(0930 - 1005)	(1025 - 1110)	(1115 - 1200)	(1400 - 1440)	(1445 - 1530)	(1534 - 1615)
0	5.8	5.9	5.9	5.9	6.2	6.4	6.8
2	5.7	5.9	5.8	5.9	6.1	6.3	6.8
5	5.7	5.8	5.7	5.7	5.9	6.2	6.5
10	5.7	5.8	5.6	5.6	5.8	6.0	6.0
15	5.7	5.7	5.6	5.5	5.7	5.8	5.8
20	5.8	5.7	5.6	5.5	5.7	5.7	5.7
30-40	5.7	5.7	5.5	5.5	5.5	5.5	5.6
Grand Avg*	5.7	5.8	5.6	5.6	5.8	5.9	6.0

Traverse at Restricted Zone Boundary (1400' Downstream)

Depth	Time (0937 - 0951)	(1416 - 1430)	(1551 - 1604)
0	6.0	5.9	6.0
2	6.0	5.9	6.0
5	6.0	5.9	6.0
10	6.0	5.9	6.0
15	6.0	5.9	6.0
20	6.0	5.9	6.0
30-40	6.0	5.9	6.0
Grand Avg*	6.0	5.9	6.0

Traverse B (3600' Downstream)

Depth	Time (0906 - 0929)	(1005 - 1041)	(1052 - 1110)	(1441 - 1456)	(1504 - 1528)	(1609 - 1629)
0	5.9	5.9	5.9	5.9	5.9	6.0
2	5.9	5.9	5.9	5.9	5.9	6.0
5	5.9	5.9	5.9	5.9	6.0	6.0
10	5.9	5.9	5.9	5.9	5.9	6.0
15	5.9	5.9	5.9	5.9	5.9	6.0
20	5.9	5.8	5.9	5.9	5.9	6.0
Grand Avg*	5.9	5.9	5.9	5.9	5.9	6.0

* Depth values from 0 - 5 ft. averaged as one depth.

Table 8
Dissolved Oxygen Data (mg/L) for 9-4-87[1]
Traverse Comparison with Lag Times

(A) Time of Transect at Traverse A	(B) DO at Traverse A	(C) Time Traverse A Water Arrives at Traverse RZ	(D) Time of Transect at Traverse RZ	(E) DO at Traverse RZ	(F) [2] DO at RZ Minus DO at A	(G) Time Traverse A Water Arrives at Traverse B	(H) Time of Transect at Traverse B	(I) DO at Traverse B	(J) [2] DO at B Minus DO at A
0825-0900	6.0	1055-1130	0920-0932	6.1	NA	1125-1200	0940-1001	6.2	NA
0905-0950	6.0	1135-1220	1012-1023	6.3	(0.3)	1205-1250	1031-1053	6.4	(0.4)
0955-1020	6.0	1225-1250	1352-1403	6.5	0.5	1255-1320	1108-1126	6.4	0.4
1030-1100	6.1	1300-1330	1539-1549	6.7	(0.5)	1330-1400	1141-1201	6.5	0.5
1115-1145	6.0	1345-1415	---	---	---	1415-1445	1431-1452	6.6	0.6
1340-1455	6.2	1610-1725	---	---	---	1640-1755	1456-1520	6.6	(0.6)
1455-1550	6.3	NA	---	---	---	NA	1555-1614	6.7	(0.5)
---	---	---	---	---	---	---	1617-1635	6.7	(0.5)

(1) DO saturation = 8.4

(2) Includes nearly overlapping transects within 45 minutes. These values are shown in parentheses.

Table 9
Summary of Dissolved Oxygen Data (mg/L) for 9-29-87
DO Transects

Traverse A (2500' Upstream)

Depth	Time (1000 - 1053)	(1057 - 1145)	(1212 - 1247)	(1300 - 1340)	(1430 - 1509)	(1510 - 1550)
0	7.9	7.9	7.9	8.0	8.0	7.9
2	7.9	7.8	7.9	7.9	7.9	7.9
5	7.9	7.8	7.8	7.9	7.9	7.8
10	7.8	7.7	7.8	7.8	7.8	7.8
15	7.8	7.7	7.8	7.8	7.8	7.8
20	7.8	7.7	7.7	7.8	7.8	7.7
30-40	7.7	7.6	7.7	7.7	7.7	7.7
Grand Avg*	7.8	7.7	7.8	7.8	7.8	7.8

Traverse at Restricted Zone Boundary (1400' Downstream)

Depth	Time (1011 - 1030)	(1103 - 1114)	(1321 - 1336)	(1538 - 1552)
0	7.6	7.7	7.8	7.8
2	7.5	7.6	7.8	7.8
5	7.6	7.6	7.8	7.7
10	7.5	7.6	7.7	7.7
15	7.5	7.6	7.8	7.7
20	7.5	7.5	7.8	7.7
20-30	7.4	7.5	7.7	7.5
Grand Avg*	7.5	7.6	7.8	7.7

Traverse B (3600' Downstream)

Depth	Time (0946 - 1006)	(1035 - 1055)	(1235 - 1258)	(1300 - 1317)	(1339 - 1356)	(1422 - 1450)	(1512 - 1530)	(1616 - 1630)
0	7.6	7.6	7.7	7.9	7.8	7.8	7.7	7.6
2	7.6	7.6	7.7	7.8	7.8	7.8	7.7	7.7
5	7.6	7.6	7.7	7.8	7.7	7.8	7.6	7.7
10	7.6	7.6	7.7	7.7	7.7	7.7	7.6	7.7
15	7.6	7.6	7.7	7.8	7.7	7.7	7.6	7.7
15-20	7.6	7.5	7.6	7.7	7.6	7.6	7.5	7.6
Grand Avg*	7.6	7.6	7.7	7.8	7.7	7.7	7.6	7.7

* Depth values from 0 - 5 ft. averaged as one depth.

Table 10
Dissolved Oxygen Data (mg/L) for 9-29-87[1]
Transect Comparison with Lag Times

(A) Time of Transect at Traverse A	(B) DO at Traverse A	(C) Time Traverse A Water Arrives at Traverse RZ	(D) Time of Transect at Traverse RZ	(E) DO at Traverse RZ	(2)(F) DO at RZ Minus DO at A	(G) Time Traverse A Water Arrives at Traverse B	(H) Time of Transect at Traverse B	(I) DO at Traverse B	(2)(J) DO at B Minus DO at A
1000-1053	7.8	1130-1223	1011-1030	7.5	NA	1200-1253	1035-1055	7.6	NA
1057-1140	7.7	1227-1310	1103-1114	7.6	(-0.2)	1257-1340	1235-1258	7.7	-0.1, (0)
1212-1247	7.8	1342-1417	1321-1336	7.8	(-0.1, 0)	1412-1447	1300-1317	7.8	+0.1
1300-1340	7.8	1430-1510	1538-1552	7.7	(-0.1)	1500-1540	1339-1356	7.7	0
1430-1509	7.8	1600-1639	---	---	---	1630-1709	1422-1450	7.7	-0.1
1510-1550	7.8	1640-1720	---	---	---	1710-1750	1512-1530	7.6	-0.2
---	---	---	---	---	---	---	1616-1630	7.7	-0.1

(1) DO saturation = 9.2

(2) Includes nearly overlapping transects within 45 minutes. These values are shown in parentheses.

Table 11
Summary of Dissolved Oxygen Data (mg/L) for 9-30-87
DO Transects

Transect A (Upstream 2500')

Depth	Time (0812-0855)	(0905-0942)	(1000-1045)	(1048-1132)	(1218-1255)	(1259-1340)	(1342-1428)
0	7.6	7.6	7.5	7.6	7.6	7.6	7.6
2	7.6	7.5	7.5	7.6	7.6	7.5	7.6
5	7.5	7.5	7.5	7.6	7.6	7.5	7.5
10	7.5	7.5	7.5	7.5	7.5	7.5	7.5
15	7.5	7.4	7.5	7.5	7.5	7.5	7.5
20	7.5	7.5	7.5	7.5	7.5	7.4	7.5
30-40	7.5	7.4	7.5	7.5	7.5	7.4	7.5
Grand Avg*	7.5	7.5	7.5	7.5	7.5	7.5	7.5

Transect at Restricted Zone Boundary (1400' Downstream)

Depth	Time (1147-1206)	(1334-1350)	(1427-1435)	(1512-1522)	(1544-1552)
0	7.4	7.8	7.8	7.8	7.8
2	7.3	7.8	7.8	7.8	7.8
5	7.3	7.8	7.8	7.8	7.8
10	7.3	7.8	7.8	7.8	7.8
15	7.3	7.7	7.8	7.8	7.8
20	7.3	7.7	7.8	7.8	7.8
20-30	7.1	7.7	7.8	7.8	7.7
Grand Avg*	7.3	7.7	7.8	7.8	7.8

Transect B (3600' Downstream)

Depth	Time (0918-0939)	(1125-1140)	(1318-1331)	(1348-1358)	(1411-1423)	(1444-1457)	(1524-1536)	(1556-1607)	(1640-1652)
0	7.3	7.4	7.7	7.8	7.8	7.8	7.8	7.9	7.9
2	7.3	7.4	7.7	7.8	7.8	7.8	7.8	7.9	7.9
5	7.3	7.3	7.7	7.8	7.8	7.8	7.8	7.9	7.9
10	7.3	7.3	7.7	7.8	7.8	7.8	7.8	7.9	7.9
15	7.3	7.3	7.7	7.8	7.8	7.8	7.8	7.9	7.9
15-20	7.3	7.1	7.7	7.8	7.7	7.8	7.9	7.8	7.8
Grand Avg*	7.3	7.3	7.7	7.8	7.8	7.8	7.8	7.9	7.9

* Depth values from 0 - 5 ft. averaged as one depth.

Table 12
Dissolved Oxygen Data (mg/L) for 9-30-87[1]
Transect Comparison with Lag Times

(A) Time of Transect at Traverse A	(B) DO at Traverse A	(C) Time Traverse A Water Arrives at Traverse RZ	(D) Time of Transect at Traverse RZ	(E) DO at Traverse RZ	(F) [2] DO at RZ Minus DO at A	(G) Time Traverse A Water Arrives at Traverse B	(H) Time of Transect at Traverse B	(I) DO at Traverse B	(J) [2] DO at B Minus DO at A
0812-0855	7.5	1012-1055	1147-1206	7.3	(-0.2)	1042-1125	0918-0939	7.3	NA
0905-0942	7.5	1105-1142	1334-1350	7.7	(0.2)	1135-1212	1125-1140	7.3	-0.2
1000-1045	7.5	1200-1243	1427-1435	7.8	+0.3	1230-1315	1318-1331	7.7	+0.2
1048-1132	7.5	1248-1332	1512-1522	7.8	0.3	1318-1402	1348-1358	7.8	+0.3
1218-1255	7.5	1418-1455	1544-1552	7.8	0.3	1448-1525	1411-1423	7.8	(+0.3)
1259-1340	7.5	1459-1540	---	---	---	1529-1610	1444-1457	7.8	+0.3
1342-1428	7.5	1542-1628	---	---	---	1612-1658	1524-1536	7.8	+0.3
---	---	---	---	---	---	---	1555-1607	7.9	+0.4
---	---	---	---	---	---	---	1640-1652	7.9	+0.4

(1) DO saturation = 9.2

(2) Includes nearly overlapping transects within 45 minutes. These values are shown in parentheses.

Table 13

Summary of Downstream DO Impacts

Day and Study Conditions	Upstream DO as % DO Saturation	Difference Between Upstream and Downstream DO (mg/L)
9-1-87 o Dam Discharge = 12,000 cfs o Hydro Discharge = 13,000 cfs	68	0.3
9-2-87 a.m. o Dam Discharge = 3,000-5,250 cfs o Hydro Discharge = 14,460 cfs o Air Injection = 200 scfm at Discharge Ring	64	0.3
9-2-87 p.m. o Dam Discharge = 3,000-5,250 cfs o Hydro Discharge = 14,460 cfs o Air Injection = 450 scfm at Discharge Ring	64	0.2
9-3-87 a.m. o Dam Discharge = 18,000 cfs o Hydro Discharge = 0	69	0.2
9-3-87 p.m. o Dam Discharge = 2,250 cfs o Hydro Discharge = 15,570 cfs	67 - 71	0.2 - 0.3
9-4-87 o Dam Discharge = 0 o Hydro Discharge = 15,750 cfs o Air Injection = 220 scfm at Discharge Ring	71 - 75	0.3 - 0.6
9-29-87 o Dam Discharge = 25,500 cfs o Hydro Discharge = 0	81	-0.2 - 0.10
9-30-87 o Dam Discharge = 0 o Hydro Discharge = 20,000 cfs	82	-0.2 - 0.4

APPENDIX I

Program for a Water Quality Study at the Racine Dam on the Ohio River

Program for a Water Quality Study at the Racine Dam on the Ohio River

Introduction

The Racine Hydroelectric Project, owned by Ohio Power Company and operated by Appalachian Power Company, is located at the Ohio end of the Army Corps of Engineers' Racine Locks and Dam on the Ohio River (Mile 237.5). The Project includes two 24-megawatt units, consisting of two parallel horizontal water passages in each of which a horizontal-axis, bulb-type Kaplan turbine is installed. These units are specifically designed to operate over a wide range of heads inherent at this site, especially low heads, to maximize use of varying river flows. Head is the difference in height between the water levels upstream and downstream of the dam. As stated in the operating agreement with the Corps, during normal operation the Project will generate electricity with one or two of the units 24 hours a day when favorable river conditions exist. The approximate flow range is 4,000 cfs (minimum turbine discharge) to about 150,000 cfs. River flows from approximately 4,000 cfs to 31,300 (Project discharge capacity) normally will be passed through the turbines but may be passed through both the Project and the dam in a coordinated effort if required. For river flows between 31,300 cfs and 150,000 cfs, discharges will be made through both the dam and the Project. For river flows in excess of 150,000 cfs, the hydroelectric units are shut down due to lack of operating head.

During low-flow periods of the Ohio River, usually in August, September, and October, the dissolved oxygen (D.O.) levels in the river tend to decrease, occasionally falling below the ORSANCO water quality standard of 5.0 mg/l daily average. Under these conditions, the Corps of Engineers previously discharged the available flow through as few gates as possible as a means of increasing turbulence to improve aeration and increase D.O. levels in the river. The value of this program has not been determined. Now, when river flows are less than 31,000 cfs and greater than 4,000 cfs during normal project operation, all of the river flow passes through the hydro turbines. This eliminates the Corps' means of aeration. In accordance with Article 49 of the FERC License, Ohio Power Company has installed an air injection system with injection ports at three locations: the upstream bulkheads, the discharge rings, and the downstream bulkheads within the turbine water passages. This system is to be operated whenever the D.O. concentration in the water upstream of the dam is below 5.0 mg/l daily average.

The purpose of this water quality study is to determine the efficacy of the air injection system to raise the D.O. concentration during low D.O. conditions to satisfy the condition in Article 50 of the FERC License requiring post-operational water quality studies. This study should also show the most effective of the three injection locations.

Testing Program

1.0 Preliminary

1.1 Tests of D.O. concentrations will be conducted during the low-flow period of the Ohio River, probably in August or September, but only when the river flows are below 31,000 cfs and above 4,000 cfs and when the D.O. is at least 2.0 mg/l below saturation for the ambient water temperature.

1.2 Two traverses will be tested each with portable D.O. meters, one upstream (~2500 ft) and one downstream (~3600 ft). Each traverse will consist of six sampling points equally spaced across the river and approximately 200 feet apart. Each sample point will be tested at depths of 1, 2, 5, 10, 15, 20, and 40 ft. or bottom. (Note: In the interest of doing as many traverse runs as possible, we may want to reduce the number of depths to be tested.)

1.3 Parameters to be measured at each depth at each sampling point are D.O. and temperature.

1.4 Temperature and D.O. data recorded at ORSANCO's Addison Station (RM 260) will be obtained.

1.5 Other items to be recorded include the flow of air being injected (if possible); river flow; pool levels; gate leakage; lock operation; type, timing and direction of river traffic; weather conditions; ponding operation; and power generation.

1.6 Two boats will be used, each with three-man crews.

1.7 An attempt will be made to determine the flow pattern of the discharge (see 3.3).

2.0 Equipment and Labor

2.1 Two boats and all proper safety equipment.

2.2 Three temperature/D.O. electronic meters (one back-up), each with probes on 50' leads and attached to chains marked at 1' intervals.

2.3 Three hand-held, two-way radios.

2.4 Twenty bleach or similar plastic bottles to be used as buoys, with lines and anchors.

2.5 128 - 6" x 2" x 4" sections of wood painted orange for current pattern studies.

2.6 Range finder for estimating distances (C&SOE).

2.7 Spare batteries for motors, meters, and hand-held radios.

2.8 Personnel from AEP, APCo, and ORSANCO and the Corps as available.

3.0 First Test Day -- Run-of-River Operation (No Air Injection)

3.1 Use a modified Winkler Test to calibrate the meters during the test period. Check out the meters three times per day -- morning, noon, and late afternoon or as appropriate. If the Schneider continuous D.O. monitor is in service, compare the modified Winkler Test D.O. readings with the Schneider reading.

3.2 Locate traverses, mark sampling points by placing buoys, measure depths and distances from shore.

3.3 Drop the 2" x 4" wood sections in each turbine discharge to determine flow patterns. Sketch the patterns as they become apparent.

3.4 Record dissolved oxygen and temperature at depths of 1, 2, 5, 10, 15, 20, and 40 ft. or at bottom for each sampling point.

3.5 As feasible, personnel on shore will monitor river flow, lock and dam operations, pool levels, D.O. at Addison and Belleville, etc., and relay unusual conditions to boat crews.

3.6 Make as many traverse runs as possible, one crew with boat working the upstream traverse and the other crew with boat working the downstream traverse.

3.7 Each traverse will be completed by returning to the sampling point measured first and making repeat measurements at a minimum of two of the same depths.

3.8 If time allows, consideration will be given to making a third traverse further downstream.

4.0 Second Day -- Run-of-River Operation (Air Injection Only at Upstream Bulkheads)

4.1 Same as first day excluding 3.3

5.0 Third Day -- Run-of-River Operation (Air Injection Only at Discharge Rings)

5.1 Same as first day excluding 3.3.

6.0 Fourth Day -- Run-of-River Operation (Air Injection Only at Downstream Bulkheads)

6.1 Same as first day excluding 3.3.

7.0 Fifth Day -- Contingency (or repeat first-day test)

7.1 Pack up and move out.

8.0 Data Analysis

8.1 Evaluate effect of Run-of-River Operation on downstream D.O. concentrations by comparison with upstream D.O. concentrations and with saturation D.O.

8.2 Evaluate effect of air injection at all three points on downstream D.O. concentrations.

8.3 Evaluate effect of air injection on electrical generation.

8.4 Evaluate stratification of D.O. upstream and downstream.

8.5 Evaluate the sample intake point for the Schneider continuous analyzer against the upstream cross-section.

9.0 Submit Report to ORSANCO, Corps, and FERC

9.1 Introduction

9.2 Test Program

9.3 Discussion of results

9.4 Conclusions

Record of Consultation

Ohio Power Company and Appalachian Power Company have consulted with ORSANCO and the U.S. Army Corps of Engineers during the development of this study plan. Ohio Power plans to continue consultation with ORSANCO and the Corps through meetings to work out the details of the plan. Significant correspondence follows this list.

Meetings

-- July 2, 1980 meeting between William Klein (ORSANCO), Glen Drummond (Corps of Engineers) and AEPSC/Ohio Power personnel in Cincinnati.

Meetings, cont'd.

-- August 4, 1980 meeting between William Klein (ORSANCO), Ronald Yates, William Eicher, Charles Knighting (Corps of Engineers), and AEPSC/OPCo/APCo personnel at the Racine Project.

-- August 28, 1986 meeting between William Klein (ORSANCO), Dr. George Kincaid, Charles W. Knighting, Howard Pullin (Corps of Engineers) and AEPSC/OPCo/APCo personnel at the Racine Project.

-- August 26, 1987 meeting with Howard Pullin and Vince Marchaise (Corps of Engineers) and AEPSC personnel at the Racine Project.

Correspondence

-- December 17, 1985 letter from M. R. Robida to William L. Klein (ORSANCO) and Charles E. Vandevelde (Corps).

-- December 27, 1985 letter from William L. Klein (ORSANCO) to M. R. Robida.

-- January 10, 1986 letter from M. R. Robida to William L. Klein (ORSANCO).

-- January 17, 1986 letter from William L. Klein (ORSANCO) to M. R. Robida.

-- January 29, 1986 letter from Charles E. Vandevelde to M. R. Robida.

-- February 12, 1986 letter from Richard C. Armstrong (Ohio River Division Corps) to M. R. Robida.

Revised 12/18/87

APPENDIX II

Correspondence Between AEPSC and FERC on Water Quality Study Plan

AMERICAN ELECTRIC POWER *Service Corporation*

AEP

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P.O. Box 16631
Columbus, Ohio 43216-6631

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August 31, 1987

Mr. Fred E. Springer
Acting Director
Office of Hydropower Licensing
Federal Energy Regulatory Commission
Washington, D. C. 20426

Dear Mr. Springer:

Re: Project No. 2570-008-Ohio
Racine Project
Ohio Power Company

On February 4, 1986, I filed, on behalf of Ohio Power Company, materials to satisfy the requirements of Articles 49 and 50 of the license for the Racine Project. These included operating plans for the water quality monitor and air injection system, as well as a program to test the efficacy of the air injection system under certain river conditions. These materials were developed following consultations with the Ohio River Valley Water Sanitation Commission (ORSANCO) and the Corps of Engineers Huntington District. The filing was approved by letters issued by the Commission April 3 and April 17, 1986.

This letter responds to your letter of July 27, 1987 which asks that the dissolved oxygen study the American Electric Power Service Corporation (AEPSC) plans to conduct in 1987 at the Racine Project on behalf of Ohio Power Company be expanded and modified. This letter also confirms subsequent discussions held between George Taylor of your office and Michael Robida of AEPSC on the information contained in your letter. In summary, your July 27, 1987 letter contained the following main items regarding the dissolved oxygen study.

1. A recommendation to conduct the dissolved oxygen and temperature transect measurements at two different flows less than 4,000 cfs, when the plant is not in operation if possible.

2. A request to either:

   a) show how the results of the turbine aeration study can be extrapolated to calculate the downstream dissolved oxygen levels at other river flows, temperatures, and upstream dissolved oxygen deficits, or

   b) repeat measurements at three flows higher than 4,000 cfs in order to describe aeration from the power plant at various flows and dissolved oxygen deficits.

3. A request that the dissolved oxygen study to be conducted this summer be filed with the Commission by November 15, 1987 and include certain additional data such as cost information, efficiency, design information, and any operational problems incurred.

As your letter mentioned, the purpose of the dissolved oxygen study is to determine the efficacy of the air injection system installed at Racine to add air to the river during low dissolved oxygen periods in order to replace the aeration from the Corps of Engineers dam spillage at times when the entire river flow is passing through the hydro units. All of the river flow will pass through both hydro units at flows between 4,000 and 31,000 cfs. During one unit operation this flow range would be 4,000 to 16,000 cfs. The air injection system is to be operated during hydro operation when the daily average dissolved oxygen concentration in the river upstream of the dam falls below 5 mg/l average.

In regard to conducting dissolved oxygen and temperature measurements at flows less than 4,000 cfs when the hydro units are not in operation, a review of USGS historical flow data from the Belleville Dam just upstream from Racine shows that river flows less than 4,000 cfs are very unlikely to occur at Racine. During the period of record for the USGS data collection at Belleville (1974-1985) the minimum daily flow that occurred was 4,830 cfs. USGS data for Belleville from 1981 to 1985 are attached for your easy reference. It can also be seen from these data that the river flows are not consistent and fluctuate widely. Additionally, since the hydro units do not operate at flows less than 4,000 cfs, we do not see the benefit to be gained with respect to the Racine Project by conducting tests at these flows.

With respect to Item 2a (above), the development of a model to show how the data obtained from the study could be extrapolated to predict dissolved oxygen concentrations at various flows and dissolved oxygen deficits is well beyond the scope of the study at Racine. The study will be conducted during certain river conditions that are beyond our control. We also believe that there are many factors effecting dissolved oxygen in the river, such as oxygen demand, algae activity, and the weather, which would be difficult to address in any study. We will, however, address whatever correlations can be made from the data obtained, but do not believe valid extrapolations can be made.

In regard to conducting the study at three different flows above 4,000 cfs (item 2.b above), it is important to note the river conditions required for this study (as previously established) and to note that river flows do not remain constant. The river conditions required for the study are:

1) that the dissolved oxygen concentration in the river be 2.0 mg/l below saturation (to allow detection of dissolved oxygen increases resulting from air injection) and that the dissolved oxygen level be near ORSANCO's criteria of 5.0 mg/l, and

2) that the river flows be between 4,000 cfs and 31,000 cfs for two-unit operation and between 4,000 and 16,000 cfs for one-unit operation, which are the ranges where all river flow (except lockage and leakage) passes through the hydro units.

During 1986 when we were prepared to conduct this study, the dissolved oxygen content in the river rarely dropped below 2 mg/l below saturation and was not consistent. This year, as well, dissolved oxygen readings in the river have been close to saturation and sometimes have exceeded saturation. Therefore, based on dissolved oxygen concentrations alone, it may not be possible to conduct the study at any flow. Additionally, the river flow in the vicinity of Racine does not remain constant for any length of time. We have seen fluctuations in river flow as much as 10,000 cfs or more in the course of a day during low flow periods. The wide range of day-to-day fluctuations can be seen from the attached USGS data from the Belleville Dam. Therefore, it is likely that during the test many different river flows will occur. However, it is very unlikely that we will ever be able to complete the study at three different flows. During the discussions between Messrs. Robida and Taylor, it was agreed that it was not feasible to plan to conduct the study for three different flows. However, it was agreed that AEPSC would conduct an additional day of testing with air injection at the location previously determined as most efficient for half of the day and half of the day with no air injection. As presently planned this would occur during the fifth day of the study, previously planned for contingency. Additionally, Mr. Taylor requested that we consider lowering our dissolved oxygen content requirement for the study from 2.0 mg/l below saturation to 1.0 mg/l. It was agreed that we would lower the criteria to 1.5 mg/l below saturation.

In regard to filing a report of the results with the Commission by November 15, 1987, a filing date of December 15 was agreed to between Messrs. Robida and Taylor provided the study can be conducted in September. The requested technical data which is available will be included.

We appreciated the opportunity to discuss your letter with Mr. Taylor and come to this agreement. We will keep Mr. Taylor advised of our progress. At the time of this writing, the river conditions meeting

the agreed upon criteria to conduct the study have occurred and we have mobilized to begin the studies.

Very truly yours,

R. W. Harmon

RWH/MRR/kme

Attachments: Fred E. Springer letter dated July 27, 1987
Belleville Flow Records

cc: Dr. George P. Kincaid
Chief, Water Quality Branch
Hydrology and Hydraulic Branch
U.S. Army Corps of Engineers
Federal Building
P.O. Box 2127
Huntington, WV 25721

Alan Vicory
Executive Director
Ohio River Valley Water
Sanitation Commission
414 Walnut Street
Cincinnati, OH 45202

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D. C. 20426

JUL 27 1987

Project No. 2570-008-Ohio
Racine Project
Ohio Power Company

Robert W. Harmon, Senior Attorney
American Electric Power Service Corporation
1 Riverside Plaza, P. O. Box 16631
Columbus, OH 43216-6631

Dear Mr. Harmon:

On behalf of the Ohio Power Company, American Electric Power Service Corporation (AEP) filed, on February 4, 1986, material pertaining to postoperational studies that were planned to be conducted to determine, among other items, if project operation is affecting the quality of water above and below the Racine Project. These studies are required by article 50 of your license. Subsequently, the Acting Director of the Office of Hydropower Licensing sent a letter to you dated April 17, 1986, stating that the material submitted was consistent with and in compliance with the requirements of article 50.

It is my understanding that AEP is planning on conducting the water quality study during the summer of 1987. The stated purpose of the study is to determine the efficacy of the installed air injection system to raise dissolved oxygen (DO) levels during low DO periods, and to satisfy requirements of article 50. In addition, the study is planned to show the most effective locations of the three air injection ports for raising DO levels during project operation.

The water quality study, as presently proposed, may not be adequate to determine the effects of project operation on the quality of the water in the river as required by article 50. For example, the proposed study should be capable of describing aeration at the dam and hydropower plant over a range of flows, rather than at only one flow. It is therefore recommended that the proposed DO and temperature transect measurements be repeated at two flows less than 4,000 cubic feet per second (cfs), when the plant is not in operation if possible. These low flow measurements would be needed to quantify aeration at the dam at river flows lower than the minimum flow required for generation. In addition, the proposed turbine aeration study should also either (a) show how the results of the turbine aeration study

can be extrapolated to calculate the downstream DO levels at other river flows, temperatures, and upstream DO deficits, or (b) be repeated at three flows higher than 4,000 cfs in order to describe aeration from the powerplant at various flows and DO deficits.

(D) The results of the study when filed should indicate the rate of air flow during air injection into each of the three different ports and the efficiency of air entrainment by using each of the ports. The report on study results should also describe the impact of the operation of the air injection system on turbine efficiency, the loss to power generation during operation of each of the three injection ports, and the actual cost of operating the air injection system, such as the cost of operating the compressor units used in air injection. The report should note if the use of the aeration system causes any turbine cavitation or vibration problems during operation of the air injection system. The report on the study results should also include a detailed description of the aeration system, with design drawings and manufacturer's specifications.

Article 50 requires that copies of the report on the results of the subject study be filed at the Commission within one year after the completion of the study. The results of the water quality study, to be conducted this summer, should be filed with the Commission by November 15, 1987. Your cooperation in modifying the study as described and in providing the results of the study according to the schedule indicated will be greatly appreciated. If you have any questions concerning these requirements for compliance with article 50, please contact Mr. George Taylor at (202) 376-9288. Your prompt reply as to your intention to address these requirements is also appreciated.

Sincerely,

Fred E. Springer
Acting Director, Office of
Hydropower Licensing

APPENDIX III

Tabulation of Raw DO Data
for September 1-4, 1987 and September 29-30, 1987

WAPORA
ENVIRONMENTAL ENGINEERS/SCIENTISTS
5700 Hillside Avenue, Cincinnati, Ohio 45233
Phone 513-941-6000

Racine Locks and Dam
Dissolved Oxygen and Temperature Data

Submitted to:

Mike Robida
American Electric Power Service Corporation
1 Riverside Plaza
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Columbus, OH 43216-6631

Submitted by:

Curtis Meininger
Biologist/Data Analyst
WAPORA, Inc.
5700 Hillside Ave.
Cincinnati, OH 45233

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Racine Locks and Dam

Dissolved Oxygen Sampling Effort:

I

RACINE DISSOLVED OXYGEN STUDY
UPSTREAM TRANSECT
Dates: 9-1-87 to 9-4-87

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-1-87
Time: 11:31
Winkler Oxygen Calibration
ppm Oxygen= 5.9

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1 DO	1 T	2 DO	2 T	3 DO	3 T	4 DO	4 T	5 DO	5 T	6 DO	6 T	W. VIRGINIA 7 DO
1	6.0		6.1	26.0	6.1		6.1		6.1		6.1		6.1
2	5.9		6.0	26.0	6.0		6.0		5.9		5.9		6.0
5	5.8		5.7	25.5	5.7		5.7		5.7		5.7		5.9
10	5.6		5.7	25.5	5.7		5.7		5.7		5.7		5.8
15	5.6		5.7	25.5	5.6		5.6		5.6		5.6		5.7
20	5.6		5.6	25.5	5.6		5.6		5.6		5.6		5.7
Bottom @depth	5.6	@32	5.5	25.5	5.4	@32	5.4	@38	5.5	@38	5.5	@37	5.6 @38
AVG. =	5.7		5.8	25.6	5.7		5.7		5.7		5.7		5.8

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELCIUS) = 25.6

PERCENT SATURATION = 67.1

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-1-87
Time: 13:50
Winkler Oxygen Calibration
ppm Oxygen= 5.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	
1	6.0	X	5.9	26.3	6.0	26.0	6.1	26.0	6.1	26.0	6.1	26.8	6.1	26.
2	5.9		5.9	26.0	5.8	26.0	5.9	26.0	6.0	26.0	6.0	26.0	6.0	26.
5	5.8		5.8	25.8	5.6	25.5	5.8	25.8	5.9	25.8	5.6	25.8	5.6	25.
10	5.8		5.7	25.5	5.5	25.5	5.6	25.5	5.6	25.8	5.5	25.5	5.5	25.
15	5.6		5.6	25.5	5.5	25.5	5.5	25.5	5.5	25.5	5.5	25.5	5.5	25.
20	5.4		5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.5	5.4	25.3	5.4	25.
Bottom @depth	5.3	@26	5.3	25.3 @36	5.3	25.3 @36	5.3	25.3 @36	5.3	25.0 @36	5.3	25.3 @36	5.3	25.
AVG. =	5.7	0.0	5.7	25.6	5.6	25.6	5.7	25.6	5.7	25.6	5.6	25.7	5.6	25.

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.6
TEMPERATURE (CELCIUS) = 25.6

PERCENT SATURATION = 66.0

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-1-87
Time: 14:45
Winkler Oxygen Calibration
ppm Oxygen= 5.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....:

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.1	26.0	6.2	26.0	6.2	26.0	6.1	26.0	6.2	26.0	6.0	26.0	5.9	26.0
2	6.0	26.0	6.2	26.0	6.1	26.0	6.0	26.0	6.0	26.0	5.9	25.3	5.8	26.0
5	5.9	26.0	5.9	26.0	6.0	26.0	5.9	25.8	5.7	25.8	5.6	25.3	5.7	25.8
10	5.9	25.8	5.8	25.8	5.9	26.0	5.4	25.5	5.5	25.5	5.4	25.5	5.6	25.5
15	5.8	25.8	5.7	25.8	5.6	25.5	5.3	25.5	5.4	25.5	5.4	25.5	5.4	25.5
20	5.6	25.8	5.5	25.5	5.5	25.5	5.3	25.3	5.3	25.3	5.4	25.5	5.4	25.3
Bottom @depth	5.6	25.8	5.2	25.3	5.2	25.5	5.2	25.3	5.1	25.3	5.2	25.5	5.3	25.3
	@22		@36		#36		@36		@38		@38		@	
AVG. =	5.8	25.9	5.8	25.8	5.8	25.8	5.6	25.6	5.6	25.6	5.6	25.5	5.6	25.6

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELCIUS) = 25.7

PERCENT SATURATION = 66.4

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-1-87
Time: 15:35
Winkler Oxygen Calibration
ppm Oxygen= 6.0

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.2	26.0	6.3	26.0	6.3	26.0	6.3	26.0	6.2	26.0	6.3	26.0	6.1	26.0
2	6.0	26.0	6.2	26.0	6.2	26.0	6.2	26.0	6.1	26.0	6.1	26.0	6.0	26.0
	6.0	26.0	6.1	26.0	6.0	26.0	5.9	26.0	5.9	26.0	5.7	26.0	5.7	25.8
10	5.9	26.0	5.9	25.8	5.8	25.8	5.7	25.8	5.5	25.8	5.5	25.5	5.5	25.5
15	5.9	25.8	5.6	25.8	5.6	25.8	5.5	25.5	5.4	25.5	5.4	25.5	5.5	25.5
20	5.6	25.5	5.5	25.5	5.4	25.5	5.4	25.5	5.3	25.5	5.3	25.3	5.4	25.3
Bottom @depth	5.3	25.5 @30	5.3	25.3 @36	5.1	25.3 @36	5.1	25.3 @36	5.2	25.5 @36	5.1	25.3 @38	5.3	25.3 @.
AVG. =	5.8	25.8	5.8	25.8	5.8	25.8	5.7	25.7	5.7	25.8	5.6	25.6	5.6	25.6

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELCIUS) = 25.7

PERCENT SATURATION = 67.0

RACINE DISSOLVED OXYGEN STUDY

PSTREAM TRANSECT
Date: 9-1-87
Time: 16.28
Winkler Oxygen Calibration
ppm Oxygen= 6.2

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.3	26.0	6.3	26.0	6.3	26.0	6.3	26.0	6.4	26.0	6.2	26.0	6.2	26.0
2	6.2	26.0	6.2	26.0	6.3	26.0	6.3	26.0	6.3	26.0	6.1	26.0	6.1	26.0
5	6.2	26.0	5.9	26.0	5.9	26.0	6.1	26.0	5.8	26.0	5.6	25.8	5.6	25.5
10	6.1	26.0	5.9	26.0	5.6	25.8	5.9	26.0	5.6	25.5	5.4	25.5	5.6	25.5
15	6.0	26.0	5.7	25.8	5.5	25.5	5.9	26.0	5.5	25.5	5.4	25.5	5.4	25.5
20	5.4	25.5	5.5	25.5	5.5	25.5	5.6	25.5	5.4	25.3	5.4	25.5	5.4	25.5
Bottom @depth	5.2	25.3	5.3	25.3	5.3	25.3	5.2	25.3	5.3	25.3	5.3	25.3	5.3	25.3
	@26		@32		@36		@38		@36		@36		@	
AVG. =	5.9	25.8	5.8	25.8	5.8	25.7	5.9	25.8	5.8	25.6	5.6	25.6	5.7	25.6

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.8
TEMPERATURE (CELCIUS) = 25.7

PERCENT SATURATION = 67.6

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-2-87
Time: 09:05
Winkler Oxygen Calibration
ppm Oxygen= 5.5

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....:

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.6	25.5	5.5	25.3	5.5	25.3	5.5	25.3	5.5	25.3	5.5	25.3	5.5	25.3
2	5.5	25.3	5.5	25.3	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.5	25.3
5	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3
10	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.3	25.3	5.4	25.3
15	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.3	25.3	5.4	25.3
20	5.4	25.3	5.4	25.3	5.3	25.3	5.4	25.3	5.4	25.3	5.3	25.3	5.4	25.3
Bottom @depth	5.4	25.3 @30	5.2	25.3 @34	5.3	25.3 @34	5.2	25.3 @36	5.3	25.3 @36	5.3	25.3 @36	5.3	25.3 @
AVG. =	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.4
TEMPERATURE (CELCIUS) = 25.3

PERCENT SATURATION = 62.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-2-87
Time: 09:46
Winkler Oxygen Calibration
ppm Oxygen= 5.5

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.6	25.5	5.6	25.5	5.6	25.5	5.6	25.5	5.7	25.5	5.7	25.5	5.7	25.5
2	5.5	25.5	5.6	25.5	5.6	25.5	5.5	25.5	5.6	25.5	5.6	25.5	5.6	25.5
5	5.5	25.3	5.5	25.3	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.5	25.3
10	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3
15	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3
20	5.4	25.3	5.4	25.3	5.4	25.3	5.3	25.3	5.3	25.3	5.4	25.3	5.4	25.3
Bottom @depth	5.4	25.3 @30	5.3	25.3 @34	5.3	25.3 @34	5.3	25.3 @34	5.3	25.3 @36	5.3	25.3 @36	5.3	25.3
AVG. =	5.5	25.3	5.5	25.3	5.5	25.3	5.4	25.3	5.4	25.3	5.5	25.3	5.5	25.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.5
TEMPERATURE (CELCIUS) = 25.3

PERCENT SATURATION = 63.3

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-2-87
Time: 10:37

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
1	5.7	25.5	5.7	25.5	5.7	25.5	5.7	25.5	5.7	25.5	5.7	25.5	5.7 25.
2	5.6	25.5	5.7	25.4	5.6	25.5	5.6	25.5	5.6	25.5	5.6	25.5	5.7 25.
5	5.4	25.3	5.5	25.3	5.5	25.3	5.4	25.3	5.4	28.3	5.4	25.3	5.5 25.
10	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.3 25.
15	5.4	25.3	5.3	25.3	5.3	25.3	5.4	25.3	5.3	25.3	5.4	25.3	5.3 25.
20	5.4	25.3	5.3	25.3	5.3	25.3	5.3	25.3	5.3	25.3	5.4	25.3	5.3 25.
Bottom @depth	5.3	25.3 @30	5.3	25.3 @32	5.3	25.3 @34	5.3	25.3 @34	5.2	25.5 @36	5.3	25.3 @36	5.3 25.
AVG. =	5.5	25.3	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.8	5.5	25.3	5.4 25.

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.4
TEMPERATURE (CELCIUS) = 25.4

PERCENT SATURATION = 63.3

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-2-87
Time: 11:23

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
1	5.7	25.5	5.7	25.5	5.7	25.3	5.6	25.3	5.7	25.5	5.7	25.5	5.7 25.
2	5.7	25.3	5.7	25.5	5.6	25.3	5.6	25.3	5.6	25.5	5.6	25.5	5.7 25.
5	5.5	25.3	5.7	25.3	5.6	25.3	5.6	25.3	5.5	25.3	5.5	25.5	5.5 25.
10	5.5	25.3	5.5	25.3	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.5 25.
15	5.4	25.3	5.4	25.3	5.4	25.3	5.3	25.3	5.3	25.3	5.3	25.3	5.4 25.
20	5.4	25.3	5.3	25.3	5.3	25.3	5.3	25.3	5.3	25.3	5.3	25.3	5.4 25.
Bottom @depth	5.2	25.3 @22	5.2	25.3 @34	5.2	25.3 @34	5.3	25.3 @34	5.2	25.3 @34	5.3	25.3 @36	5.3 25.
AVG. =	5.5	25.3	5.5	25.3	5.5	25.3	5.4	25.3	5.4	25.3	5.4	25.4	5.5 25.

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.5
TEMPERATURE (CELCIUS) = 25.3

PERCENT SATURATION = 63.5

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-2-87
Time: 14:10

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINI 7
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
1	6.0	25.8	6.0	25.8	6.1	25.8	6.2	25.8	6.2	25.8	5.9	25.5	5.8 25
2	6.0	25.8	6.0	25.8	6.0	25.8	6.1	25.8	6.1	25.8	6.1	25.5	5.8 25
5	6.0	25.8	5.8	25.5	5.9	25.8	6.1	25.8	5.9	25.5	5.9	25.5	6.0 25
10	5.7	25.5	5.7	25.3	5.7	25.3	5.9	25.5	5.5	25.3	5.8	25.3	5.4 25
15	5.6	25.5	5.5	25.3	5.6	25.3	5.6	25.3	5.5	25.3	5.4	25.3	5.5 25
20	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.4	25.3	5.6	25.3	5.5 25
Bottom @depth	5.1	25.3 @30	5.3	25.3 @34	5.3	25.3 @34	5.3	25.3 @34	5.2	25.3 @34	5.2	25.3 @36	5.3 25
AVG. =	5.7	25.5	5.7	25.4	5.7	25.5	5.8	25.5	5.7	25.4	5.7	25.4	5.6 25

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELCIUS) = 25.4

PERCENT SATURATION = 66.3

RACINE DISSOLVED OXYGEN STUDY

PSTREAM TRANSECT
Date: 9-2-87
Time: 16:45
Winkler Oxygen Calibration
ppm Oxygen= 5.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.3	25.8												
2	5.9	25.5												
5	5.9	25.3												
10	5.9	25.3												
15														
20														
Bottom @depth														
AVG. =	6.0	25.4												

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELCIUS) = 25.4

PERCENT SATURATION = 69.8

RACINE DISSOLVED OXYGEN STUDY

L STREAM TRANSECT
Date: 9-3-87
Time: 08:40
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1 DO	T	2 DO	T	3 DO	T	4 DO	T	5 DO	T	6 DO	T	W. VIRGINIA 7 DO	T
1	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.9	25.0
2	5.7	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0
	5.6	25.0	5.6	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.8	25.0
10	5.6	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0
1	5.6	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0
20	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0
Bottom @depth	5.6	25.0 @22	5.7	25.0 @34	5.8	25.0 @34	5.7	25.0 @36	5.8	25.0 @34	5.8	25.0 @34	5.8	25.0 @3
A.G. =	5.6	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELCIUS) = 25.0

PERCENT SATURATION = 66.3

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-3-87
Time: 09:30

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
1	5.9	25.0	5.9	25.0	5.9	25.0	5.9	25.0	5.9	25.0	5.9	25.0	5.9 25.
2	5.9	25.0	5.9	25.0	5.8	25.0	5.8	25.0	5.9	25.0	5.9	25.0	5.9 25.
5	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8 25.
10	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8 25.
15	5.7	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.7	25.0	5.7 25.
20	5.8	25.0	5.7	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.7	25.0	5.7 25.
Bottom @depth	5.7	25.0 @24	5.7	25.0 @32	5.7	25.0 @34	5.7	25.0 @36	5.8	25.0 @34	5.7	25.0 @34	5.8 25.
AVG. =	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8	25.0	5.8 25.

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.8
TEMPERATURE (CELCIUS) = 25.0

PERCENT SATURATION = 67.0

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-3-87
Time: 10:25
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.9	25.0	5.8	25.0	5.8	25.0	5.9	25.0	5.9	25.0	5.9	25.0	5.9	25.0
2	5.8	25.0	5.8	25.0	5.7	25.0	5.9	25.0	5.8	25.0	5.9	25.0	5.9	25.0
5	5.7	25.0	5.7	25.0	5.6	25.0	5.8	25.0	5.7	25.0	5.7	25.0	5.7	25.0
10	5.7	25.0	5.6	25.0	5.6	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0
15	5.7	25.0	5.6	25.0	5.6	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0
20	5.7	25.0	5.6	25.0	5.6	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0
Bottom @depth	5.7	25.0 @30	5.5	25.0 @32	5.6	25.0 @34	5.5	25.0 @34	5.5	25.0 @34	5.5	25.0 @36	5.5	25.0
AVG. =	5.7	25.0	5.7	25.0	5.6	25.0	5.7	25.0	5.6	25.0	5.6	25.0	5.6	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.6
TEMPERATURE (CELCIUS) = 25.0

PERCENT SATURATION = 64.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-3-87
Time: 11:15

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3	6.0	25.3	5.9	25.3
2	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3
5	5.5	25.0	5.7	25.0	5.7	25.0	5.9	25.0	5.7	25.0	5.7	25.0	5.9	25.0
10	5.6	25.0	5.5	25.0	5.6	25.0	5.8	25.0	5.5	25.0	5.5	25.0	5.6	25.0
15	5.6	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0
20	5.7	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0
Bottom @depth	5.6	25.0 @22	5.5	25.0 @34	5.5	25.0 @34	5.5	25.0 @34	5.4	25.0 @36	5.4	25.0 @36	5.4	25.0
AVG. =	5.7	25.1	5.6	25.1	5.7	25.1	5.7	25.1	5.6	25.1	5.6	25.1	5.7	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELCIUS) = 25.1

PERCENT SATURATION = 65.5

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-3-87
Time: 14:00
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.5	25.8	6.3	25.8	6.2	25.5	6.0	25.3	6.0	25.3	6.1	25.3	6.1	25.3
2	6.4	25.8	6.3	25.8	6.1	25.5	5.9	25.3	6.0	25.3	5.9	25.3	6.0	25.3
5	5.9	25.5	6.1	25.5	5.9	25.5	5.9	25.3	5.9	25.3	5.9	25.3	5.9	25.3
10	5.9	25.3	5.8	25.3	5.9	25.3	5.7	25.0	5.9	25.0	5.9	25.3	5.8	25.0
15	5.7	25.3	5.7	25.0	5.8	25.3	5.6	25.0	5.7	25.0	5.8	25.3	5.8	25.0
20	5.7	25.0	5.6	25.0	5.7	25.0	5.6	25.0	5.6	25.0	5.7	25.0	5.7	25.0
Bottom @depth	5.4	25.0	5.5	25.0	5.5	25.0	5.6	25.0	5.4	25.0	5.5	25.0	5.6	25.0
	@22		@34		@34		@34		@34		@40			
AVG. =	5.9	25.4	5.9	25.3	5.9	25.3	5.8	25.1	5.8	25.1	5.8	25.2	5.8	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.8
TEMPERATURE (CELCIUS) = 25.2

PERCENT SATURATION = 67.8

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-3-87
Time: 14:45
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.4	25.8	6.3	25.5	6.3	25.5	6.4	25.5	6.5	25.5	6.5	25.5	6.3	25.5
2	6.2	25.5	6.2	25.5	6.2	25.5	6.3	25.5	6.5	25.5	6.5	25.5	6.3	25.5
5	6.2	25.5	6.1	25.5	6.2	25.5	6.3	25.5	6.4	25.5	6.2	25.5	6.2	25.5
10	5.9	25.3	6.0	25.3	6.1	25.3	6.2	25.3	6.1	25.3	6.0	25.3	5.9	25.3
15	5.9	25.3	5.8	25.3	5.9	25.3	5.9	25.3	5.8	25.0	5.8	25.3	5.7	25.0
20	5.9	25.3	5.7	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.7	25.0
Bottom @depth	5.7	25.0	5.5	25.0	5.5	25.0	5.4	25.0	5.4	25.0	5.5	25.0	5.5	25.0
	@24		@34		@34		@36		@36		@36			
AVG. =	6.0	25.4	5.9	25.3	6.0	25.3	6.0	25.3	6.1	25.3	6.0	25.3	5.9	25.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELCIUS) = 25.3

PERCENT SATURATION = 69.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-3-87
Time: 15:34
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.7	25.8	6.6	25.8	6.9	25.8	6.8	25.8	6.9	25.8	7.0	25.8	6.9	25.8
2	6.6	25.8	6.5	25.8	6.8	25.8	6.8	25.8	6.9	25.8	6.9	25.8	6.9	25.8
5	6.5	25.8	6.5	25.8	6.8	25.8	6.4	25.5	6.4	25.5	6.5	25.5	6.7	25.5
10	6.1	25.5	5.9	25.5	5.9	25.3	6.1	25.3	6.3	25.3	5.9	25.3	5.9	25.3
15	5.7	25.3	5.8	25.3	5.8	25.3	5.9	25.3	5.7	25.3	5.8	25.0	5.9	25.3
20	5.7	25.0	5.7	25.0	5.8	25.0	5.7	25.0	5.7	25.0	5.7	25.0	5.9	25.0
Bottom @depth	5.7	25.0	5.6	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.6	25.0
		@24		@34		@34		@36		@36		@36		
AVG. =	6.1	25.4	6.1	25.4	6.2	25.4	6.2	25.4	6.2	25.4	6.2	25.3	6.3	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.2
TEMPERATURE (CELCIUS) = 25.4

PERCENT SATURATION = 71.9

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-4-87
Time: 08:25
Winkler Oxygen Calibration
ppm Oxygen= 6.0

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.1	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.0	24.8	6.0	24.8
2	6.0	24.8	6.0	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.0	24.8	6.0	24.8
5	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
10	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
15	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
20	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
Bottom @depth	6.0	24.8	6.0	24.8	6.0	24.8	5.9	24.8	5.9	24.8	5.9	24.8	5.9	24.8
	X		@22	@34			@34		@34		@34		@36	
AVG. =	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELCIUS) = 24.8

PERCENT SATURATION = 69.1

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-4-87
Time: 09:05
Winkler Oxygen Calibration
ppm Oxygen= 6.1

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.1	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.2	24.8	6.2	25.0
2	6.0	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.1	24.8	6.2	24.8	6.1	25.0
5	6.0	24.8	6.1	24.8	6.1	24.8	6.0	24.8	6.1	24.8	6.1	24.8	6.0	24.8
10	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
15	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
20	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
Bottom @depth	6.0	24.8 @24	5.9	24.8 @34	5.9	24.8 @34	5.9	24.8 @34	5.9	24.8 @34	5.9	24.8 @36	5.9	24.8
AVG. =	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.1	24.8	6.0	24.8

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELCIUS) = 24.8

PERCENT SATURATION = 69.4

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-4-87
Time: 09:55

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.2	25.0	6.3	25.0	6.2	25.0	6.3	25.0	6.4	25.0	6.2	25.0	6.1	25.0
2	6.2	25.0	6.2	25.0	6.2	25.0	6.2	25.0	6.3	25.0	6.1	25.0	6.1	25.0
5	6.2	25.0	6.0	25.0	6.1	25.0	6.1	25.0	6.0	25.0	6.1	24.8	6.0	25.0
0	6.1	25.0	6.0	25.0	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
15	6.1	25.0	6.0	25.0	6.0	24.8	6.0	24.8	6.0	25.0	6.0	24.8	6.0	24.8
20	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8
Bottom @depth	6.0	24.8	5.9	24.8	5.9	24.8	5.9	24.8	5.9	24.8	6.0	24.8	6.0	24.8
	@24		@34		@34		@34		@36		@36		@	
AVG. =	6.1	24.9	6.1	24.9	6.1	24.9	6.1	24.9	6.1	24.9	6.1	24.8	6.0	24.9

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.1
TEMPERATURE (CELCIUS) = 24.9

PERCENT SATURATION = 69.9

RACINE DISSOLVED OXYGEN STUDY

JPSTREAM TRANSECT
Date: 9-4-87
Time: 10:30

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.3	25.0	6.3	25.0	6.3	25.0	6.4	25.0	6.5	25.0	6.4	25.0	6.4	25.0
2	6.2	25.0	6.2	25.0	6.3	25.0	6.4	25.0	6.5	25.0	6.3	25.0	6.3	25.0
5	6.2	25.0	6.1	25.0	6.2	25.0	6.2	25.0	6.1	25.0	6.1	25.0	6.2	25.0
	6.1	24.8	6.1	24.8	6.1	25.0	6.0	24.8	6.0	24.8	6.0	25.0	6.1	25.0
15	6.1	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	25.0	6.1	25.0
20	6.1	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.0	24.8	6.1	25.0
Bottom @depth	6.0	24.8 @26	6.0	24.8 @32	6.0	24.5 @34	6.0	24.8 @34	6.0	24.8 @36	6.0	24.8 @36	6.0	24.8 @4
AVG. =	6.1	24.9	6.1	24.9	6.1	24.9	6.1	24.9	6.2	24.9	6.1	24.9	6.2	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.1
TEMPERATURE (CELCIUS) = 24.9

PERCENT SATURATION = 70.8

RACINE DISSOLVED OXYGEN STUDY

PSTREAM TRANSECT
Date: 9-4-87
Time: 11:15
Winkler Oxygen Calibration
ppm Oxygen= 6.5

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.6	25.5	6.6	25.5	6.7	25.5	6.6	25.5	6.6	25.5	6.6	25.3	6.5	25.5
2	6.5	25.3	6.6	25.3	6.6	25.3	6.5	25.3	6.6	25.3	6.5	25.3	6.4	25.5
5	6.3	25.0	6.4	25.0	6.3	25.0	6.3	25.0	6.1	25.0	6.1	25.0	6.2	25.0
10	6.0	25.0	6.0	25.0	6.0	25.0	6.0	25.0	6.0	25.0	6.0	25.0	6.0	25.0
15	5.9	25.0	6.0	25.0	5.9	25.0	5.9	24.8	5.9	25.0	5.9	25.0	6.0	25.0
20	5.9	25.0	5.9	25.0	5.9	25.0	5.9	24.8	5.9	25.0	5.9	24.8	5.9	24.8
Bottom @depth	5.9	24.8 @32	5.9	24.8 @32	5.9	24.8 @34	5.9	24.8 @34	5.9	24.8 @34	5.9	24.8 @36	5.9	24.8 @
AVG. =	6.2	25.1	6.2	25.1	6.2	25.1	6.2	25.0	6.1	25.1	6.1	25.0	6.1	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.2
TEMPERATURE (CELCIUS) = 25.1

PERCENT SATURATION = 71.2

RACINE DISSOLVED OXYGEN STUDY

STREAM TRANSECT
Date: 9-4-87
Time: 13:40
Winkler Oxygen Calibration
ppm Oxygen= 6.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
	7.1	26.8	7.6	26.3	7.9	26.5	8.1	26.5	7.7	26.5	7.5	26.3	7.7	26.3
2	7.1	26.0	6.9	26.3	7.7	25.8	7.8	26.0	7.6	26.0	7.4	26.3	7.7	26.3
	7.0	25.5	6.9	25.3	6.3	25.3	6.9	25.5	6.5	25.3	6.4	25.5	7.2	25.3
10	6.4	25.0	6.4	25.0	6.2	25.0	6.0	25.0	6.0	25.0	6.2	25.0	5.9	25.0
	6.1	25.0	6.1	25.0	6.0	25.0	5.8	24.8	5.8	24.8	5.7	24.8	5.7	24.8
	6.0	25.0	5.8	25.0	5.9	25.0	5.6	24.8	5.7	24.8	5.7	24.8	5.7	24.8
Bottom	5.9	25.0	5.8	24.8	5.7	25.0	5.6	24.8	5.6	24.8	5.6	24.8	5.6	24.8
@depth		@28		@32		@34		@34		@36		@36		@38
AVG. =	6.5	25.5	6.5	25.4	6.5	25.4	6.5	25.3	6.4	25.3	6.4	25.3	6.5	25.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.5
TEMPERATURE (CELCIUS) = 25.3

PERCENT SATURATION = 75.3

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-4-87
Time: 14:55

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.4	26.8	7.9	27.0	7.8	26.8	8.4	26.5	8.2	26.5	8.0	26.5	8.2	26.5
2	7.4	26.8	7.9	26.0	8.6	26.3	8.3	26.5	8.0	26.5	8.0	26.5	8.1	26.5
5	7.3	25.0	7.2	25.5	7.5	25.8	7.9	25.8	7.7	25.5	7.5	26.0	7.5	26.0
10	5.9	25.0	6.7	25.3	6.4	25.3	6.6	25.3	6.4	25.0	6.1	25.3	6.0	25.0
15	5.7	24.8	6.5	25.0	6.0	25.0	6.0	25.0	6.2	25.0	5.8	25.0	5.8	25.0
20	5.7	24.8	5.7	25.0	5.8	25.0	5.8	25.0	6.8	25.0	5.7	25.0	5.6	25.0
Bottom @depth	5.6	24.8	5.6	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.5	25.0	5.6	25.0
		@24		@32		@32		@34		@34		@36		
AVG. =	6.4	25.4	6.8	25.5	6.8	25.6	6.9	25.6	7.0	25.5	6.7	25.6	6.7	25.6

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.8
TEMPERATURE (CELSIUS) = 25.5

PERCENT SATURATION = 78.7

RACINE DISSOLVED OXYGEN STUDY
DOWNSTREAM NEAR RESTRICTED ZONE
Dates: 9-2-87 to 9-4-87

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-2-87
Time: 10:53

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	5.7	25.0	5.7	25.2	5.7	25.2	5.8	25.1
2	5.7	25.1	5.7	25.2	5.7	25.1	5.8	25.1
5	5.7	25.2	5.7	25.2	5.7	25.2	5.8	25.1
10	5.7	25.2	5.7	25.2	5.8	25.2	5.8	25.1
15	5.7	25.2	5.7	25.2	5.8	25.1	5.8	25.2
20	5.7	25.2	5.7	25.1	5.7	25.1	5.8	25.2
and = @ depth	5.7	25.2 30	5.7	25.1 25	5.7	25.1 30	5.7	25.2 30
AVG. =	5.7	25.2	5.7	25.2	5.7	25.1	5.8	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 66.40

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-2-87
Time: 14:42
Winkler Oxygen Calibration
ppm Oxygen= 6.1

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	5.7	25.7	5.7	25.0	5.7	25.5	5.7	25.4
2	5.6	25.7	5.7	25.0	5.7	25.6	5.7	25.4
5	5.6	25.7	5.7	25.0	5.7	25.6	5.7	25.4
10	5.6	25.7	5.7	25.0	5.7	25.6	5.7	25.4
15	5.6	25.7	5.7	25.6	5.7	25.6	5.7	25.4
20	5.6	25.6	5.7	25.6	5.7	25.6	5.7	25.3
and = @ depth	5.6	25.6 30	5.7	25.6 25	5.7	25.2 24	5.7	25.2 30
AVG. =	5.6	25.7	5.7	25.3	5.7	25.5	5.7	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.5

PERCENT SATURATION = 66.16

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-3-87
Time: 9:37

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2
2	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2
5	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2
10	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2
15	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2
20	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2
and = @ depth	6.0	25.1 27	6.0	25.1 25	6.0	25.1 25	6.0	25.2 25
AVG. =	6.0	25.1	6.0	25.1	6.0	25.1	6.0	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 69.51

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-3-87
Time: 11:20

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	5.9	25.1	NA	NA	NA	NA	NA	NA
2	5.9	25.1						
5	5.9	25.1						
10	5.9	25.1						
15	6.0	25.1						
20	6.0	25.1						
and = @ depth	6.0	25.1	30	NA	NA	NA	NA	
AVG. =	5.9	25.1	0.0	0.0	0.0	0.0	0.0	0.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 68.32

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-3-87
Time: 14:16

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	5.8	25.5	5.9	25.5	5.8	25.5	5.9	25.5
2	5.8	25.5	5.9	25.5	5.8	25.5	5.9	25.5
5	5.8	25.4	5.8	25.5	5.9	25.5	5.9	25.4
10	5.8	25.3	5.8	25.4	5.9	25.4	5.9	25.4
15	5.8	25.3	5.8	25.3	5.9	25.4	5.9	25.3
20	5.8	25.2	5.9	25.4	5.9	25.4	5.9	25.3
and = @ depth	5.8	25.2 30	5.9	25.3 25	5.8	25.3 30	5.9	25.1 30
AVG. =	5.8	25.3	5.9	25.4	5.9	25.4	5.9	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.4

PERCENT SATURATION = 68.12

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-3-87
Time: 15:51

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.0	25.5	6.0	25.0	6.0	25.0	5.8	25.5
2	6.0	25.5	6.0	25.2	6.0	25.1	5.9	25.4
5	6.0	25.3	6.0	25.2	6.0	25.2	6.0	25.4
10	6.0	25.3	6.0	25.2	6.0	25.2	6.0	25.4
15	6.0	25.1	6.0	25.2	6.0	25.1	6.0	25.4
20	6.0	25.0	6.0	25.2	6.0	25.1	6.0	25.0
and = @ depth	6.0	25.0 25	6.0	25.2 25	6.0	25.2 25	6.0	25.0 25
AVG. =	6.0	25.2	6.0	25.2	6.0	25.1	6.0	25.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 69.49

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-4-87
Time: 9:20

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.0	25.2	6.0	25.0	6.1	25.2	6.0	25.1
2	6.0	25.2	6.0	25.1	6.1	25.2	6.1	25.1
5	6.0	25.2	6.1	25.1	6.0	25.2	6.1	25.1
10	6.0	25.1	6.1	25.1	6.0	25.2	6.1	25.1
15	6.0	25.1	6.1	25.1	6.0	25.2	6.1	25.1
20	6.0	25.1	6.1	25.1	6.0	25.0	6.1	25.1
and = @ depth	6.0	25.0 30	6.0	25.1 25	6.0	25.0 30	6.1	25.1 30
AVG. =	6.0	25.1	6.1	25.1	6.0	25.1	6.1	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 69.99

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-4-87
Time: 10:12

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9
2	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9
5	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9
10	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9
15	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9
20	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9
and = @ depth	6.2	24.9 25	6.2	24.9 25	6.2	24.9 25	6.3	24.9 25
AVG. =	6.2	24.9	6.2	24.9	6.3	24.9	6.3	24.9

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.2
TEMPERATURE (CELSIUS) = 24.9

PERCENT SATURATION = 72.08

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-4-87
Time: 13:52

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.5	25.2	6.5	25.2	6.5	25.2	6.6	25.2
2	6.5	25.2	6.5	25.2	6.5	25.2	6.6	25.2
5	6.5	25.2	6.5	25.2	6.6	25.2	6.6	25.2
10	6.5	25.2	6.5	25.2	6.5	25.2	6.6	25.2
15	6.5	25.2	6.5	25.2	6.6	25.2	6.6	25.2
20	6.5	25.2	6.5	25.2	6.6	25.2	6.6	25.2
and = @ depth	6.5	25.2 25	6.4	25.2 25	6.3	25.2 25	6.6	25.1 25
AVG. =	6.5	25.2	6.5	25.2	6.5	25.2	6.6	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.5
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 75.69

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-4-87
Time: 15:39

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.7	25.2	6.7	25.1	6.7	25.2	6.7	25.2
2	6.8	25.2	6.7	25.2	6.7	25.2	6.7	25.2
5	6.8	25.2	6.8	25.2	6.7	25.2	6.7	25.2
10	6.8	25.2	6.7	25.1	6.7	25.2	6.7	25.2
15	6.8	25.2	6.7	25.2	6.7	25.2	6.7	25.2
20	6.8	25.2	6.7	25.2	6.7	25.2	6.7	25.1
and = @ depth	6.8	25.2 25	6.7	25.2 27	6.7	25.2 25	6.7	25.1 25
AVG. =	6.8	25.2	6.7	25.2	6.7	25.2	6.7	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.7
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 77.99

RACINE DISSOLVED OXYGEN STUDY
DOWNSTREAM TRANSECT "B"
Dates: 9-1-87 to 9-4-87

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-1-87
Time: 11:23
Winkler Oxygen Calibration
ppm Oxygen= 5.7

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.9	25.7	5.9	25.7	5.9	25.7	5.9	25.7	5.9	25.7	5.8	25.9
2	5.9	25.7	5.9	25.7	5.9	25.7	5.9	25.7	5.9	25.7	5.8	25.9
5	5.8	25.7	5.9	25.7	5.8	25.7	5.9	25.7	5.9	25.7	5.7	25.7
10	5.8	25.7	5.8	25.7	5.8	25.7	5.8	25.7	5.8	25.6	5.6	25.7
15	5.8	25.7	5.8	25.7	5.8	25.7	5.9	25.7	5.9	25.6	5.6	25.6
20	5.8	25.7	5.8	25.7							5.7	25.6
and = @ depth	5.8	25.7 23	NA		NA		NA		NA		NA	
AVG. =	5.8	25.7	5.8	25.7	5.8	25.7	5.9	25.7	5.9	25.7	5.7	25.7

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.8
TEMPERATURE (CELSIUS) = 25.7

PERCENT SATURATION = 68.0

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-1-87
Time: 13:52
Winkler Oxygen Calibration
ppm Oxygen= 6.0

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.0	25.7	6.1	25.7	6.0	25.7	6.0	25.7	6.1	26.2	6.0	26.2
2	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.6	6.0	26.0	6.1	26.2
5	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.7	6.0	26.2	6.0	25.8
10	6.0	25.7	6.0	25.7	6.0	25.7	5.9	25.5	5.8	25.5	5.9	25.8
15	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.5	6.0	25.6	5.8	25.4
20	6.0	25.7									5.9	25.4
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.6	6.0	25.9	5.9	25.8

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.7

PERCENT SATURATION = 70.1

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-1-87
Time: 14:27

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.1	25.8	6.1	25.7	6.1	25.8	6.0	25.7	6.0	25.7	6.0	25.5
2	6.1	25.7	6.1	25.7	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.5
5	6.1	25.7	6.1	25.7	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.8
10	6.1	25.7	6.1	25.7	6.0	25.7	6.0	25.7	6.0	25.7	5.9	25.7
15	6.1	25.7	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.7	5.9	25.7
20	6.1	25.7			6.0	25.6						
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	6.1	25.7	6.1	25.7	6.0	25.7	6.0	25.7	6.0	25.7	6.0	25.6

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.7

PERCENT SATURATION = 70.4

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-2-87
Time: 09:53-11:55 (barge traffic)
Winkler Oxygen Calibration
ppm Oxygen= 5.7

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2
2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2
5	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2
10	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.6	25.1
15	5.7	25.1	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.1
20	5.7	25.1	5.7	25.2							5.7	25.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	5.7	25.2	N/A	N/A	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 66.0

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-2-87
Time: 10:06

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2
2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2
5	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.8	25.2
10	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.8	25.2
15	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2
20	5.7	25.2	5.7	25.2							5.6	25.2
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2	5.7	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 66.1

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-2-87
Time: 15:56

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.7	25.4	5.7	25.4	5.7	25.4	5.8	25.4	5.7	25.4	5.7	25.4
2	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
5	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
10	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
15	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
20	5.7	25.4	5.7	25.4								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.4

PERCENT SATURATION = 66.3

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-2-87
Time: 15:06

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
2	5.6	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.6	25.4
5	5.6	25.4	5.6	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.6	25.4
10	5.7	25.4	5.7	25.4	5.6	25.4	5.7	25.4	5.7	25.4	5.6	25.4
15	5.6	25.4	5.6	25.4	5.6	25.4	5.7	25.3	5.7	25.4	5.6	25.4
20	5.6	25.4	5.6	25.4	5.6	25.4					5.6	25.4
and = @ depth	NA		NA		NA		NA		5.7	25.4 17	NA	
AVG. =	5.6	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.6	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.4

PERCENT SATURATION = 65.8

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-2-87
Time: 16:18
Winkler Oxygen Calibration
ppm Oxygen= 5.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.8	25.4
2	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.8	25.4
5	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.8	25.4
10	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
15	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4
20											5.7	25.4
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.7	25.4	5.8	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.7
TEMPERATURE (CELSIUS) = 25.4

PERCENT SATURATION = 66.4

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-3-87
Time: 09:06
Winkler Oxygen Calibration
ppm Oxygen= 5.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.9	25.2	6.0	25.2	5.9	25.1	5.9	25.2	6.0	25.2	5.9	25.0
2	5.9	25.2	6.0	25.2	5.9	25.1	5.9	25.2	5.9	25.2	5.9	25.0
5	5.9	25.2	5.9	25.2	5.9	25.1	5.9	25.2	5.9	25.2	5.9	25.0
10	5.9	25.2	5.9	25.2	6.0	25.1	5.9	25.2	5.9	25.2	5.9	25.0
15	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.2	5.9	25.2	5.9	25.0
20	5.9	25.1	5.9	25.1								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	5.9	25.2	5.9	25.2	5.9	25.1	5.9	25.2	5.9	25.2	5.9	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 68.5

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-3-87
Time: 10:05
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....:

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6		
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	
1	5.9	25.2	5.9	25.1	5.9	25.1	6.0	25.1	5.9	25.1	5.9	25.1	
2	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	
5	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	
10	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	
15	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	
20	5.8	25.1	5.8	25.1									
and = @ depth	NA		NA		NA		NA		NA		5.9	25.1	18
AVG. =	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	5.9	25.1	

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 68.3

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-3-87
Time: 10:52

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.9	25.2	5.9	25.2	5.9	25.2	5.9	25.2	6.0	25.1	6.0	25.1
2	5.9	25.2	5.9	25.2	5.9	25.2	5.9	25.2	6.0	25.1	6.0	25.1
5	5.9	25.2	5.9	25.2	5.9	25.2	5.9	25.2	6.0	25.1	6.0	25.1
10	5.9	25.1	5.9	25.2	5.9	25.1	5.9	25.1	6.0	25.1	6.0	25.1
15	5.9	25.1	5.8	25.1	5.8	25.1	5.9	25.1	5.9	25.0	6.0	25.1
20	5.9	25.1	5.8	25.1								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	5.9	25.2	5.9	25.2	5.9	25.2	5.9	25.2	6.0	25.1	6.0	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 68.6

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-3-87
Time: 14:41
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....:

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	5.9	25.5	5.9	25.2	5.7	25.1	5.9	25.3	5.8	25.0	5.9	25.0
2	5.9	25.4	5.9	25.2	5.8	25.1	5.9	25.3	5.9	25.0	5.8	25.0
5	5.8	25.4	5.9	25.2	5.9	25.2	5.9	25.3	5.9	25.0	5.8	25.0
10	5.9	25.4	5.9	25.2	5.9	25.2	5.9	25.3	5.9	25.0	5.8	25.0
15	5.9	25.3	5.9	25.2	5.9	25.2	5.9	25.3	5.9	25.0	5.9	25.0
20	5.9	25.3	5.8	25.2							5.8	25.0
and = @ depth	NA		NA		5.9	25.2	5.8	25.3	5.9	25.0	NA	
					17		17		17			
AVG. =	5.9	25.4	5.9	25.2	5.9	25.2	5.9	25.3	5.9	25.0	5.8	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 68.0

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-3-87
Time: 15:04

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1 DO	1 T	2 DO	2 T	3 DO	3 T	4 DO	4 T	5 DO	5 T	W. VIRGINIA 6 DO	6 T
1	5.9	25.3	6.0	25.5	6.0	25.4	5.9	25.3	5.9	25.5	5.9	25.5
2	5.9	25.3	6.0	25.5	5.9	25.4	5.9	25.3	5.9	25.4	5.9	25.5
5	5.9	25.3	6.0	25.4	6.0	25.4	6.0	25.2	5.9	25.4	6.0	25.4
10	5.9	25.3	6.0	25.4	5.9	25.3	5.9	25.2	5.9	25.4	5.9	25.4
15	5.9	25.3	6.0	25.4	5.9	25.3	5.9	25.0	5.9	25.3	5.9	25.1
20			5.9	25.2								
and = @ depth	5.9	25.0							5.8	25.3	5.8	25.1
	18		NA		NA		NA		17		17	
AVG. =	5.9	25.3	6.0	25.4	5.9	25.4	5.9	25.2	5.9	25.4	5.9	25.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.9
TEMPERATURE (CELSIUS) = 25.3

PERCENT SATURATION = 68.8

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-3-87
Time: 16:09

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.0	25.2	6.0	25.2	6.0	25.0	6.0	25.5	6.0	25.0	6.0	25.2
2	6.0	25.2	6.0	25.2	6.0	25.1	6.1	25.5	6.0	25.0	6.0	25.2
5	6.0	25.2	6.0	25.2	6.0	25.1	6.0	25.5	6.1	25.0	6.0	25.2
10	6.1	25.2	6.1	25.2	6.0	25.1	6.0	25.5	6.0	25.0	6.0	25.2
15	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.5	6.0	25.3	5.9	25.2
20			6.0	25.2					5.9	25.3		
and = @ depth	6.0	25.2	17		NA		NA		NA		NA	
AVG. =	6.0	25.2	6.0	25.2	6.0	25.1	6.0	25.5	6.0	25.1	6.0	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 69.6

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 08:55
Winkler Oxygen Calibration
ppm Oxygen= co-calibrated upstream

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6		
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	
1	6.0	25.1	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	
2	6.0	25.1	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	
5	6.0	25.1	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	
10	6.0	25.0	6.1	25.2	6.0	25.1	6.0	25.2	6.0	25.2	6.0	25.2	
15	6.0	25.0	6.0	25.0	6.0	25.1	6.0	25.1	6.0	25.2	6.0	25.2	
20	5.9	24.9	6.0	25.0									
and = @ depth	NA		NA		NA		NA		NA		6.0	25.1	19
AVG. =	6.0	25.0	6.0	25.1	6.0	25.2	6.0	25.2	6.0	25.2	6.0	25.2	

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 69.5

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 09:40

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.1	24.9	6.1	25.1	6.1	24.9	6.2	24.9	6.2	24.9	6.2	25.1
2	6.1	24.9	6.1	25.1	6.2	24.9	6.2	24.9	6.2	24.9	6.2	25.1
5	6.2	24.9	6.2	25.1	6.2	24.9	6.2	24.9	6.2	24.9	6.3	25.1
10	6.1	24.9	6.1	25.1	6.2	24.9	6.2	24.9	6.2	24.9	6.3	25.1
15	6.1	24.9	6.1	25.0	6.2	24.9	6.2	24.9	6.2	24.9	6.3	25.1
20	6.0	24.9									6.2	24.9
and = @ depth			6.1	25.0	19		NA		NA		NA	
AVG. =	6.1	24.9	6.1	25.1	6.2	24.9	6.2	24.9	6.2	24.9	6.3	25.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.2
TEMPERATURE (CELSIUS) = 25.0

PERCENT SATURATION = 71.3

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 10:31

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.4	25.0	6.4	25.0	6.4	25.1	6.3	25.0	6.3	25.0	6.3	25.0
2	6.4	25.0	6.4	25.0	6.4	25.1	6.3	25.0	6.3	25.0	6.3	25.0
5	6.4	25.0	6.4	25.0	6.4	25.1	6.3	25.0	6.4	25.0	6.3	25.0
10	6.4	25.0	6.4	25.0	6.4	25.1	6.3	25.0	6.3	25.0	6.3	25.0
15	6.4	25.0	6.4	25.0	6.3	25.0	6.4	25.0	6.3	25.0	6.3	24.9
20	6.3	25.0	6.3	24.9							6.3	24.9
and = @ depth	NA		NA		NA		NA		6.2	25.0	19	NA
AVG. =	6.4	25.0	6.4	25.0	6.4	25.1	6.3	25.0	6.3	25.0	6.3	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.3
TEMPERATURE (CELSIUS) = 25.0

PERCENT SATURATION = 73.3

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 11:08

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.5	25.1	6.4	25.1	6.4	25.0	6.3	25.0	6.3	25.0	6.4	25.0
2	6.5	25.1	6.5	25.1	6.4	25.0	6.3	25.0	6.3	25.0	6.4	25.0
5	6.4	25.1	6.5	25.1	6.4	25.0	6.3	25.0	6.3	25.0	6.4	25.0
10	6.4	25.1	6.5	25.1	6.4	25.0	6.3	25.0	6.3	25.0	6.4	25.0
15	6.4	25.0	6.5	25.0	6.4	24.9	6.3	24.9	6.3	25.0	6.2	25.0
20	6.4	24.9	6.5	24.9								
and = @ depth	NA		NA		NA		NA		6.3	25.0	19	NA
AVG. =	6.4	25.1	6.5	25.1	6.4	25.0	6.3	25.0	6.3	25.0	6.4	25.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.4
TEMPERATURE (CELSIUS) = 25.0

PERCENT SATURATION = 73.7

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 11:41
Winkler Oxygen Calibration
ppm Oxygen= 6.4

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.4	25.2	6.5	25.2	6.4	25.1	6.4	25.1	6.4	25.0	6.4	25.1
2	6.4	25.2	6.5	25.1	6.4	25.1	6.4	25.1	6.4	25.0	6.4	25.1
5	6.5	25.2	6.5	25.1	6.4	25.1	6.4	25.1	6.5	25.0	6.4	25.1
10	6.5	25.1	6.5	25.1	6.4	25.1	6.5	25.1	6.5	25.0	6.4	25.0
15	6.5	25.1	6.5	25.0	6.4	25.1	6.5	25.1	6.5	25.0	6.4	25.0
20	6.5	25.0	6.5	25.0								
and = @ depth	NA		NA		NA		NA		NA		6.4	25.0
AVG. =	6.5	25.1	6.5	25.1	6.4	25.1	6.4	25.1	6.5	25.0	6.4	25.1

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GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.4
TEMPERATURE (CELSIUS) = 25.1

PERCENT SATURATION = 74.6

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 14:31

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.8	25.6	6.6	25.2	6.6	25.2	6.7	25.2	6.6	25.2	6.7	25.2
2	6.8	25.4	6.6	25.2	6.6	25.2	6.6	25.2	6.7	25.2	6.7	25.2
5	6.8	25.3	6.6	25.2	6.6	25.2	6.6	25.3	6.7	25.2	6.7	25.2
10	6.5	25.1	6.6	25.2	6.6	25.2	6.5	25.2	6.7	25.2	6.7	25.2
15	6.6	25.0	6.6	25.2	6.6	25.2	6.6	25.1	6.6	25.2	6.7	25.2
20	6.5	25.0	6.6	25.2					6.6	25.2	6.6	25.2
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	6.7	25.2	6.6	25.2	6.6	25.2	6.6	25.2	6.7	25.2	6.7	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.6
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 76.9

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 14:56

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.8	25.4	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2
2	6.8	25.4	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2
5	6.7	25.4	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2
10	6.5	25.2	6.6	25.2	6.6	25.2	6.7	25.2	6.7	25.2	6.7	25.2
15	6.5	25.0	6.6	25.2	6.6	25.2	6.7	25.2	6.7	25.2	6.7	25.1
20			6.6	25.2							6.6	25.1
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	6.7	25.3	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.7
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 77.4

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 15:55
Winkler Oxygen Calibration
ppm Oxygen= 6.7

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.7	25.4	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.3	6.7	25.2
2	6.7	25.4	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.3	6.7	25.2
5	6.7	25.4	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2
10	6.6	25.3	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2
15	6.6	25.3	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2
20	6.6	25.2	6.7	25.2								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	6.7	25.3	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2	6.7	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.7
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 77.6

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-4-87
Time: 16:17

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	6.9	25.4	6.8	25.3	6.7	25.2	6.8	25.2	6.7	25.2	6.8	25.2
2	6.8	25.4	6.8	25.3	6.7	25.2	6.8	25.2	6.8	25.2	6.8	25.2
5	6.8	25.4	6.8	25.2	6.7	25.2	6.8	25.2	6.8	25.2	6.8	25.2
10	6.6	25.3	6.7	25.1	6.7	25.2	6.8	25.2	6.8	25.2	6.8	25.2
15	6.6	25.2	6.7	25.1	6.7	25.2	6.8	25.2	6.8	25.2	6.8	25.2
20	6.5	25.2										
and = @ depth	NA		NA		NA		NA		NA		6.7	25.2 19
AVG. =	6.7	25.3	6.8	25.2	6.7	25.2	6.8	25.2	6.8	25.2	6.8	25.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.8
TEMPERATURE (CELSIUS) = 25.2

PERCENT SATURATION = 78.3

RACINE DISSOLVED OXYGEN STUDY
DOWNSTREAM TRANSECT "C"
Date: 9-1-87

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "C"
Date: 9-1-87
Time: 12:04
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	5.9	25.5	5.8	25.6	5.9	25.6	5.9	25.6
2	5.8	25.4	5.8	25.4	5.8	25.6	5.8	25.6
5	5.8	25.5	5.8	25.5	5.8	25.5	5.9	25.5
10	5.8	25.5	5.8	25.5	5.8	25.5	5.9	25.5
15	5.8	25.5	5.8	25.5	5.8	25.5	5.9	25.5
20	5.8	25.4	5.8	25.5	5.8	25.5	5.8	25.5
and = @ depth	5.8	25.4	5.8	25.5	5.8	25.5	5.8	25.2
	22		27		30		30	
AVG. =	5.8	25.5	5.8	25.5	5.8	25.5	5.8	25.5

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 5.8
TEMPERATURE (CELSIUS) = 25.5

PERCENT SATURATION = 67.67

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "C"
Date: 9-1-87
Time: 15:04
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.0	25.6	6.0	25.6	6.1	25.8	5.9	25.6
2	6.0	25.6	6.0	25.6	6.1	25.6	6.0	25.6
5	6.0	25.6	6.1	25.6	6.0	25.5	5.9	25.7
10	6.1	25.6	6.1	25.6	6.0	25.6	5.9	25.6
15	6.1	25.6	6.1	25.6	6.0	25.6	5.9	25.6
20	6.1	25.6	6.1	25.6	6.0	25.6	5.9	25.6
30					6.0	25.6	5.9	25.6
depth	NA		NA		30		30	
AVG. =	6.1	25.6	6.1	25.6	6.0	25.6	5.9	25.6

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.6

PERCENT SATURATION = 70.27

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "C"
Date: 9-1-87
Time: 15:28
Winkler Oxygen Calibration
ppm Oxygen= air calib.

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	6.1	25.6	6.0	25.4	6.0	25.4	6.0	25.5
2	6.1	25.6	6.0	25.3	6.0	25.4	6.0	25.5
5	6.0	25.4	6.0	25.3	6.0	25.3	6.0	25.3
10	6.1	25.6	6.1	25.4	6.0	25.3	6.0	25.5
15	6.0	25.5	6.1	25.4	6.0	25.4	6.0	25.5
20	6.0	25.5	6.1	25.2	6.0	25.3	6.0	25.4
and = @ depth	6.0	25.5 30	6.1	25.2 30	6.0	25.3 30	6.0	25.4 30
AVG. =	6.0	25.5	6.1	25.3	6.0	25.3	6.0	25.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 6.0
TEMPERATURE (CELSIUS) = 25.4

PERCENT SATURATION = 70.14

Racine Locks and Dam

Dissolved Oxygen Sampling Effort:

II

Racine Locks and Dam

Dissolved Oxygen Sampling Effort:

II

RACINE DISSOLVED OXYGEN STUDY
UPSTREAM TRANSECT
Dates: 9-29-87 to 9-30-87

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-29-87
Time: 10:00
Winkler Oxygen Calibration
ppm Oxygen=7.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	20.1	8.1	20.0	7.9	20.1	8.0	20.0	7.9	20.0	7.9	20.1	7.9	20.0
2	7.9	20.1	8.2	20.0	7.8	20.0	7.8	20.0	7.9	20.0	7.9	20.1	7.9	20.0
5	7.9	20.1	7.9	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
10	7.8	20.0	7.9	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
15	7.7	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.7	20.0	7.7	20.0	7.8	20.0
20	7.8	20.0	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.7	20.0	7.8	20.0
Bottom @depth	7.7	20.0	7.6	20.0	7.8	20.0	7.7	20.0			7.7	20.0	7.7	20.0
	32		34		34		36				42			
AVG. =	7.8	20.0	7.9	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 83.2

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-29-87
Time: 10:57
Winkler Oxygen Calibration
ppm Oxygen= 7.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.8	20.1	8.0	20.0	7.8	20.1	7.9	20.1	7.9	20.1	7.9	20.1	7.8	20.1
2	7.8	20.1	7.9	20.0	7.8	20.1	7.9	20.1	7.8	20.1	7.8	20.1	7.9	20.1
5	7.8	20.1	7.8	20.0	7.8	20.1	7.7	20.1	7.7	20.0	7.7	20.0	7.8	20.1
10	7.8	20.0	7.8	19.9	7.7	20.0	7.7	20.1	7.7	20.0	7.7	20.0	7.7	20.0
15	7.7	20.0	7.9	20.0	7.7	20.0	7.7	20.1	7.7	20.0	7.7	20.0	7.7	20.0
20	7.7	20.0	7.8	20.0	7.7	20.0	7.7	20.0	7.7	20.0	7.7	20.0	7.8	20.1
Bottom @depth	7.7	20.0	7.6	20.0	7.6	20.0	7.6	20.0	7.6	20.0	7.7	20.0	7.7	20.0
	32		33		35		35		37		40			
AVG. =	7.8	20.0	7.8	20.0	7.7	20.0	7.7	20.1	7.7	20.0	7.7	20.0	7.8	20.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 82.5

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-29-87
Time: 12:12
Winkler Oxygen Calibration
ppm Oxygen= 7.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	8.0	20.4	8.0	20.3	7.9	20.4	7.9	20.4	7.9	20.4	7.9	20.4	7.9	20.4
2	8.0	20.4	7.9	20.3	7.9	20.3	7.9	20.4	7.8	20.4	7.9	20.4	7.9	20.3
5	7.9	20.3	7.8	20.2	7.8	20.3	7.8	20.3	7.8	20.3	7.8	20.3	7.9	20.2
10	7.9	20.3	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2
15	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.1	7.9	20.2	7.8	20.2
20	7.8	20.2	7.6	20.2	7.7	20.1	7.7	20.1	7.7	20.1	7.8	20.1	7.8	20.1
Bottom @depth	7.8	20.2	7.6	20.1	7.6	20.1	7.6	20.1	7.6	20.1	7.7	20.1	7.8	20.1
	36		33		34		37		37		40			
AVG. =	7.9	20.3	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2	7.8	20.2

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.2

PERCENT SATURATION = 83.4

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-29-87
Time: 13:00

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	8.0	20.0	8.0	20.6	8.0	20.6	8.0	20.6	8.0	20.6	8.0	20.6	8.0	20.4
2	8.0	20.4	7.9	20.5	7.9	20.5	7.9	20.5	7.9	20.5	8.0	20.5	7.8	20.4
5	7.9	20.3	7.9	20.3	7.9	20.3	7.9	20.4	7.9	20.4	7.9	20.4	7.8	20.3
10	7.9	20.1	7.8	20.1	7.8	20.1	7.8	20.2	7.8	20.2	7.9	20.3	7.8	20.2
15	7.8	20.1	7.8	20.1	7.8	20.1	7.8	20.1	7.7	20.1	7.8	20.2	7.8	20.2
20	7.7	20.1	7.8	20.1	7.8	20.1	7.8	20.1	7.7	20.1	7.7	20.2	7.8	20.2
Bottom @depth	7.6	20.1	7.7	20.1	7.7	20.1	7.7	20.1	7.7	20.1	7.7	20.1	7.7	20.2
	32		38		34		36		36		40			
AVG. =	7.8	20.2	7.8	20.3	7.8	20.3	7.8	20.3	7.8	20.3	7.9	20.3	7.8	20.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.3

PERCENT SATURATION = 83.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-29-87
Time: 14:30
Winkler Oxygen Calibration
ppm Oxygen= 8.0

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	8.1	20.5	8.0	20.3	7.9	20.2	7.9	20.2	8.0	20.2	8.1	20.3	8.0	20.5
2	8.2	20.5	7.8	20.2	7.8	20.2	7.9	20.2	7.9	20.2	8.0	20.4	8.0	20.5
5	8.0	20.2	7.8	20.2	7.8	20.1	7.8	20.2	7.8	20.2	8.0	20.4	7.9	20.5
10	7.9	20.1	7.9	20.1	7.8	20.1	7.8	20.2	7.8	20.2	7.9	20.4	7.8	20.3
15	7.8	20.1	7.7	20.1	7.8	20.1	7.7	20.2	7.9	20.2	7.9	20.3	7.8	20.2
20	7.8	20.1	7.7	20.1	7.8	20.1	7.8	20.1	7.8	20.1	7.9	20.2	7.7	20.2
Bottom @depth	7.7	20.1	7.7	20.1	7.6	20.1	7.7	20.1	7.7	20.1	7.7	20.1	7.8	20.2
	32		36		34		36		36		40			
AVG. =	7.9	20.2	7.8	20.2	7.8	20.1	7.8	20.2	7.8	20.2	7.9	20.3	7.9	20.3

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.2

PERCENT SATURATION = 83.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-29-87
Time: 15:10

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	20.2	7.9	20.2	7.9	20.2	7.9	20.2	8.0	20.4	7.9	20.3	8.0	20.5
2	7.8	20.2	7.8	20.2	7.9	20.2	7.8	20.2	8.0	20.4	8.0	20.4	8.0	20.5
5	7.7	20.2	7.9	20.2	7.8	20.2	7.8	20.2	7.9	20.3	7.8	20.4	7.9	20.5
.0	7.8	20.2	7.7	20.2	7.8	20.2	7.8	20.2	7.7	20.2	7.9	20.3	7.9	20.4
15	7.8	20.1	7.7	20.1	7.7	20.2	7.7	20.2	7.8	20.2	7.8	20.3	7.9	20.4
20	7.8	20.1	7.7	20.1	7.7	20.2	7.6	20.1	7.7	20.2	7.8	20.3	7.9	20.3
Bottom @depth	7.6	20.1	7.5	20.1	7.7	20.1	7.7	20.1	7.7	20.1	7.8	20.2	7.8	20.2
	33		34		38		36		37		40			
AVG. =	7.8	20.2	7.7	20.2	7.8	20.2	7.8	20.2	7.8	20.3	7.9	20.3	7.9	20.4

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.2

PERCENT SATURATION = 83.3

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 08:12
Winkler Oxygen Calibration
ppm Oxygen= 7.7

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.8	19.9	7.7	20.0	7.5	20.0	7.5	20.0	7.6	20.0	7.6	20.0	7.6	20.0
2	7.7	19.9	7.7	20.0	7.5	20.0	7.5	20.0	7.6	20.0	7.6	20.0	7.5	20.0
5	7.6	19.9	7.6	20.0	7.4	20.0	7.5	20.0	7.4	20.0	7.4	20.0	7.5	20.0
10	7.6	19.9	7.6	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0
15	7.6	19.9	7.6	20.0	7.5	20.0	7.5	20.0	7.6	20.0	7.5	20.0	7.5	20.0
20	7.6	20.0	7.6	20.0	7.5	20.0	7.5	20.0	7.6	20.0	7.5	20.0	7.5	20.0
Bottom @depth	7.6	20.0	7.7	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.5	20.0
	32		33		33		34		37		40			
AVG. =	7.6	19.9	7.6	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 80.2

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 09:05
Winkler Oxygen Calibration
ppm Oxygen= 7.9

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....:

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.7	20.0	7.6	20.0	7.6	20.0	7.6	20.0	7.5	20.0	7.5	20.0	7.5	20.0
2	7.6	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0
5	7.6	20.0	7.4	20.0	7.5	20.0	7.4	20.0	7.4	20.0	7.5	20.0	7.4	20.0
10	7.5	20.0	7.4	20.0	7.4	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0
15	7.5	20.0	7.2	20.0	7.4	20.0	7.4	20.0	7.4	20.0	7.5	20.0	7.5	20.0
20	7.5	20.0	7.5	20.0	7.4	20.0	7.3	20.0	7.5	20.0	7.5	20.0	7.5	20.0
Bottom @depth	7.5	19.9	7.3	20.0	7.3	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0
	32		33		33		36		36		40			
AVG. =	7.6	20.0	7.4	20.0	7.4	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 79.5

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 10:00
Winkler Oxygen Calibration
ppm Oxygen= 7.6

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1 DO	1 T	2 DO	2 T	3 DO	3 T	4 DO	4 T	5 DO	5 T	6 DO	6 T	W. VIRGINIA 7 DO
1	7.6	19.9	7.7	20.0	7.6	20.0	7.6	20.0	7.4	20.0	7.4	20.0	7.5 20.(
2	7.5	20.0	7.6	20.0	7.5	20.0	7.6	20.0	7.5	20.0	7.3	20.0	7.3 20.(
5	7.6	20.0	7.5	20.0	7.6	20.0	7.6	20.0	7.5	20.0	7.4	20.0	7.2 20.(
10	7.6	20.0	7.5	20.0	7.4	20.0	7.6	20.0	7.5	20.0	7.4	20.0	7.5 20.(
15	7.6	19.9	7.5	20.0	7.5	20.0	7.6	20.0	7.6	20.0	7.5	20.0	7.5 20.(
20	7.4	19.9	7.5	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.5	20.0	7.5 20.(
Bottom @depth	7.5	19.9	7.4	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.4 20.(
	32		33		34		36		36		40		
AVG. =	7.5	19.9	7.5	20.0	7.5	20.0	7.6	20.0	7.5	20.0	7.4	20.0	7.4 20.(

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 79.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 10:48

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....:

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.4	20.1	7.6	20.1	7.6	20.0	7.6	20.0	7.6	20.0	7.6	20.0	7.7	20.1
2	7.6	20.1	7.6	20.1	7.6	20.1	7.6	20.0	7.5	20.0	7.6	20.0	7.6	20.1
5	7.5	20.0	7.6	20.0	7.6	20.0	7.5	20.0	7.6	20.0	7.5	20.0	7.6	20.0
10	7.5	20.0	7.6	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.5	20.0	7.5	20.0
15	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	19.9	7.5	20.0
20	7.5	20.0	7.5	20.0	7.4	20.0	7.4	19.9	7.5	19.9	7.5	19.9	7.5	20.0
Bottom @depth	7.5	20.0 34	7.5	20.0 34	7.3	20.0 34	7.4	19.9 34	7.5	20.0 34	7.4	19.9 39	7.6	20.0
AVG. =	7.5	20.0	7.6	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.6	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 80.0

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 12:18

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.7	20.1	7.6	20.0	7.6	20.0	7.6	20.0	7.6	19.9	7.7	20.0	7.6	20.0
2	7.6	20.1	7.6	20.0	7.6	20.0	7.6	20.0	7.4	19.9	7.6	20.0	7.6	20.0
5	7.6	20.1	7.6	20.0	7.6	20.0	7.6	20.0	7.5	20.0	7.6	20.0	7.6	20.0
10	7.6	20.0	7.6	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.6	20.0	7.4	20.0
15	7.6	20.0	7.5	20.0	7.5	19.9	7.4	20.0	7.3	19.9	7.5	20.0	7.6	20.0
20	7.5	20.0	7.6	20.0	7.4	19.9	7.4	19.9	7.3	19.9	7.6	20.0	7.5	20.0
Bottom @depth	7.5	20.0 33	7.5	20.0 33	7.4	19.9 34	7.5	19.9 35	7.6	19.9 36	7.6	20.0 39	7.5	20.0
AVG. =	7.6	20.0	7.6	20.0	7.5	20.0	7.5	20.0	7.4	19.9	7.6	20.0	7.5	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 80.1

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 12:59
Winkler Oxygen Calibration
ppm Oxygen= 7.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.6	20.0	7.6	20.0	7.6	20.0	7.6	20.0	7.5	20.1	7.6	20.0	7.6	20.1
2	7.6	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.5	20.0	7.4	20.0	7.6	20.1
5	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.6	20.0	7.4	20.0	7.6	20.1
10	7.6	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.5	20.0	7.5	20.0	7.5	20.0
15	7.5	20.0	7.4	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.5	20.0
20	7.6	20.0	7.3	20.0	7.5	20.0	7.4	20.0	7.4	20.0	7.4	20.0	7.4	20.0
Bottom @depth	7.4	20.0	7.5	20.0	7.4	20.0	7.4	20.0	7.5	20.0	7.5	20.0	7.4	20.0
	32		33		33		35		40		42			
AVG. =	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0	7.5	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 79.7

RACINE DISSOLVED OXYGEN STUDY

UPSTREAM TRANSECT
Date: 9-30-87
Time: 13:42

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		6		W. VIRGINIA 7	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.7	20.1	7.7	20.1	7.5	20.0	7.6	19.9	7.5	20.0	7.7	20.0	7.7	20.1
2	7.7	20.1	7.5	20.0	7.3	20.0	7.5	20.0	7.5	20.0	7.6	20.0	7.8	20.1
5	7.6	20.1	7.5	20.0	7.5	20.0	7.5	20.0	7.4	20.0	7.6	20.0	7.7	20.1
)	7.6	20.0	7.5	20.0	7.4	20.0	7.4	20.0	7.4	20.0	7.5	20.0	7.5	20.0
15	7.6	20.0	7.4	20.0	7.6	20.0	7.4	20.0	7.3	20.0	7.6	20.0	7.5	20.0
20	7.5	20.0	7.4	20.0	7.4	20.0	7.4	20.0	7.3	20.0	7.6	20.0	7.6	20.0
Bottom @depth	7.4	20.0 32	7.4	20.0 33	7.4	19.9 36	7.5	20.0 34	7.5	19.9 36	7.5	20.0 40	7.5	20.0 3
AVG. =	7.6	20.0	7.5	20.0	7.4	20.0	7.5	20.0	7.4	20.0	7.6	20.0	7.6	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 79.9

RACINE DISSOLVED OXYGEN STUDY
DOWNSTREAM NEAR RESTRICTED ZONE
Dates: 9-29-87 to 9-30-87

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-29-87
Time: 10:11

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.7	22.0	7.6	22.0	7.6	21.5	7.6	21.0
2	7.5	21.5	7.6	21.5	7.5	21.0	7.5	21.0
5	7.6	21.0	7.5	21.5	7.5	21.0	7.6	21.0
10	7.6	21.5	7.5	21.5	7.5	21.0	7.5	21.0
15	7.6	21.5	7.5	21.0	7.5	21.0	7.5	21.0
20	7.6	21.5	7.5	21.0	7.4	21.0	7.4	21.0
and = @ depth	NA		NA		7.4	21.0	7.4	21.0
					24		25	
AVG. =	7.6	21.5	7.5	21.4	7.5	21.1	7.5	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.5
TEMPERATURE (CELSIUS) = 21.2

PERCENT SATURATION = 81.73

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-29-87
Time: 11:03

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.7	21.0	7.7	21.5	7.7	21.0	7.7	21.0
2	7.6	21.0	7.6	21.0	7.6	21.0	7.7	21.0
5	7.5	20.5	7.6	21.0	7.6	21.0	7.7	21.0
10	7.5	20.5	7.6	21.0	7.6	21.0	7.6	21.0
15	7.5	20.5	7.6	21.0	7.6	21.0	7.6	21.0
20	7.5	20.5	7.5	21.0	7.5	20.5	7.6	21.0
and =	7.5	20.5			7.4	20.5		
@ depth	22		NA		25		NA	
AVG. =	7.5	20.6	7.6	21.1	7.6	20.9	7.7	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.6
TEMPERATURE (CELSIUS) = 20.9

PERCENT SATURATION = 81.92

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-29-87
Time: 13:21

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.8	20.0	7.8	20.0	7.7	21.0	7.8	20.5
2	7.8	20.0	7.9	20.0	7.8	21.0	7.8	21.0
5	7.8	20.0	7.8	20.0	7.8	21.0	7.8	21.0
10	7.8	20.0	7.7	20.0	7.7	21.0	7.7	21.0
15	7.8	20.0	7.8	20.0	7.7	21.0	7.7	21.0
20	7.9	20.0	7.7	20.0	7.6	21.0	7.7	21.0
and = @ depth	NA		7.6	20.0 26	7.7	20.5 26	7.7	21.0 25
AVG. =	7.8	20.0	7.8	20.0	7.7	20.9	7.7	20.9

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.5

PERCENT SATURATION = 83.14

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-29-87
Time: 15:38

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.9	20.5	7.8	21.0	7.8	21.0	7.8	21.0
2	7.8	21.0	7.8	21.0	7.7	21.0	7.7	21.0
5	7.8	21.0	7.7	21.0	7.7	21.0	7.7	21.0
10	7.7	21.0	7.7	21.0	7.7	21.0	7.6	21.0
15	7.7	21.0	7.6	21.0	7.7	21.0	7.6	21.0
20	7.7	21.0	7.6	21.0	7.7	21.0	7.6	21.0
and = @ depth	7.4	21.0 25	7.5	21.0 25	7.6	21.0 22	7.5	21.0 25
AVG. =	7.7	20.9	7.7	21.0	7.7	21.0	7.6	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.7
TEMPERATURE (CELSIUS) = 21.0

PERCENT SATURATION = 83.02

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-30-87
Time: 11:47

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.4	21.0	7.3	20.5	7.4	20.5	7.3	20.0
2	7.3	21.0	7.3	20.5	7.3	20.5	7.4	20.0
5	7.3	21.0	7.3	20.5	7.3	20.0	7.4	20.0
10	7.2	21.0	7.4	20.5	7.2	20.0	7.4	20.0
15	7.2	21.0	7.4	20.5	7.2	20.0	7.4	20.0
20	7.2	20.0	7.4	20.0	7.1	20.0	7.3	20.0
and = @ depth	7.1	20.0			7.1	20.0		
	25		NA		25		NA	
AVG. =	7.2	20.7	7.4	20.4	7.2	20.1	7.4	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.3
TEMPERATURE (CELSIUS) = 20.3

PERCENT SATURATION = 78.02

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-30-87
Time: 13:34

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.8	20.0	7.9	20.0	7.8	20.0	7.8	20.0
2	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
5	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
10	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0
15	7.8	20.0	7.7	20.0	7.7	20.0	7.7	20.0
20	7.8	20.0	7.6	20.0	7.7	20.0	7.7	20.0
and = @ depth	7.7	20.0 25	7.6	20.0 25	7.7	20.0 25	7.6	20.0 25
AVG. =	7.8	20.0	7.7	20.0	7.8	20.0	7.7	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 82.48

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-30-87
Time: 14:27

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.7	20.0	7.8	20.0	7.8	20.0	7.9	20.0
2	7.7	20.0	7.8	20.0	7.8	20.0	7.9	20.0
5	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
10	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
15	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
20	7.8	19.0	7.8	20.0	7.8	20.0	7.8	20.0
and = @ depth	7.8	19.0	25	NA	7.7	20.0	25	NA
AVG. =	7.8	19.7	7.8	20.0	7.8	20.0	7.8	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 19.9

PERCENT SATURATION = 82.85

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-30-87
Time: 15:12

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1 DO	OHIO 1 T	2 DO	2 T	3 DO	3 T	W. VIRGINIA 4 DO	W. VIRGINIA 4 T
1	7.7	21.0	7.8	21.0	7.8	21.0	7.8	21.0
2	7.7	21.0	7.8	21.0	7.8	21.0	7.9	21.0
5	7.7	21.0	7.8	21.0	7.8	21.0	7.8	21.0
10	7.7	20.0	7.8	21.0	7.8	21.0	7.8	21.0
15	7.7	20.0	7.8	20.0	7.8	21.0	7.8	20.0
20	7.7	20.0	7.8	20.0	7.8	20.0	7.7	20.0
and = @ depth	7.7	20.0 25	7.8	20.0 25	7.8	20.0 25		NA
AVG. =	7.7	20.4	7.8	20.6	7.8	20.7	7.8	20.7

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.6

PERCENT SATURATION = 83.50

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM NEAR RESTRICTED ZONE
Date: 9-30-87
Time: 15:44

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (at restricted zone bouys)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		W. VIRGINIA 4	
	DO	T	DO	T	DO	T	DO	T
1	7.8	20.0	7.8	20.5	7.8	21.0	7.8	21.0
2	7.8	20.0	7.9	20.5	7.8	21.0	7.7	21.0
5	7.8	20.0	7.9	20.5	7.8	21.0	7.7	21.0
10	7.8	20.0	7.8	20.5	7.7	21.0	7.7	21.0
15	7.8	20.0	7.8	20.5	7.8	20.0	7.7	21.0
20	7.8	20.0	7.8	20.0	7.7	20.0	7.7	20.0
and = @ depth	7.7	20.0 25	7.8	20.0 25	7.7	20.0 25	7.7	20.0 25
AVG. =	7.8	20.0	7.8	20.4	7.8	20.6	7.7	20.7

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.4

PERCENT SATURATION = 83.22

RACINE DISSOLVED OXYGEN STUDY
DOWNSTREAM TRANSECT "B"
Dates: 9-29-87 to 9-30-87

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 9:46
Winkler Oxygen Calibration
ppm Oxygen= 7.6

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.6	22.0	7.6	22.0	7.7	21.5	7.6	21.5	7.4	21.5	7.6	22.0
2	7.6	21.5	7.7	22.0	7.6	22.0	7.6	21.5	7.6	21.5	7.6	22.0
5	7.5	21.5	7.7	22.0	7.6	21.5	7.6	21.5	7.5	21.5	7.7	22.5
10	7.5	21.5	7.7	22.0	7.6	21.5	7.5	21.5	7.5	21.5	7.7	22.0
15	7.6	21.5	7.7	22.0	7.6	21.5	7.5	21.5	7.5	21.5	7.6	22.0
20	7.5	21.5	7.6	22.0	7.6	21.5	7.5	21.5	7.5	21.5	7.6	22.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.6	21.6	7.7	22.0	7.6	21.6	7.6	21.5	7.5	21.5	7.6	22.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.6
TEMPERATURE (CELSIUS) = 21.7

PERCENT SATURATION = 82.9

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 10:35

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.6	21.0	7.6	21.5	7.6	21.0	7.6	21.0	7.6	21.0	7.5	20.5
2	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.5	20.5
5	7.5	21.0	7.6	21.0	7.6	21.0	7.7	21.0	7.7	21.5	7.5	20.5
10	7.5	21.0	7.5	21.0	7.6	21.0	7.7	21.0	7.6	21.0	7.5	20.5
15	7.4	21.0	7.5	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.6	20.5
20	7.4	21.0	7.5	21.0			7.6	21.0	7.6	21.0	7.5	20.5
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.5	21.0	7.6	21.1	7.6	21.0	7.6	21.0	7.6	21.1	7.5	20.5

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.6
TEMPERATURE (CELSIUS) = 20.9

PERCENT SATURATION = 81.7

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 12:35
Winkler Oxygen Calibration
ppm Oxygen= 7.7

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.7	21.5	7.7	21.0	7.7	20.0	7.7	20.0	7.7	20.0	7.7	20.0
2	7.7	21.5	7.7	20.5	7.7	20.0	7.7	20.0	7.7	20.0	7.8	20.0
5	7.7	21.5	7.7	20.5	7.7	20.0	7.7	20.0	7.7	20.0	7.8	20.0
10	7.7	21.0	7.6	20.0	7.7	20.0	7.7	20.0	7.7	20.0	7.7	20.0
15	7.7	21.0	7.5	19.5	7.7	20.0	7.7	20.0	7.7	20.0	7.7	20.0
20	7.7	21.0	7.4	19.5	7.6	20.0	7.5	20.0	7.6	20.0	7.7	20.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.7	21.3	7.6	20.2	7.7	20.0	7.7	20.0	7.7	20.0	7.7	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.7
TEMPERATURE (CELSIUS) = 20.2

PERCENT SATURATION = 81.9

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 13:00

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	20.5	7.9	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.9	20.0
2	7.7	20.5	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.9	20.0
5	7.7	20.5	7.8	20.5	7.7	20.0	7.7	20.0	7.8	20.0	7.9	20.0
10	7.7	20.5	7.8	20.5	7.7	20.0	7.7	20.0	7.7	20.0	7.8	20.0
15	7.7	20.5	7.8	21.0	7.7	20.0	7.7	20.0	7.8	20.0	7.8	20.0
20	7.7	20.5	7.7	20.5	7.6	20.0	7.6	20.0	7.7	20.0	7.7	20.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.7	20.5	7.8	20.4	7.7	20.0	7.7	20.0	7.8	20.0	7.8	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.2

PERCENT SATURATION = 82.7

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 13:39

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	21.0	7.8	21.0	7.8	21.0	7.6	21.0	7.7	21.0	7.8	21.0
2	7.9	21.0	7.8	21.0	7.8	21.0	7.7	21.0	7.7	21.0	7.7	21.0
5	7.9	21.0	7.7	21.0	7.7	21.0	7.7	21.0	7.7	21.0	7.6	21.0
10	7.8	21.0	7.7	21.0	7.7	21.0	7.7	21.0	7.7	21.0	7.6	21.0
15	7.8	21.0	7.7	21.0	7.6	21.0	7.7	21.0	7.7	21.0	7.6	21.0
20	7.8	21.0	7.6	21.0			7.6	21.0	7.6	20.5	7.3	21.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.9	21.0	7.7	21.0	7.7	21.0	7.7	21.0	7.7	20.9	7.6	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.7
TEMPERATURE (CELSIUS) = 21.0

PERCENT SATURATION = 83.2

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 14:22

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	20.0	7.8	21.0	7.7	21.0	7.7	21.0	7.9	21.0	7.7	21.0
2	7.9	20.0	7.7	21.0	7.7	21.0	7.6	21.0	7.9	21.0	7.7	21.0
5	7.8	21.0	7.8	21.0	7.7	21.0	7.7	20.5	7.8	21.5	7.7	21.0
10	7.7	21.0	7.7	21.0	7.7	21.0	7.7	21.0	7.8	21.5	7.6	21.0
15	7.8	21.5	7.7	21.0	7.7	21.0	7.6	20.5	7.8	21.5	7.5	21.0
20	7.6	21.0	7.6	21.0			7.4	21.0	7.7	21.0	7.5	21.0
and = @ depth	7.6	21.0	7.5	21.0								
	22		22		NA		NA		NA		NA	
AVG. =	7.8	20.8	7.7	21.0	7.7	21.0	7.6	20.8	7.8	21.3	7.6	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.7
TEMPERATURE (CELSIUS) = 21.0

PERCENT SATURATION = 83.2

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 15:12
Winkler Oxygen Calibration
ppm Oxygen= 7.6

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.7	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.9	21.0
2	7.7	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.8	21.0
5	7.6	21.0	7.6	21.0	7.5	21.0	7.7	21.0	7.6	21.0	7.7	21.0
10	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.7	21.0
15	7.6	20.5	7.6	21.0	7.6	21.0	7.5	21.0	7.6	21.0	7.6	21.0
20	7.5	21.0	7.5	21.0	7.5	21.0			7.5	21.0	7.5	21.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.6	20.9	7.6	21.0	7.6	21.0	7.6	21.0	7.6	21.0	7.7	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.6
TEMPERATURE (CELSIUS) = 21.0

PERCENT SATURATION = 82.2

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-29-87
Time: 16:16

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	22.0	7.6	21.0	7.5	21.0	7.6	21.0	7.5	21.0	7.6	21.0
2	7.9	22.0	7.7	21.0	7.6	21.0	7.7	21.0	7.7	21.0	7.6	21.0
5	7.8	22.0	7.6	22.0	7.6	21.0	7.7	21.0	7.7	21.0	7.6	21.0
10	7.8	22.0	7.6	22.0	7.6	21.0	7.7	21.0	7.7	21.0	7.7	21.0
15	7.7	22.0	7.6	21.0	7.7	20.0	7.6	21.0	7.7	21.0	7.7	21.0
20	7.6	21.5	7.7	21.0					7.6	21.0	7.6	21.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.8	21.9	7.6	21.3	7.6	20.8	7.7	21.0	7.7	21.0	7.6	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.7
TEMPERATURE (CELSIUS) = 21.2

PERCENT SATURATION = 83.0

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 9:18
Winkler Oxygen Calibration
ppm Oxygen= 7.4

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.4	21.0	7.3	21.0	7.3	21.0	7.3	21.0	7.3	21.0	7.2	21.0
2	7.4	21.0	7.3	21.0	7.3	21.0	7.2	21.0	7.4	21.0	7.2	21.0
5	7.3	21.0	7.3	21.0	7.2	21.0	7.2	21.0	7.4	21.0	7.2	21.0
10	7.3	21.0	7.3	21.0	7.2	21.0	7.3	21.0	7.3	21.0	7.2	21.0
15	7.3	21.0	7.3	21.0	7.2	21.0	7.2	21.0	7.3	21.0	7.2	21.0
20	7.3	21.0	7.3	21.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.3	21.0	7.3	21.0	7.2	21.0	7.2	21.0	7.3	21.0	7.2	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.3
TEMPERATURE (CELSIUS) = 21.0

PERCENT SATURATION = 78.6

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 11:25

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.4	21.0	7.4	21.0	7.4	21.0	7.5	21.0	7.4	20.5	7.4	20.5
2	7.3	21.0	7.4	21.0	7.3	21.0	7.5	21.0	7.4	20.5	7.4	20.5
5	7.2	21.0	7.4	21.0	7.3	21.0	7.3	21.0	7.4	20.5	7.4	20.5
10	7.2	21.0	7.3	21.0	7.3	21.0	7.3	21.0	7.3	20.0	7.3	20.5
15	7.2	21.0	7.2	21.0	7.4	21.0	7.3	21.0	7.3	20.0	7.3	21.0
20	7.1	21.0	7.1	21.0							7.2	21.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.2	21.0	7.3	21.0	7.3	21.0	7.4	21.0	7.4	20.3	7.3	20.7

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.3
TEMPERATURE (CELSIUS) = 20.8

PERCENT SATURATION = 78.9

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 13:18
Winkler Oxygen Calibration
ppm Oxygen= 7.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.6	20.0	7.6	20.0	7.6	20.0	7.8	20.5	7.8	20.0	7.9	20.0
2	7.6	20.0	7.7	20.0	7.6	20.0	7.8	20.5	7.8	20.0	7.9	20.0
5	7.6	20.0	7.7	20.0	7.6	20.0	7.8	20.0	7.8	20.0	7.8	20.0
10	7.6	20.0	7.6	20.0	7.6	20.0	7.7	20.0	7.8	20.0	7.8	20.0
15	7.5	20.0	7.6	20.0	7.6	20.0	7.7	20.0	7.8	20.0	7.8	20.0
20	7.6	20.0	7.6	20.0			7.7	20.0			7.8	20.0
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.6	20.0	7.6	20.0	7.6	20.0	7.8	20.2	7.8	20.0	7.8	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.7
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 81.9

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 13:48

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.8	20.0	7.9	20.0	7.9	20.0	7.8	20.0	7.7	20.0	7.8	20.0
2	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0
5	7.8	20.0	7.9	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
10	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
15	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
20	7.8	20.0	7.8	20.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 83.0

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 14:11

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.7	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0
2	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0	7.8	20.0
5	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0	7.9	20.0
10	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0	7.8	20.0
15	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0	7.8	20.0
20			7.7	20.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.8	20.0	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0	7.8	20.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 82.8

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 14:44
Winkler Oxygen Calibration
ppm Oxygen= 7.8

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.8	20.0	7.7	20.5
2	7.9	20.0	7.8	20.0	7.8	20.0	7.9	20.0	7.8	20.0	7.7	20.0
5	7.8	20.0	7.8	20.0	7.7	20.0	7.9	20.0	7.8	20.0	7.7	20.0
10	7.8	20.0	7.8	20.0	7.7	20.0	7.9	20.0	7.8	20.0	7.7	20.0
15	7.8	19.0	7.8	20.0	7.7	20.0	7.8	20.0	7.8	20.0	7.7	20.0
20	7.8	19.0	7.8	20.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.8	19.7	7.8	20.0	7.7	20.0	7.9	20.0	7.8	20.0	7.7	20.1

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.0

PERCENT SATURATION = 82.7

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 15:24

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.8	21.0	7.9	21.0	7.8	21.0	7.8	21.0	7.8	21.0	7.8	21.0
2	7.8	21.0	7.9	21.0	7.8	21.0	7.8	21.0	7.8	21.0	7.8	21.0
5	7.8	21.0	7.8	21.0	7.8	21.0	7.8	21.0	7.8	21.0	7.8	21.0
10	7.8	21.0	7.9	21.0	7.8	21.0	7.8	21.0	7.8	21.0	7.8	21.0
15	7.8	21.0	7.9	21.0	7.7	20.5	7.8	20.5	7.8	20.5	7.8	20.5
20	7.8	20.5	7.9	21.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.8	20.9	7.9	21.0	7.8	20.9	7.8	20.9	7.8	20.9	7.8	20.9

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.8
TEMPERATURE (CELSIUS) = 20.9

PERCENT SATURATION = 84.3

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 15:55

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.8	21.0	7.9	21.0	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0
2	7.8	21.0	7.9	21.0	7.8	21.0	7.9	21.0	7.9	21.0	8.0	21.0
5	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0	7.9	21.0	7.9	21.0
10	7.8	21.0	7.9	21.0	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0
15	7.8	21.0	7.8	21.0	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0
20	7.8	20.5	7.8	21.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.8	20.9	7.9	21.0	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.9
TEMPERATURE (CELSIUS) = 21.0

PERCENT SATURATION = 85.0

RACINE DISSOLVED OXYGEN STUDY

DOWNSTREAM TRANSECT "B"
Date: 9-30-87
Time: 16:40

YSI MODEL 57 OXYGEN-TEMPERATURE DATA (DO/Temp.)

SAMPLE LOCATION (approx. 200 ft. intervals)
from shores of.....

DEPTH (FT)	OHIO 1		2		3		4		5		W. VIRGINIA 6	
	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T
1	7.9	21.0	7.8	21.0	8.0	21.0	7.9	21.0	7.9	21.0	7.9	21.0
2	8.0	20.0	7.8	21.0	8.0	21.0	7.9	21.0	7.9	21.0	7.9	21.0
5	8.0	20.0	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0	7.9	21.0
10	7.9	20.0	7.8	21.0	7.9	21.0	7.9	21.0	7.9	21.0	7.9	21.0
15	7.8	20.0	7.8	21.0	7.8	21.0	7.9	20.5	7.9	21.0	7.9	21.0
20	7.8	20.0	7.8	21.0								
and = @ depth	NA		NA		NA		NA		NA		NA	
AVG. =	7.9	20.2	7.8	21.0	7.9	21.0	7.9	20.9	7.9	21.0	7.9	21.0

GRAND AVERAGE: DISSOLVED OXYGEN (PPM) = 7.9
TEMPERATURE (CELSIUS) = 20.8

PERCENT SATURATION = 85.0

Appendix C. Online Visitor Use Survey Questionnaire

ONLINE RECREATION SURVEY
Racine Hydroelectric Project (FERC No. 2570)
Recreation Survey Questionnaire

AEP Generation Resources, Inc. (AEPGR) is the licensee, owner, and operator of the 47.5 megawatt (MW) Racine Hydroelectric Project (Project or Racine Project) which is licensed by the Federal Energy Regulatory Commission (FERC). There is one FERC-approved recreation facility associated with the Project, which is located immediately downstream of the Project. The current operating license for the Project was issued on December 27, 1973, and expires on November 30, 2023. AEPGR must file its application with FERC for a new license no later than November 30, 2021. As part of the relicensing process, AEPGR is conducting studies on environmental resources to enable FERC to prepare an environmental document. The purpose of this survey is to collect information about use of the Project's FERC-approved recreation facility.

Recreation Location:	**Racine Tailwater Fishing Access and Picnic Area**		
Home Zip Code:	_____	**Date:**	_____
Age:	_____		_____
Are you:	**Male** ☐	**Female** ☐	**Prefer not to answer** ☐

Q-1. Regarding the Racine Project area, do you consider yourself: (**Please circle one)**

1. A regular visitor to this area (*3 or more times per year*)
2. An occasional visitor (*1-2 times per year*)
3. An infrequent visitor (*Less than 1 time per year*)
4. This is my first visit

Q-2. On this trip to the Racine Project area, when did you arrive?

Arrival Date **Arrival Time**

_____/_____/_____ _____AM/PM

When did you/or do you expect to leave the Racine Project area?

Departure Date **Departure Time**

_____/_____/_____ _____AM/PM

Q-3. During the last 12 months (including this trip), which month(s) did you visit the Racine Project area? **(Please select all that apply)**

Jan ☐ Feb ☐ Mar ☐ Apr ☐ May ☐ Jun ☐ Jul ☐ Aug ☐ Sep ☐ Oct ☐ Nov ☐ Dec ☐

Q-4. About how many miles did you travel to get to the Racine Project area?

A. _____miles

Q-5. Are you staying overnight in the Racine Project area (not including at your own home) on this trip?

1. Yes 2. No

Q-6. If you answered yes to **Q-5**, at what type of accommodations will you be staying? (**Please select one)**

1. RV/Auto/Tent Campground
2. Motel/hotel
3. Bed and Breakfast
4. Vacation or rental home
5. Other (Please specify: _____)

Q-7. On this trip to the Racine Project area, in which of the following activities did you participate in? (**Please select all that apply**)

1. Bank fishing	5. Picnicking	8. Hunting
2. Boat fishing	6. Swimming	9. Wildlife viewing
3. Pleasure boating	7. Sight-seeing	10. Other (please describe)
4. Canoeing/kayaking		

Q-8. Of the activities you circled in Q-7 above, what is the primary activity that you participated in on this visit? (Please write in the corresponding number **from above**)

A. Primary activity # _____

Q-9. If you specified that fishing is the primary activity you participated in please rate the following:

	Totally Unacceptable	**Unacceptable**	**Neutral**	**Acceptable**	**Totally Acceptable**
Safety	1	2	3	4	5
Enjoyment	1	2	3	4	5
Crowding	1	2	3	4	5
Overall Experience	1	2	3	4	5

Q-10. If you participated in recreational activities in the Racine Project area today or in the past, please rate the following:

	Racine Tailrace Fishing Access and Picnic Area
Accessibility	
Parking	
Crowding	
Safety	
Condition of Recreation Facilities	
Available Facilities	
Overall Experience	

Q-11. Please tell us what type(s) of recreation enhancements you believe are needed at the Racine Project.

Description of recreation enhancement:

_____
_____
_____
_____

Q-15. Please share any other comments that you have regarding recreation near the Racine Project:_____
_____
_____
_____
_____
_____
_____
_____

Thank you for completing the Recreation Survey!

Appendix D. West Virginia Department of Natural Resources Mussel Summary Data Sheet

Mussel Survey Summary Data Sheet

Section A

1. Collector Name: **2. Permit ID:**

1b. Surveyor(s) (Last Name, First, MI) **1c. Company:**

3. Stream Name:

4. Site Name:

5. Date: MM/DD/YYY

6. Project:

Section B: Survey Method	Section C: Survey Time & Area	Section D: Surveys Conducted
○ Waterscope	Total Effort (min) _____	○ Transects
○ SCUBA /SSA	Total Area (m^2) _____	○ Cells
○ Snorkel		○ Quantitative with excavation
○ Other_____		○ Qualitative

Section E Species	Area					Total Number Live	Fresh Dead	Weathered Dead
Search Effort (min)								
Search Area (m^2)								

NOTES

1/8/2018