WATER QUALITY REPORT

Mahoning Creek Hydroelectric Project

Armstrong County, Pennsylvania
FERC Project No. P-12555

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TABLE OF CONTENTS

TABLES

PLATES

1.0 INTRODUCTION

1.1 PROJECT LOCATION AND DESCRIPTION

Mahoning Creek Dam is located in Armstrong County, Pennsylvania, on Mahoning Creek, 22.9 miles upstream of its confluence with the Allegheny River at Allegheny River mile 55.5. It controls 340 square miles of the total 425 square mile drainage area of Mahoning Creek. Including a parapet wall reduced from an original height of 4.5 feet to a height of 2.9 feet in 1986, it is a 163.6 feet high concrete gravity structure. Initial work on the dam began in November 1938 and the dam was essentially completed and operational by June 1941, though the final phases of construction were not completed until 1951.

From the perspective of water quality, important structural features of the dam are the low intake elevations of the outlets. The elevations of these outlets influence thermal and chemical stratification patterns in the reservoir, which in turn affect the quality of water being released. The outlet works consist of five conduits extending through the dam. Three main sluices, 5 2/3 feet wide by 10 feet high, are located at the center of spillway monoliths 11, 12, and 13 at invert elevation 1015 feet National Geodetic Vertical Datum (NGVD). There are two low flow conduits with 4 feet diameter openings, one located at the center of spillway monolith 10, at invert elevation 1021 feet NGVD, and the other at the center of abutment monolith 9, at invert elevation 1025 feet NGVD. Water discharged through both low flow conduits is controlled by electric motor operated, 24 inch, square bottomed, gate valves, and hand operated 36 inch emergency gate valves.

In the center of the left abutment monoliths 15 and 16, there are two identical 9 feet diameter plugged hydropower penstock openings. They both have a center line outlet elevation of 1034.03 feet NGVD. At the inlet they are both sealed with 13 feet diameter, 8 feet thick concrete plugs.

Because of its present and future potential impacts on gas exchange processes and re-aeration, features of the stilling basin below Mahoning Dam are also very important from the perspective of water quality. Features of the stilling basin include two rows of four feet high concrete floor baffles located 60.5 and 74.0 feet downstream of the spillway monoliths and a stilling weir located further downstream. The stilling basin is 180 feet wide and the length of the basin is 271 feet from the axis of the dam to the termination of the stilling basin at the four step end sill, and 950 feet to the 17.5 feet high stilling weir (crest elevation 1019.5 feet NGVD).

At its currently regulated minimum summer pool elevation of 1098 feet NGVD, Mahoning Creek Lake is a 6.2 mile long, 280 acre surface area impoundment, which stores 9,500 acre feet of water, or 0.53 inches of equivalent runoff from its 340 square mile drainage basin. At its full pool elevation of 1162 feet NGVD, the lake is 19.5 miles long with a surface area of 2,370 acres, and a storage capacity of 74,200 acre feet, or 4.09 inches of equivalent runoff. At the regulated minimum winter pool elevation of 1075 feet NGVD, the impoundment is 4.0 miles long. The surface area of the lake is 170 acres, and its volume is 4,500 acre feet, or 0.25 inches of equivalent runoff. The project was originally operated year-round with a minimum pool elevation of 1075 feet NGVD. In 1980, the storage schedule was modified to provide for summer season recreation by raising the summer pool to elevation 1098 feet NGVD.

Mahoning Creek Lake project lands total 2,953.9 acres: 351 acres of streambed, 83.5 acres of flowage easements, and 2,519.4 acres owned in fee. Of these, 860 acres are out granted to the Pennsylvania Fish and Boat Commission and 1,280 acres to the Pennsylvania Game Commission for fish and wildlife management, respectively. An additional 28 acres are leased to

Armstrong County for the Milton Loop Recreation Area. The Milton Loop facility includes a boat launching ramp and 52 campsites. The Corps of Engineers maintains a picnic area near the dam, and an outflow fishing area. Annually, there are about 125,000 recreation visitations to the project. Local relief, especially in the lower portion of the project, is quite steep and access to the lake is limited. Because the impoundment is too narrow to safely accommodate power boating, and to preserve the scenic and wild atmosphere of the lake, there is a 10 horsepower boating restriction.

Mahoning Creek Lake and Dam were authorized by the Flood Control Act of 22 June 1936 (Public Law No. 738, 74th Congress, Report No. 8455, Section 5), as modified by the Flood Control Act of 28 June 1938 (Public Law No. 761, 75th Congress, 3rd Session, Report No. 10618, Section 4). The original and primary purpose for the construction of Mahoning Creek Dam was to reduce flood stages along lower Mahoning Creek, the lower Allegheny River, and the upper Ohio River valleys. In 1980, the storage schedule was modified to provide for the summer recreation pool.

The Mahoning Creek Hydroelectric Company, LLC (MCHC), proposes to install and operate hydroelectric generation facilities at the existing Mahoning Dam on Mahoning Creek in Armstrong County, Pennsylvania. The “Project” will generate “green” and renewable energy for up to 4,400 homes. The Project will make use of the existing Mahoning Dam to minimize environmental impacts. Mahoning Dam was constructed by the U.S. Army Corps of Engineers (USACE) and the dam is presently, and will continue to be, owned and operated by the USACE. Existing facilities at Mahoning Dam will be used as much as possible, including an existing power conduit built into the dam specifically for the purpose of future hydroelectric generation. The Project requires a license from the Federal Energy Regulatory Commission (FERC). Plate 1 illustrates the Project site location.

The electricity generated by this Project will be prospectively fed into the PJM System, which is the regional public utility transmission system. The electricity generated by this Project is not designated for any specific purpose. Proposed project facilities and components include a new powerhouse, turbines, generators, penstock, intake structure, reuse of a service road, and transmission line. The transmission line will utilize or upgrade an existing transmission line to the Belknap substation for most of the transmission line route. The Project will utilize an existing unpaved service road for access to the powerhouse location.

The Project will be operated using only regulated discharges from Mahoning Dam, as dictated and managed by the USACE (nominal “run-of-the-river” operations within USACE operating guidelines). The Project will utilize these USACE-controlled discharges to generate power. Project operations for hydropower production will not change management of water levels in Mahoning Creek Lake, the impoundment formed by Mahoning Dam. There will be no pooling or peaking power operations under either of two (2) powerhouse location alternatives being considered. The nominal run-of-the-river mode minimizes adverse impacts to aquatic resources in Mahoning Creek due to changes in water level elevation in the impoundment while providing natural river flows downstream of the project.

Two powerhouse location alternatives being considered are Alternative A and Alternative B. The alternatives differ primarily in the location of the proposed powerhouse and location of the discharge from the powerhouse back to Mahoning Creek. Regardless of the alternative selected, any flows in excess of project capacity will continue to be released through the dam.

In Alternative A, the powerhouse and return flow will be located about 200 feet downstream of the existing dam. The flow will return to the stilling basin, which is immediately below the dam and which presently receives water discharged from the dam. Alternative A will not change the total flow that discharges to the stilling basin or water levels in the stilling basin. Some of the flow to the stilling basin will be diverted through the powerhouse and the remainder will still be discharged from the dam. The water discharged from the powerhouse will have lower velocity than water discharged from the dam. The water levels in the stilling basin are controlled by a stilling weir at the downstream end of the stilling basin and total flow to the basin. Alternative A will not change water levels in the basin, total flow to the basin, flow over the weir or flow downstream of the weir.

In Alternative B, the powerhouse would be located about 1,000 feet downstream of the dam and just downstream of the stilling basin weir. Water used for power generation would return to Mahoning Creek just downstream of the stilling basin weir. As a result, there would be a decrease in the total flow to the stilling basin and over the stilling basin weir. Under Alternative B the minimum water level of the stilling basin would not change since it is controlled by the elevation of the stilling basin weir. The average and maximum water levels of the stilling basin may decrease somewhat since flow through the basin would be less. The flow over the stilling basin weir would decrease and the distribution of flow downstream of the stilling weir would change since some water that otherwise would go over the weir would be discharged from the powerhouse just downstream of the weir. Alternative B would require a longer penstock since the powerhouse would be further away from the dam.

The water quality study presented in this report was conducted according to a FERC reviewed and approved plan, *Water Quality Work Plan*, *Appendix C of the Revised Study Plan, Mahoning Creek Hydroelectric Project, Armstrong County, Pennsylvania, FERC Project No. P–12555*, *September 2006*. This *Water Quality Work Plan* is one of several individual work plans submitted as part of the *Revised Study Plan, Mahoning Creek Hydroelectric Project* submitted to the FERC. *The Revised Study Plan* provides the FERC and other parties with proposed studies to gather site-specific information necessary for the environmental analysis section of the draft license application; the FERC's scoping document, and the environmental assessment under the National Environmental Policy Act (NEPA).

Additional information on the proposed Project is presented in the *Preliminary Application Document* (PAD) (submitted to the FERC by MCHC on December 27, 2005) and the Scoping Document (SD1) which was prepared by the FERC. Other study plans are presented in the *Revised Study Plan*, of which the *Water Quality Work Plan* is a part. The PAD, SD1, and a complete copy of the *Revised Study Plan* are available on the FERC's website at http://elibrary.ferc.gov/idmws/docket_search.asp . (Note: Select "docket search" and enter "P-12555 for Docket Number.)

1.2 REGULATIONS AND STUDY PLAN DEVELOPMENT PROCESS

MCHC was issued a Preliminary Permit effective March 1st, 2005 and is following the Integrated Licensing Process (ILP) to apply for FERC licensing for this Project. The contents of the Study Plan are specified by FERC regulations in 18 (CFR) Part 5, Section 5.11:

- Description of study and method.
- Schedule.
- Provision for progress reports.
- Reasons for not adopting a requested study.
- Provision for initial and updated study reports and meetings.
- Goals and objectives.
- Relevant resource management goals of agencies/tribes with jurisdiction.
- Description of existing information and need for additional information.

- Nexus between project operations, effects, and informing license requirements.
- Justification for methods and schedule.
- Cost.
- Proposal for study plan meeting.

Overall *Revised Study Plan* objectives, scope, and schedule are presented in the *Revised Study Plan*. The reasons for not adopting any requested study are discussed in Section 1.7 of the *Revised Study Plan*. A definition of the study area for the water quality study components is included in this individual Work Plan.

1.3 HISTORY OF STUDY PLAN DEVELOPMENT

The PAD and SD1 identified several studies needed to complete environmental evaluations. Additionally, MCHC and FERC coordinated a Study Plan Workshop and the Project Scoping Document 1 (SD1) meetings on March 22 and March 23, 2006, that were open to public agencies, tribes, special interest groups, and the general public. These groups had until April 26, 2006, to submit formal comments on the PAD, the FERC's SD1 and the study requests. Several agencies, interested groups, and individuals submitted study requests as outlined in Section 2 of the *Revised Study Plan*.

Study requests relevant to this individual Work Plan include comments from the following:

- US Fish and Wildlife Service (USFWS) – Accession No. 20060426-5044

These comments are summarized in Table 2 of the *Revised Study Plan*. Complete copies of the study requests are available on the FERC's website at http://elibrary.ferc.gov/idmws/docket_search.asp. (Note: Enter "P-12555" for Docket Number and search for the unique Accession No. noted above for individual documents).

Additional information on the more recent history of study plan development is contained in Section 4.1 of an appendix entitled "Provisions for *Initial Study Plan* Meeting, Initial and Updated Study Reports, and Other Meetings." Also, in terms of an historical perspective, on January 26, 1984, FERC issued an Order Issuing License to Atlantic Power Development Corporation for retrofit hydropower at Mahoning Dam (FERC 3228-001). This license was later terminated. On May 7, 1990, the project was re-licensed to Mahoning Hydro Associates (FERC 10521-007) which license was then surrendered March 16th, 1994.

2.0 WATER QUALITY STUDY

2.1 GOALS AND OBJECTIVES

The goal of this study was to assess the effects of the proposed Project on water quality in the impoundment in the area of the proposed intake structure, in the stilling basin, and Mahoning Creek downstream of the stilling basin. Appropriate tables and graphs were used to address these objectives.

The work plan focuses on the impacts of proposed hydroelectric power generation at the Mahoning Dam compared to the No-Action alternative. The No-Action alternative is the Project not being constructed, and the site remaining as it is currently (i.e., the dam would remain in place). The proposed study focuses on impacts of the Project, not on impacts of the dam except as necessary to identify impacts of the project. It is beyond the scope of this Project to investigate portions of the impoundment beyond the area of the proposed intake structure.

Objectives:

- Define baseline water quality conditions in the impoundment. This includes a temporal evaluation of the vertical distribution of water temperature, dissolved oxygen (DO), total dissolved gases (TDG), turbidity, hydrogen sulfide, and selected metals concentrations in the surface and subsurface of the impoundment.

- Define the baseline water quality conditions (including DO, temperature, total dissolved gas, turbidity, and hydrogen sulfide) in Mahoning Creek, in the stilling basin, and downstream of the stilling weir.

- Describe the projected water flow regimes in the stilling basin and downstream of the stilling weir discharge location and compare these to the “No Action” alternative.

- Use predictive modeling to describe the potential impacts to DO, temperature, hydrogen sulfide, total dissolved gas, and turbidity at the following locations:

    - In the impoundment near the intake after the Project is operational
    - In the stilling basin between the dam and Powerhouse Alternative A (for Alternative A)
    - In the stilling basin between Powerhouse Alternative A and the stilling weir
    - Downstream of the stilling weir discharge location after the Project is operational
    - In Mahoning Creek approximately 200 feet below the discharge from Powerhouse Alternative B (under Alternative B)

- Compare the existing and pertinent water quality parameters (existing and predicted) to State water quality standards.

- Evaluate the potential for the discharges from the two powerhouse alternatives to increase stream bank erosion relative to the No-Action alternative.

- Evaluate the feasibility and cost of a flexible operational mode and/or aeration methods to improve downstream DO concentrations.

2.2 NEXUS BETWEEN PROJECT OPERATIONS AND EFFECTS

Construction and operation of the Project consists of the addition of a subsurface intake structure and a change in discharge location and discharge velocity. The project will use water only for generation of electricity and will not involve consumptive use of water or diversion of water from Mahoning Creek drainage basin. This *Water Quality Report*, with other related studies, will provide necessary information to assess the effects of the Project on water quality in the area of the proposed intake and downstream of the dam.

Potential impacts that may typically result from projects such as this include: changes to total flow and impoundment water levels, downstream water usage and water rights, physical and chemical impacts on aquatic habitat. For this project, however, there are anticipated to be no impacts to *total* flow (although flow through the stilling basin would be altered), impoundment water levels, and water use and water rights as described in detail, below.

The results of this study will aid in the design of the Project to avoid or minimize impacts to these resources and help develop an in-stream flow license condition that incorporates multiple purposes (the needs of the aquatic ecosystem, water quality standards, hydropower generation, recreation, etc.).

Under Powerhouse Alternative A, river flow will not change except where the discharge enters the stilling basin. The first 800 cfs of the USACE controlled discharge will be utilized for hydropower and released approximately 200 feet downstream of the dam and immediately downstream of the proposed powerhouse rather than at the foot of the dam. The total flow into the stilling basin and water elevation will remain the same as the No-Action alternative. Under Powerhouse Alternative B, an agreed upon minimum flow will continue to enter the stilling basin at the dam and the water utilized by the hydropower operation will be discharged approximately 1,000 feet downstream of the dam at the location of the proposed powerhouse. A minimum water level will be maintained in the stilling basin during low to moderate flows, as determined by the elevation of the weir at the end of the stilling basin and the dam's flow release schedule. Both alternatives provide that USACE controlled operations will not change relative to the No-Action alternative. Thus, water levels in the stilling basin will continue to increase during large storm events or controlled releases over 800 cfs, and flow in excess of project capacity will continue to be released through the dam.

The Project will not have a significant impact on water use and water rights. The right to use the land, power conduit, and water will be provided by an agreement to be negotiated between MCHC and the USACE during the next phases of the ILP/Licensing Process. The Project is not within a navigable reach of Mahoning Creek and neither the hydraulics nor downstream navigation in Mahoning Creek or the Allegheny River will be adversely impacted. The affected portion of the river is within the Project Area and within the area to be covered by the agreement with the USACE. The proposed operations will not change river flow except for where the discharge enters the river within the first 1,000 of the dam, so riparian water rights downstream of the project will not be affected.

Aquatic biota may be impacted by the Project through physical means, changes in water quality, and changes in habitat area. Operation of the proposed intake structure has the potential to impact juvenile and adult fish in the impoundment through impingement or entrainment. During periods of stratification of the impoundment, water containing lower levels of dissolved oxygen (DO) could be released to Mahoning Creek downstream of the powerhouse (see Section 3.3.3). Lower DO levels may lead to reduced fish growth and fish survival. MCHC will investigate potential use of aeration methods or flexible operational modes to maintain downstream DO concentrations at agreed upon levels. The area of habitat for fish and benthic macro-invertebrates in the stilling basin will not change under either alternative.

2.3 DESCRIPTION OF EXISTING INFORMATION AND NEED FOR ADDITIONAL INFORMATION

The results of previous water quality studies of the Mahoning Creek in the vicinity of the Project Area are presented in the 1993 Mahoning Creek Lake, Reservoir Limnology, Aquatic Life and Water Quality Report (the Limnology Report)[1], are summarized in the *Preliminary Application Document* (PAD), and are briefly summarized here. Past Mahoning Creek Lake limnological surveys included vertical sampling of the impoundment, impoundment inflows, and impoundment discharge to the stilling basin for approximately 50 different parameters, including temperature, DO, nutrients, metals, chlorophyll, and phytoplankton composition and concentration. The USACE used the water quality model CE-QUAL-R1 of the pool and outflow to demonstrate potential water quality impacts of higher elevation hydropower withdrawal from the lake associated with a previous hydroelectric proposal at Mahoning Dam.

Previous water quality studies have shown that Mahoning Creek Lake does not develop the well-defined patterns of thermal stratification that would be expected in a natural lake of similar dimensions in this area. Only a gradual vertical thermal gradient has been observed in the lake. Among the factors that influence its temperature and limit the development of stronger and more persistent patterns of summer thermal stratification are its short hydraulic retention time, and the low elevation from which waters are withdrawn from the lake. Because the existing outlets at the dam withdraw from the deepest strata of the lake, the coolest deeper waters of the lake are constantly being withdrawn and discharged to the stilling basin during the summer. The stratum occupied by the cool discharge waters is then subsequently replaced by layers of overlying warmer waters. This tends to weaken thermal stratification and warm the impoundment during the summer season[2]. Since 1980, hypolimnetic (bottom water) anoxia has become more characteristic of the deeper waters of the lake during the summer. This is attributed to the increased hydraulic retention times in Mahoning Creek Lake that resulted when the Summer Pool elevation was raised by 23 feet in 1980. This has also directly and indirectly influenced the concentrations and distribution of metals in the impoundment.

Previous water quality surveys of Mahoning Creek Lake, specifically conducted during periods of summer season thermal and chemical stratification since the 1980 increase in summer pool elevation, include vertical water temperature and dissolved oxygen concentration profiling by the USACE at Station SA 6 on 1 July 1985, 2 August 1985, and 5 September 1985, Julian Days (JDs) 182, 214, and 248, respectively. The results of these three 1985 surveys were used by the USACE to calibrate their 1993 CE-QUAL-R1 model of the potential impacts of retrofit hydropower development at Mahoning Creek Dam and will be examined in the following discussion. Other USACE surveys of interest which included dissolved oxygen vertical profiles at Station SA 6 were conducted on 10 July 2003 (JD 191), 13 August 2003 (JD 225), 24 September 2003 (JD 269), 3 July 2006 (JD 184), and 19 July 2006 (JD 200). Except for the two 2006 surveys, approximately near surface, mid-depth, and near bottom samples for metals were collected by the USACE for reference and comparison with the results of the 2007 MCHC study. The USACE also has records of numerous water temperature only vertical profiles collected at this station.

[1] Mahoning Creek Lake, Reservoir Limnology, Aquatic Life and Water Quality, 1993. U.S. Army Engineer District, Pittsburgh Corps of Engineers, Pittsburgh, Pennsylvania.
[2] Mahoning Creek Lake Reservoir Limnology, Aquatic Life and Water Quality, 1993. U.S. Army Engineer District, Pittsburgh Corps of Engineers, Pittsburgh, Pennsylvania.

According to information on the EPA's website[3] two tributaries to Mahoning Creek upstream of the impoundment are impaired with metals contamination. Although the overall water quality of Mahoning Creek has improved in recent years due to efforts to control the impacts of acid mine drainage from tributaries to Mahoning Creek[4], the concentrations and distribution of metals within the impoundment remain a concern. Metal concentrations in the hypolimnion during the summer may be increased due to depressed DO concentrations experienced with the higher summer pool elevations. Results of previous studies show a tendency for total iron, total manganese, total aluminum, total copper, total nickel, total acidity, ammonia nitrogen, Kjeldahl nitrogen, apparent color, suspended solids, and turbidity concentrations to increase with depth. Conversely, water temperature, and DO values tended to decrease with depth.

In spite of withdrawal of low oxygen hypolimnetic waters from the impoundment during summer stratification, high DO concentrations were measured at a series of stations starting at the toe of the dam and extending to the stilling basin weir. A mean outflow DO concentration of 9.8 mg/l suggests that turbulent re-aeration to near DO saturation concentrations occurs immediately where the water discharges to the stilling basin.[IBID] In order to evaluate the water quality impacts of a proposed change on the withdrawal zone of Mahoning Creek Dam, the USACE ran a series of CE-QUAL-R1 water quality model simulations of various hydropower operational scenarios. Model results suggest that minimum outflow DO criteria may not be achieved in the absence of engineering controls with previous and currently proposed hydroelectric operations.

Additionally, the USACE expressed concern in their 1993 report that a higher elevation intake associated with one of the 9-foot diameter penstock openings (intake invert elevation of 1,050.5 feet NGVD) might adversely affect the quality of outflow waters due to high summer hypolimnetic metals concentrations. Without engineering controls (e.g., a variable elevation intake system), flows would be withdrawn from the lake from 1,050.5 feet NGVD, which is 25.5 feet higher than the inlet invert elevations of the dam's current two low flow discharge conduits. Warmer and less dense summer inflows to the impoundment could flow to the penstock intake over the colder, denser deep waters, leaving the water in the deeper portions of the lake undisturbed.[IBID] This could further increase hydraulic retention times of the deep waters which could further influence the concentration of metals in the deep strata.

During the licensing process for the previous hydroelectric project, FERC staff compared the benefits of various alternatives to meet various DO and fishery objectives. The total project benefits were maximized with the project maintaining a DO level of 6.0 mg/l. However, the USFWS and PFBC recommended that downstream DO levels be maintained at pre-project levels to protect fishery resources in Mahoning Creek, notably cool water walleye and smallmouth bass. FERC determined that the USFWS and PFBC request to require the project proponent to maintain DO at pre-project levels was inconsistent with Sections 4(e) and 10(a) of the Federal Power Act (Act). Accordingly, the previous FERC license required the maintenance of 6.0 mg/l DO[5]. USEPA studies have shown non-degradation of warm water fisheries of 6.5 mg/L. This has been adopted by FERC at other project locations[6].

A water quality study was recommended for the MCHC project to obtain more current lake and river data. Because the hydraulic retention time of this lake is so short, inflow-outflow controlled horizontal water movements in the lake become very important; therefore, vertical profile information is recommended to verify that stratification patterns are similar to conditions

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[3] Information gleaned from TMDL data available at the EPA's website http://oaspub.epa.gov/pls/tmdl/enviro.control?p_list_id=PAAMD17D_47974&p_cycle=2002.

[4] Personal communication, Mike Fowles, Fish and Wildlife Specialist, USCOE.

[5] FERC Order Issuing License, May 7, 1990. Mahoning Hydro Associates, FERC Project No. 10521-000.

[6] http://www.ecy.wa.gov/pubs/0410022.doc http://www.ecy.wa.gov/programs/wq/swqs/supporting_docs/summary_discussion.pdf (example).

previously modeled. In accordance with the FERC approved plan, if the model results are shown to still be predictive, then potential water quality impacts with MCHC's proposed operating conditions can be assessed using the existing model outputs. An engineering study was also recommended to investigate potential use of an aeration facility or flexible operational modes to maintain downstream DO concentrations at agreed upon levels.

2.4 RESOURCE MANAGEMENT GOALS OF AGENCIES/TRIBES WITH JURISDICTION

The mission of the USFWS is to ensure the protection of federally endangered and threatened species in accordance with the Endangered Species Act of 1973 to ensure the protection of fish and wildlife resources in accordance with the Fish and Wildlife Coordination Act.

The mission of the PFBC is to provide fishing and boating opportunities through the protection and management of aquatic resources. The PFBC's Division of Environmental Services (DES) has a "proactive program" in which PFBC staff work with expert scientists and engineers from a variety of disciplines to insure that the aquatic resources (both game and non game) which live in Commonwealth waters remain protected. PFBC DES staff review permit applications, environmental laws and regulations, and provide comment on water quality, habitat and instream flow protection issues and advise other internal PFBC program areas about environmental issues.

The USACE has to provide safe operation of the dam while evaluating effective and beneficial use of USACE managed lands and waters. The USACE environmental mission has two major focus areas: restoration and stewardship. Efforts in both areas are guided by the Corps' environmental operating principles which balance economic and environmental concerns. The USACE values water resources for their natural beauty; for the many ways they help meet human needs; and for the fact that they provide habitat for plants, fish and wildlife. The USACE has the responsibility of helping to care for these important aquatic resources and through its Civil Works program the Corps carries out a wide array of projects that provide coastal protection, flood protection, hydropower, navigable waters and ports, recreational opportunities and water supply.

The Mahoning Creek Dam was authorized by the Flood Control Acts of 1936 and 1938 and is one of 16 flood control projects of the USACE's Pittsburgh District. The original and primary purpose for the Mahoning Dam was to reduce flood stages along the lower Mahoning Creek, the lower Allegheny River, and the upper Ohio River. However, the pool elevation of the lake is increased in the summer months for recreation benefits and water quality downstream is a consideration for operational releases. The dam is presently and will continue to be owned and operated by the USACE. Mahoning Creek Dam was built with hydropower conduits for the eventual use of the dam for the production of hydropower.

3.0 METHODS

3.1 METHODS

In accordance with the *Water Quality Work Plan, Appendix C of the Revised Study Plan* of September 2006, a baseline assessment of select water quality parameters was performed during the summer of 2007 to determine current conditions in Mahoning Creek from the base of the dam to approximately 50 feet downstream of the stilling basin weir. Additionally, one station was established within the impoundment in the general location of the proposed intake structure. The results of the water quality samples collected under this task were intended to be compared with the output of the existing water quality model. Current river and lake data, MCHC's proposed operating conditions, and proposed intake design were considerations used to predict the impacts to water quality in the lake and the stilling basin. The study will also include a future engineering component that will evaluate a flexible operational mode and/or aeration facility to maintain downstream DO concentrations at agreed upon levels. Specific tasks are listed below.

- Sample the impoundment during two sampling events to determine current baseline water quality conditions. Samples to be analyzed for field and analytical chemistry parameters as noted below. This study includes a temporal evaluation of DO, temperature, turbidity, and hydrogen sulfide in the surface and subsurface of the impoundment.

- Sample the stilling basin and Mahoning Creek downstream of the stilling weir during two sample events to determine current baseline water quality conditions. Samples analyzed for field and analytical chemistry parameters as noted below.

Water Quality Sampling

The sample station locations (Sample Area or SA) and nomenclature follows the system developed for the "Aquatic Resource and Clubshell Mussel Study" (Appendix B of the Revised Study Plan). Plate 2 is a map that shows the locations of the stations. Photographs of the station locations are shown in Plates 3 to 6.

SA 1 is within the stilling basin. For the water quality sampling, the sample point was originally located at the end of the concrete wall on the south side of the stilling basin. This station is assumed to be representative of water quality within the stilling basin. As discussed under amendments, the location of this station and Station SA 2 were both subsequently moved to the north side of the stilling basin.

SA 2 is in the scour pool located downstream of the stilling basin weir on the south side of the channel in the area of the proposed discharge for Powerhouse Alternative B.

SA 6 is within the impoundment, in the deepest portion of the lake that is accessible upstream of the new trash boom upstream of the Mahoning Dam.

Water samples were collected from Station Nos. SA 1, SA 2, and SA 6 during two sampling events; 11-12 July and 27-28 August, 2007. As will be discussed later in this report, Stations SA 1 and SA 2 were both sampled from the left descending bank of Mahoning Creek during very low flow conditions on 11-12 July 2007. Because of much higher discharges from the dam, however, both of these stations were sampled from the right descending bank during the 27-28 August survey. Water samples were analyzed for the following parameters:

Laboratory Parameters

- Total Iron
- Ferrous Iron
- Total Manganese
- Total Aluminum
- Total Copper
- Total Nickel
- Hardness

Field Parameters

- pH
- Conductivity
- Temperature
- DO
- Turbidity
- Total Dissolved Gas
- Hydrogen Sulfide

Water sampling activities were collected according to United States Environmental Protection Agency (USEPA) water sample collection protocols.[9] The following general protocols were employed during water sample collection activities:

- Prior to arriving at the site, all field equipment was examined to verify that it was in good operating condition. The sampling equipment was washed with an aqueous cleaner, using elevated temperature and pressure as appropriate. After each use, the sampling equipment was washed with laboratory grade soap and rinsed in clean, distilled or de-ionized water.

- Field instruments were calibrated according to the manufacturer's instructions.

- Sample preservatives and containers were prepared and used as necessary to comply with USEPA requirements for analytes of interest.

- Field sampling crew members used a new pair of disposable latex or nitrile gloves at each location sampled, and changed them as appropriate when torn or soiled.

- Field Quality Assurance samples (Field Duplicate and Equipment Blank) were collected and submitted to the laboratory at a frequency of one duplicate per every 20 samples or at a minimum of one per sampling event. Field equipment blanks consisted of distilled water that had been routed through decontaminated sampling equipment and collected into the appropriate containers.

[9] Weber, C.I. 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. U.S. Environmental Protection Agency.

- Sample labels were completed at the time of sample collection, noting the site identification, sample location, sample depth interval (as appropriate), preservative, sample analysis, and sample date.
- For each sample collected, the applicable sampling procedure was recorded in the field notes or on a Sampling Data Sheet and laboratory chain-of-custody documentation and procedures were followed.

- Level 3 data quality laboratory and field protocols were used.

In-river samples were collected by sampling the river in a manner that minimized the disturbance of the riverbed sediments. Reservoir samples were collected from a boat using a subsurface sampling device (e.g., Kemmerer bottle) lowered to the appropriate depth. All samples were placed in the appropriate container (including preservative if appropriate) and then placed on ice in the field to keep them cool, prior to packaging and transport.

Field measurements were made at the time and location of sample collection. At sample locations SA1 and SA6, depth profiles of each of field the parameters were created by collecting measurements from the surface and at 5-foot intervals to the bottom of the water body.

Field water temperatures, dissolved oxygen concentrations, specific conductivities, pHs, and turbidities were measured with an YSI model 6820 Sonde w/650 display and 100 feet of cable. Field barometric pressure and total differential dissolved gas pressure measurements were collected with an Alpha Designs Tensionmeter Model 300 E. Field hydrogen sulfide measurements were collected with a Hach Hydrogen Sulfide Test Kit, Model HS-WR. Certificates of Calibration for these instruments from Field Environmental Instruments, Inc. and Alpha Designs In-Situ Brand are attached in Appendix A. Microbac Laboratories Inc. used EPA Method 200.7 to determine all total metals concentrations, with ferrous iron analyzed by SM Method 3500-FE D, and hardness by SM19 2340B.

Diurnal DO Monitoring

MCHC performed a diurnal DO study downstream of the dam at two locations by collecting DO samples as noted below. DO measurements were made in the stilling basin at Station SA 1 and very shortly before or thereafter at Station SA 2 at 11:00 AM, 5:00 PM and 9:30 PM on 11July and 2:30 AM, and 6:30 AM on 12 July 2007. During the 27-28 August survey, the Station SA 2 measurements were made at 11:00 AM, 4:15 PM, 9:15 PM, 2:15 AM, and 6:15 AM, and shortly before or thereafter at Station SA 1. The diurnal DO monitoring was performed on the two separate 24-hour collection events in conjunction with the other water quality sample events scheduled for July and August.

Water Quality Modeling

Potential water quality impacts were assessed under MCHC's proposed operating conditions using the existing CE-QUAL-R1 model outputs[10]. The MCHC modeling consultant used the results of the CE-QUAL-R1 model to undertake the following:

- Evaluate the hydraulics of the outflow with different flow and release scenarios.
- Predict impacts to DO, temperature, hydrogen sulfide, total dissolved gas, and turbidity at the following locations:

    - In the impoundment after the Project is operational

[10] The use of the existing CE-QUAL-R1 assumes that the model results are shown to be predictive.

- In the stilling basin between the dam and Powerhouse Alternative A
    - In the stilling basin between the Powerhouse Alternative A and the stilling weir
    - Downstream of the stilling weir discharge location after the Project is operational
    - In Mahoning Creek approximately 200 feet below the discharge from Powerhouse Alternative B (under Alternative B)
    - In the stilling basin under Alternative B

- Evaluate alternatives for addressing any deficiencies that will be identified.
- Assess water quality issues.
- Model vertical differences in the impoundment.

To mitigate potentially adverse impacts of the project on DO, temperature, hydrogen sulfide, and dissolved gas, MCHC will evaluate various engineering controls such as the utilization of a variable depth intake, turbine venting, air injection, or other means of re-aeration. Because the existing dam and existing USACE flood management operations would continue under both the Action and the No-Action alternatives, only those impacts associated with the build Project alternative relative to the existing condition will be described as potential impacts for mitigation.

The output of the next task will be a *Water Quality Technical Memorandum* which will contain the results of the water quality modeling. Tables and graphs will be utilized to quantify how the projected water quality would be different than the "No Action" alternative in the stilling basin and downstream of the stilling weir after the Project is operational. The existing and predicted pertinent water quality parameters will be compared to Pennsylvania's Warm Water Quality Standards.

The Technical Memorandum will also contain an evaluation of the potential for the discharges from the two (2) powerhouse alternatives to increase stream bank erosion relative to the No-Action alternative. It will also contain an evaluation of the feasibility and cost of a flexible operational mode and/or aeration facility to maintain downstream DO concentrations and other identified water quality issues.

The temporal scope for this analysis will be for the anticipated 50-year life of the license. The output from this task can be used to develop an in-stream flow policy that incorporates multiple purposes (the needs of the aquatic ecosystem, water quality standards, hydropower generation, recreational fishing, etc.).

Amendments

Based on the experiences of the first MCHC sampling event of July 11-12th, 2007, two minor amendments to the original study plan of September 2006 were recommended to FERC. FERC offered no objections to these recommendations and they were adopted for subsequent surveys.

RECOMMENDATION 1: Exact definition of the location of Station SA 1 in the stilling basin

In Section 3 of the plan it is stated that the location of Station SA 1 will be on the concrete wall on the south side of the stilling basin. There are several such concrete wall locations in the stilling basin. However, it was assumed that the intention of sampling from this station was to evaluate impacts from the stilling basin end weir, and the concrete wall referenced is the one on the downstream end of the basin just upstream of the end weir. This south wall location was accessed by wading the narrow chute downstream of the weir scour pool for sampling on July 11th and 12th of 2007, where samples were collected just to the outside of the left descending bank stilling basin outlet emergency bulkhead slot. While the chute below the end weir was wade able during the very low flow conditions of the July 11th and 12th, 2007 survey (75 to 89 cfs discharge from the dam), access during higher flow periods could be problematic, especially for night measurements as required during diurnal studies. Water quality measurements made during the very low flow, near worst case conditions of 11-12th July 2007 from just outside both the left and right descending bank stilling basin outlet emergency bulkhead slots demonstrated little or no difference between the north versus the south sides of the weir. Also, decades of Corps of Engineers data from the project has been collected from the north side of the stilling basin, and moving the location of the station from the south to the north side of the weir would provide not only higher degrees of safety and reliability, but also continuity with historical records. High flows encountered during the 27-28 August 2007 survey demonstrated, for the same reasons, that it was prudent to also move Station SA 2 to the right descending bank.

RECOMMENDATION 2. Timing of the second diurnal dissolved oxygen measurement

It is stated in Section 3.0 of the study plan that the vertical profiling of the impoundment will be performed in conjunction with the discharge monitoring. The first discharge monitoring was scheduled for 11:00 AM and the second for 3:00 PM. Experience from the 11-12 July 2007 survey showed that four hours is too short a time to complete the reservoir profile work and return to the discharge area for the second scheduled sampling event. It would be better if the second discharge sampling was moved back two or three hours to 5:00 or 6:00 PM. Also, a somewhat later second sampling time would better reflect late afternoon summer season diurnal dissolved oxygen maximums.

3.2 STUDY AREA

The Study Area of this Work Plan includes areas of direct and indirect effects from the proposed Project from the impoundment upstream of the dam, to downstream of the stilling basin weir, to Mahoning Creek at the crossing of PA Road T754. Specifically, for sample locations, the limits of study extend from the area between the trash boom in the lake upstream of the water intake structure at the dam to approximately 50 feet below the stilling basin weir.

There is no need to extend the sampling upstream of the proposed limits because of the following: 1) the proposed location is representative of the deep water areas of the impoundment, 2) the impoundment itself is not within the FERC “Project” boundaries, and 3) the Project will not have any impact on water levels in the impoundment (there is no provision for this Project to alter the USACE water level control regime). The water levels will continue to be controlled by the U.S. Army Corps of Engineers in the same manner as under the No-Action alternative.

There is no need to extend the Study Area downstream of the proposed limits as there is no logical reason for the water quality to change from the proposed downstream sampling station (SA2) until the location where the next tributary joins Mahoning Creek (Camp Run at PA Road T754).

3.3 JUSTIFICATION FOR METHODS

The proposed methods for the Water Quality study are standard methods for aquatic system based projects.

The CE-QUAL-R1 model was developed by the USACE to model the impacts of a previously proposed hydroelectric project and this methodology was accepted by the regulatory community. A conclusion of the 2006 FERC water quality study plan was that as long as the existing model can be shown to be reliably predictive, then the outputs from the existing model should be sufficient to accomplish the project objectives.

3.4 STAFF AND QUALIFICATIONS

MCHC procured the services of Koryak Environmental and Health Consultants (KEH), LLC to perform the water quality study and to examine the existing CE-QUAL-R1 model. Civil & Environmental Consultants, Inc. provided logistical support. Microbac Laboratories, Inc., of Warrendale, PA (PADEP State Laboratory Certification Number PADEP: 02-257) performed the chemical laboratory analyses. Michael Koryak, KEH, LLC lead limnologist, was involved with the water quality and fishery sampling activities in Mahoning Creek and Mahoning Creek Lake for the USACE, and was the principle author of the 1993 USACE report which evaluated the CE-QUAL-R1 modeling examination of the previously proposed hydroelectric project.

The firms selected to perform these activities were based on availability, cost, acceptability to agencies or other considerations.

4.0 SCHEDULE

4.1 Provisions for Initial Study Plan Meeting, Initial and Updated Study Reports, and Other Meetings

The *Initial Study Plan* was filed on June 8, 2006. Following this, the *Initial Study Plan* meeting was held within the required 30 days after the deadline date for filing of the *Initial Study Plan*, on June 28, 2006 at the Holiday Inn, Indiana, PA at 10:00 a.m. Comments received at the meeting were provided verbally by FERC; no other interested parties attended the meeting.

Study Plan follow-up meetings and discussions are required during a 90-day comment period (ending September 6, 2006) after the *Initial Study Plan* is filed in order to clarify and resolve any outstanding issues with respect to any of the individual work plans. Subsequent to the *Initial Study Plan* meeting, a meeting was held with the Pennsylvania Fish and Boat Commission (PFBC) on August 17, 2006. Comments made by PFBC are reflected herein where appropriate.

FERC provided comments in a letter dated September 5, 2006, and was the only agency that provided written comments during the comment period. Resolution of oral and written comments is provided in Table 3 of the *Revised Study Plan, Mahoning Creek Hydroelectric Project*, Armstrong County, Pennsylvania, FERC Project No. P-12555, September 2006.

The Water Quality Work Plan Appendix, together with the *Revised Study Plan,* was filed within the required 30 days from the close of the comment period (prior to October 6, 2006). From the date this revised document was submitted to FERC, interested agencies, Indian tribes and members of the public had 15 days to file comments. Within 30 days of document filing, the Director of the Office of Energy Projects issued a study plan determination that approves the study plan, with any needed modifications. If no notice of study dispute was filed within 20 days of the determination, the study plan is deemed to be approved and the studies will proceed as weather and climate permit. Additional information about upcoming milestones, changes to the work plans, and future meetings is periodically provided on FERC's website at http://elibrary.ferc.gov/idmws/docket_search.asp. Interested parties are requested to visit the website and perform a docket search for Project P-12555.

Information obtained from interested parties either directly or through the Study Plan meeting process is evaluated and incorporated as appropriate into the *Revised Study Plan* appendix.

4.2 Progress Reporting

Quarterly progress reports on each of the individual Work Plans, including this *Water Quality Study Report*, will be prepared to document progress toward implementation of the Study Plan. Text descriptions will be provided regarding progress related to each major task within each Work Plan. Agency or public interest group meetings and other major milestones will also be described. The progress reports will be provided to the USFWS (USFWS is the agency making the study plan request) and the FERC project manager, and will be posted on the FERC's website (see Section 4.1). Reports will be provided in PDF files or other appropriate format. A detailed schedule for implementation of this Study Plan is summarized in the table in Section 4.4, and is consistent with the overall schedule provided in the *Revised Study Plan,* Table 1.

4.3 PROPOSED SCHEDULE AND JUSTIFICATION

The water quality study field work took place during the summer of 2007. The vertical sampling was done during the period of summer stratification when the impoundment was thermally and chemically stratified. The diurnal DO study was conducted to coincide with the July and August 2007 water quality sampling events.

The initial work on the engineering evaluations will take place soon after the Work Plan is approved. However, as these tasks require inputs from the water quality sampling, they will not be finalized until the fall of 2007.

4.4 REPORTING AND SCHEDULE OF SUMMARY*

RESPONSIBLE ENTITY	MILESTONE OR ACTIVITY	DATE
Koryak Environmental and Health Consultants, LLC (Water Quality Consultant)	Perform Baseline Assessment • Sample during 2 events: SA 1, SA 2, & SA 6 (begin & end field work) • Sample DO: SA 1 & SA 3 (begin & end field work) Model Water Quality Impacts Prepare Technical Memo	July 2007 & August 2007 Same Late Aug 2007 – 10/4/07 10/5/07 – 11/5/07
MCHC, in consultation with Koryak Environmental and Health Consultants, LLC	Quarterly Progress Report 1 • Prepare report	6/30/07
MCHC, in consultation with Koryak Environmental and Health Consultants, LLC	Quarterly Progress Report 2 • Prepare report	9/30/07
MCHC, in consultation with consultants	Complete Initial Study Report	On or before 11/5/07 (365 days from study determination)

*Also see Table 1, "Preliminary Process Plan and Schedule," *Revised Study Plan, Mahoning Creek Hydroelectric Project*, Armstrong County, Pennsylvania, FERC Project No. P-12555, September 2006.

5.0 RESULTS

The results of the MCHC's 2007 limnological/water quality surveys of Mahoning Creek Lake and two Mahoning Creek Dam outflow stations are presented in Tables 1 to 8. Tables 1 and 2 show field parameter and laboratory parameter results, respectively, of July 11, 2007 five-feet vertical depth increment sampling at Station SA 6, Mahoning Creek Lake at the trash boom near the dam. Tables 3 and 4 show field parameter and laboratory parameter results for August 27th, 2007 with five foot depth increment sampling at the lake station. The results of diurnal monitoring of the stilling basin of Mahoning Creek Dam (Station SA 1) on July 11-12 and August 27-28, 2007, respectively, are shown in Tables 5 and 6. The results of diurnal monitoring of the riffle downstream of the stilling basin scour pool (Station SA 2) on July 11-12 and August 27-28, 2007, respectively, are shown in Tables 7 and 8. Summer season vertical dissolved oxygen profiles at Station SA 6, which were collected by both MCHC and the USACE between 1985 and 2007, are compared in Table 9. Similarly, concentrations of total iron, manganese, aluminum, copper, and nickel at near surface, mid-depth, and near bottom depths in the lake between 1985 and 2007 are compared in Table 10.

The July and August 2007 MCHC surveys captured some relatively wide extremes of summer season antecedent precipitation and flow conditions in the Mahoning Creek Lake drainage basin. For instance, District-wide, precipitation in May, June, and July of 2007 was only about 65% of normal, and the USACE was holding drought contingency meetings. In sharp contrast, prior to the late August 2007 survey, August monthly precipitation was already 180% of normal. The elevation of the pool of Mahoning Creek Lake was 1099.5 feet NGVD during the 11 July 2007 survey and 1104 feet NGVD during the 27 August 2007 survey. The discharge from the dam ranged from 75 to 89 cfs, receding, during the 11-12 July 2007 outflow diurnal monitoring period, and 960 to 890 cfs, receding, during the 27-28 August 2007 outflow diurnal monitoring period. To put these numbers into some perspective, average monthly inflows to the project for June, July, and August are 521 cfs, 513 cfs, and 252 cfs, respectively, and the average summer season inflow to Mahoning Creek Lake is 429 cfs. Ironically, the definitive antecedent low flow survey of 11 July 2007 occurred under 100% cloud cover and was punctuated by two very short duration but relatively intense precipitation events, which might have at least mildly influenced parameters such as photosynthetic activity and dissolved oxygen concentrations and outflow turbidity. In contrast, the 27 August 2007 antecedent higher summer flow survey actually occurred under clear-sky dry conditions.

5.1 VERTICAL STRATIFICATION PATTERNS WITHIN MAHONING CREEK LAKE

The results of vertical water quality profiles of Mahoning Creek Lake measured in July and August of 2007 are presented in Tables 1 to 4. Moderate thermal stratification patterns were evident during both summer season surveys. July water temperatures ranged from 26.7°C at the surface down to 22.6°C at the bottom of the lake (gradient 4.1°C). In August, vertical water temperatures ranged from 25.7 to 21.1°C (gradient 4.6°C). While water temperatures and thermal gradients were very similar during both surveys, the vertical distribution of other parameters suggests that convective limnological processes were important during the July antecedent low flow survey, and that advection processes were more dominant during the August antecedent higher flow survey, where an aerated lower conductance turbid interflow was evident at depths of about 20-35 feet beneath the surface, as well as a storm underflow at depths of about 60-75 feet. July dissolved oxygen concentrations ranged from a maximum of 9.5 mg/l at a depth of 10 feet down to a minimum of 0.7 mg/l at a depth of 65 feet. In August, the dissolved oxygen concentration at the surface of the lake was 8.8 mg/l and 6.5 mg/l near the bottom, with a minimum concentration of 5.9 mg/l at a depth of 45 feet. Relatively weak metalimnetic oxygen minimum patterns within the lake were evident at an elevation of about 1060 feet NGVD during both surveys. Total dissolved gas concentrations at the surface of the lake were 102.2% of saturation in July and 108.1% of saturation during the August 2007 survey. This difference was likely related to the fact that the July survey was conducted beneath 100% cloud cover with weaker algal photosynthetic activity, while photosynthetic activity and oxygen production was higher under clear skies in August. Phytoplankton photosynthetic activity might have also been accelerated in August by nutrients introduced to the lake by antecedent August storm runoff. Total differential gas pressure measurements (Δ P as mm Hg) from other depths are show in the tables, but not converted to % saturation because they occur under and relative to greater than atmospheric pressures. A thick fluff of very soft mud was encountered at a depth of 68 feet in July (pool elevation 1099.5 feet NGVD), and more consolidated mud at a depth of 76 feet during the August survey (pool elevation 1104 feet NGVD).

In Table 9, MCHC's 2007 vertical thermal gradient and vertical oxygen distribution data is compared with the water temperature and dissolved oxygen concentration results of eight previous USACE summer stratification season vertical profiles of the deepest portion of the lake near Mahoning Creek Dam, including 1985 data used to calibrate the USACE's CE-QUAL- R1 water quality model. As can be seen in this comparison, consistent with historical patterns, summer season thermal and chemical stratification patterns observed during 2007 in Mahoning Creek Lake are weak and unstable. Relative to other lakes of comparable size and depth in these latitudes, Mahoning Creek Lake could be characterized as being relatively warm. Among the factors that influence its temperature and limit the development of stronger and more persistent patterns of summer stratification are its short hydraulic retention time, and the low elevation from which waters are withdrawn from the lake. Because the outlets withdraw from the deepest strata of the lake, the coolest deeper waters of the lake are constantly being withdrawn and discharged downstream during the summer season. The stratum occupied by the cool discharge waters is then subsequently being replaced by layers of overlying warmer waters. All of the above tend to weaken stratification and warm the deeper waters of the impoundment during the summer season. As is clearly evident from comparison of the July 2007 very low flow survey and the higher flow August 2007 survey, this process is very sensitive and responsive to hydrometeorological conditions.

Vertical profiles of the concentrations of various metals demonstrated a tendency for total iron, total manganese, and total aluminum concentrations to increase with depth during the summer season periods sampled. July 2007 total iron concentrations increased from 0.04 mg/l at the surface to 0.31 mg/l at the bottom of the lake just above the sediment/water interface. Total aluminum concentrations increased from L 0.10 to 0.12 mg/l, and total manganese from 0.02 to 0.46 mg/l. There were no detections of ferrous iron at any depth during the July low flow survey. The higher antecedent inflows to the lake in August generally introduced more turbid water and higher concentrations of total iron (0.02 to 0.84 mg/l) and total aluminum (L 0.10 to 0.52 mg/l), as well some low concentrations of ferrous iron (maximum 0.17 mg/l). Conversely, the higher August flows appeared to both disrupt hypolimnetic manganese accumulation processes and blowout accumulated hypolimnetic manganese from the impoundment. During the August survey, no concentrations of manganese greater than 0.10 mg/l were encountered at depths above 70 feet and the maximum manganese concentration near the sediment/water interface was only 0.21 mg/l. In Table 10, the 2007 Mahoning Creek Lake metals distribution data is compared with the results of the seven USACE vertical profiles of the lake which included sampling for metals. As can be seen from this comparison, the 2007 concentrations of iron, manganese, and aluminum all fall within the range of historical project conditions, and generally again confirm the USACE observations that chemical stratification pattern within the lake are weak and unstable, metal concentrations in general are low, and the quality of project waters could be characterized as excellent.

No strata of the impoundment were totally anaerobic during either survey, and concentrations of hydrogen sulfide never exceeded limits of detection. There were no detections at all of either copper or nickel at any station during either 2007 survey of the lake. Some relatively high concentrations of copper and a few minor positive detections of nickel were measured by the USACE at Mahoning Creek Lake in 1985, which then raised concerns about potential trace heavy metal contamination problems at the project. However, subsequent monitoring by the USACE in 2003 and by MCHC in 2007 failed to detect either trace heavy metal in concentrations of concern. The only detections of either of these trace metals in 2007, both a barely detectable concentration of 0.01 mg/l, were in the 27th August 2007 field blank, indicating trace contamination of the distilled water, probably from the supplier's metal still. Metal polluted acid mine drainage from old bituminous coal mines and/or an industrial/transportation center (Punxsutawney, PA) upstream of the project might have previously contributed trace heavy metal contaminants to project waters. However, as discussed in great detail in the 1993 USACE report, acid mine drainage and industrial pollution problems have been largely abated in the watershed, and there is now probably little reason for any continued concern about trace metal contaminates in Mahoning Creek Lake.

5.2 MAHONING CREEK DAM OUTFLOW WATER QUALITY AND DIURNAL VARIATION

Outflow water quality parameter results are presented in Tables 5 to 8 and show only minor variations above and below the stilling basin weir and over diurnal sampling periods. Even during the 11-12 July 2007 very low flow survey, measured outflow water temperatures varied only from an afternoon high of 22.6°C down to a 2:00 AM low of 21.1°C (1.5°C diurnal variation). Dissolved oxygen concentrations varied only from an 8.84 mg/l afternoon maximum down to a 2:00 AM minimum of 8.16 mg/l (0.68 mg/l diurnal variation), indicating that hydraulic re-aeration, rather than diurnally sensitive photosynthetic activity, is the dominant local outflow influence on this parameter. Conductivity was steady between the narrow range of 386 to 395 µmhos/cm, pH between 7.61 and 7.79 units, and turbidity between 2.2 and 3.4 NTUs. While total manganese concentrations were moderately elevated, 0.96 mg/l at Station SA 1 and 1.35 mg/l at Station SA 2, the concentrations of other metals at the outflow stations ranged from non-detectable to low. Hydrogen sulfide concentrations were consistently below limits of detection at all stations during both surveys. With one exception, ferrous iron concentrations were below limits of detection at all depths and stations during July. This exception was a barely detectable positive measurement of 0.05 mg/l ferrous iron at station SA 2 on 11th July 2007. Since iron in the reduced ferrous valence state was not present the lake intake waters, they are an improbable source for this trace detection of ferrous iron. A possible alternative source might be a submerged spring near the left descending bank Station SA 2 location, or bank storage seeping off the left bank hillside.

During the higher flow 27-28 August 2007 monitoring period, outflow water temperatures varied only between 21.39 and 21.91°C, and dissolved oxygen concentrations varied between 8.51 and 9.38 mg/l, both with no apparent diurnal pattern. The outflow pH ranged between 7.75 and 8.06. The discharges from the dam were less mineralized (conductivity 311 to 328 µmhos/cm) and considerably more turbid (turbidity 14.8 to 34.5 NTUs) than they were during the earlier low flow survey, and the more turbid runoff resulted in minor increases in concentrations of iron and aluminum, but a sharp decrease in the outflow manganese concentration. Between the July and August surveys the concentration of total iron at outflow Station SA 2 increased very slightly from 0.58 to 0.61 mg/l, and total aluminum from 0.16 to 0.31 mg/l, while total manganese decreased from 1.35 down to 0.12 mg/l.

Conservative parameters measured at the two outflow station downstream of Mahoning Creek Dam, especially conductivity, suggest that the lake intake vortex was drawing heavily from an elevation equivalent to about 1040 feet NGVD during both the July and August 2007 water quality surveys, or depths of about 60-65 feet below the surface of the lake. During the July survey the dissolved oxygen concentration of the lake at this depth was in the range of about one mg/l (10% saturation), and about seven mg/l (78% saturation) during the August survey. Nonetheless, dissolved oxygen concentrations at the two outflow stations were consistently circumsaturated, and outflow total dissolved gas concentrations were consistently supersaturated. These observations again confirm that Mahoning Creek Dam discharges are very effectively re-aerated at their point of discharge from the dam.

Because the waters of the stilling basin downstream of the dam are already DO circumsaturated and at least slightly TDG supersaturated, the potential of the stilling basin weir to further influence gas exchange processes is difficult to evaluate. However, the high head, steep plunge angle, and deep scour pool downstream of the weir should make it an extremely efficient hydraulic re-aeration structure. This is confirmed by the influence of the weir on already gas saturated weir discharges during the two 2007 water quality surveys. During the July low discharge survey, weir discharge resulted in an additional increase in dissolved oxygen concentrations of up to 0.34 mg/l (mean 0.27 mg/l), and an additional increase in total dissolved gas concentrations of up to 0.3% saturation (mean 0.2%). The effect was more pronounced during the higher flow conditions of the August survey when weir discharge resulted in an additional increase in dissolved oxygen concentrations of up to 0.70 mg/l (mean 0.44 mg/l), and an additional increase in total dissolved gas concentrations of up to 2.3% saturation (mean 1.3%). A maximum TDG concentration of 104.3% saturation was observed at the station downstream of the weir on 28 August 2007.

5.3 CE-QUAL-R1 MODEL SIMULATIONS OF WATER QUALITY IMPACTS OF RETROFIT HYDROPOWER MODIFICATIONS

As was discussed in Section 1, FERC has granted a Preliminary Permit to MCHC for development of retrofit hydropower at Mahoning Creek Dam. For this purpose MCHC would utilize existing nine feet diameter plugged penstock openings in the dam. These penstocks both have an inlet centerline elevation of 1,055 feet NGVD, and an intake invert elevation of 1,050.5 feet NGVD. Since reservoir withdrawal zones tend to vortex upward from submerged intake portals, hydropower generation discharges would then be withdrawn from the lake from elevations higher than 1,050.5 feet NGVD. This elevation is 25.5 and 29.5 feet higher than the inlet invert elevations of the project’s two low flow discharge conduits, and 35.5 feet higher than the 1,015 feet NGVD inlet invert elevations of the sluices. Discharges in excess of hydropower turbine capacities, and/or any bypass flows, would continue to be discharged through the existing low flow conduits and/or sluices. In order to evaluate the water quality impacts of this change in the withdrawal zone of Mahoning Creek Dam, as was also proposed by a previous FERC licensee, in 1993 the USACE calibrated a CE-QUAL-R1 model with 1985 data and ran a series of five simulations of various hydropower operational scenarios.

CE-QUAL-R1 is a one dimensional mathematical model that can describe the vertical distribution of thermal energy and chemical properties in a reservoir through time. It can be used to study the effects of reservoir management operations on impoundment and outflow water quality.

This model requires an extensive data base including initial conditions, detailed reservoir morphology and operational information, geometric and physical coefficient development, biological and chemical reaction rates, and time sequences of hydrometeorological and inflow water quality concentrations.

CE-QUAL-R1 is spatially one dimensional and horizontally averaged; temperature and concentration gradients are computed only in the vertical direction. The reservoir is conceptualized as a vertical sequence of horizontal layers where thermal energy and material are uniformly distributed in each layer. The mathematical structure of the model is based on the horizontal layers whose thicknesses depend on the balance of inflowing and out flowing waters. Variable layer thicknesses permit mass balancing during periods of large inflow and outflow.

The distribution of inflowing waters among the horizontal layers is based on density differences. Simulations of surface flows, interflows, and underflows are possible. Similarly, out flowing waters are withdrawn from layers after considering layer densities, discharge rates, and outlet configurations. Reservoir outflows may take place according to a specified schedule of port releases.

Conditions which were built into the 1993 USACE's CE-QUAL-R1 model application to Mahoning Creek Lake have not changed in any significant manner. The hydrology of the drainage basin, the morphology and storage capacity of the reservoir, structural features of the dam and outlet works, and the USACE operation of the project remain essentially identical. Therefore, hydrometeorological variations during the period of summer stratification would continue to drive variations in the model output. As was discussed in Section 5.1 of this report, while vertical stratification patterns within the impoundment are responsive to these hydrometeorological variations, no apparent change in the nature or degree of this responsiveness would have been expected nor has been demonstrated, and there is no reason to believe that the USACE model is not still a useful predictive tool. According to Section 2.3 of the FERC issued *Water Quality Work Plan* of September 2006, if the model results are shown to still be predictive, then potential water quality impacts with MCHC's proposed operating conditions can be assessed using existing model outputs. CE- QUAL-R1 remains a state of the art predictive model, and since no reason has been demonstrated that this FERC condition has not been met, the following analyses are then based upon existing model outputs.

An important caveat was issued with emphasis by the authors of the 1993 USACE CE-QUAL-R1 model study of Mahoning Creek Lake. Before continuation of this discussion, their caveat is again repeated here with similar emphasis. That caveat is that all models are, by definition, simplified representations of the actual prototype. One of the benefits of this simplified representation is that the model can be manipulated for less expense and in a shorter time than experimentation on the prototype. One of the costs associated with this benefit is that a number of assumptions are used to simplify the real system, and these assumptions impose limitations on the use, accuracy and interpretation of model results. A likely significant physical limitation on the model application to Mahoning Creek Lake is that the short hydraulic retention time and strong and dynamic advective processes observed at the project would probably stress the limits of the model.

Five CE-QUAL-R1 scenarios simulated for Mahoning Creek Lake are as follows:

Scenario A – Existing conditions to compare computed and observed data for the purpose of model calibration.

Scenario B – All discharge from Mahoning Creek Dam through the hydropower penstocks, and zero discharge through the existing USACE outlets.

Scenario C – A one cubic meter per second (35.3 cfs) bypass through the existing USACE outlets, the remainder through the hydropower penstocks and turbine.

Scenario D – A 0.85 cubic meter per second (30cfs) minimum bypass through the existing USACE outlets, and a minimum 1.7 cubic meter per second (60cfs) discharge through the hydropower penstocks and turbine. *This scenario corresponds to that which was described as an operating condition in the prior license under that document's Article 403.*

Scenario E – A 1.7 cubic meter per second (60cfs) minimum bypass through the existing USACE outlets, and a minimum 1.7 cubic meter per second (60.0 cfs) discharge through the hydropower penstocks and turbine.

Scenario D (a 30 cfs bypass flow) is a simulation of a hydropower operation actually mandated by FERC in 1990 within Article 403 of the project's previous FERC licensee (Mahoning Hydro Associates, Project No. 10521-007).

The results of the model simulations are graphically summarized in Plates 7 to 14. As shown by the close correlation of observed and computed outflow water temperatures in the Scenario A plot of existing conditions on Plate 7, the model is capable of predicting outflow water temperatures with a reasonably high degree of accuracy. The Julian Day 120 to 280 period plotted extends from 30 April to 7 October 1985. The Scenario B plot of all discharge through the hydropower penstocks, which is also shown on Plate 6, demonstrates that under this operational scenario there would be some minor cooling of the discharge in June between Julian Days 155 to 180, and in late August between Julian Days 235 to 245.There was some minor warming of the outflow in early August between Julian Days 210 to 230. Similarly, changes in outflow water temperatures for hydropower operational Scenarios C, D, and E were also relatively mild.

More significant changes in the patterns of summer season thermal and chemical stratification from hydropower development at Mahoning Creek Dam, however, are predicted by the model. Plates 8 to 13 show water temperature and dissolved oxygen vertical profiles of the lake for five scenarios on two representative days, Julian Days 182 and 214, on July 1 and August 1, 1985, respectively. As can be seen in this series of plates, raising the withdrawal zone elevation would result in a layer of cooler water persisting through the summer season below the elevation of the penstock intakes. By Julian Day 214, the deep layer would be about six degrees Celsius (10.8 °F) cooler with hydropower Scenario B than with the existing conditions Scenario A. Warmer and less dense summer inflows would tend to short circuit the impoundment by over and inter-flowing the lake to the penstock intakes, leaving a stratum of cool storage in the deeper portion of the lower lake. Bottom withdrawal bypass flows would produce intensities of lake thermal stratification intermediate between the extremes of Scenarios A and B.

Dissolved oxygen concentrations would then be depleted from these isolated deep strata to a greater degree and extent than is now occurring during the season of summer stratification. For instance, while the lake was nowhere totally anaerobic under Scenario A on either Julian Day 182 or 214 of 1985, the model indicates that under Scenario B, the hypolimnion would have had zero dissolved oxygen on both days up to about the 1050.5 feet NGVD invert elevation of the penstock intakes, approximately 52 feet or 16 meters below summer pool. The elevation of the anaerobic strata, but not necessarily the anoxia strata (DO ≤ 4.0 mg/l), was lowered by about 3 to 5 meters under bypass Scenarios C and D, 35.3 and 30.0 cfs bypass flows, respectively. Little additional advantage in reduction of lake anaerobic conditions appeared to be gained by increasing the bypass flow to 60.0 cfs in Scenario E. Presumably, the increased degree and extent of reservoir hypolimnetic oxygen depletion that results from the higher elevation penstock withdrawal would also lead to greater accumulations of hypolimnetic iron, manganese, and reduced nitrogen and sulfur compounds in this deep layer during the summer season.

Here and elsewhere throughout this discussion, however, it is very important to continually maintain the perspective that these potentially negative predicted impacts are restricted to waters stored in the impoundment below the invert elevation of the penstock intakes, elevation 1050.5 feet NGVD or 47.5 feet below the minimum project summer pool elevation of 1098 feet NGVD. In contrast, the mean depth of Mahoning Creek Lake is only 31.7 feet, unadjusted for sedimentation and actually probably less than 31.7 feet. Water in any dead storage layer would only occupy a deep band within the steep V-shaped thalweg of the impoundment for a distance of about 1.5 miles upstream of the dam in the lake which is 6.2 miles long at its minimum summer pool elevation. Longer hydraulic retention times in this very deep layer below the elevation of the penstock intakes which would tend to increase localized hypolimnetic oxygen depletion and metal accumulation rates, would also conversely decrease hydraulic retention times and hypolimnetic oxygen depletion and metal accumulation rates over a much greater portion of the impoundment. In terms of both area and volume, these positive impacts would affect a much greater portion of project waters than the previously described negative water quality impacts of the higher withdrawal zone elevation.

On Plate 14, the dissolved oxygen concentration of withdrawal zone waters is compared for the Scenario A existing conditions operation versus the Scenario B all discharge through the hydropower penstocks operation. Under Scenario A, the dissolved oxygen level of withdrawal zone waters fluctuates widely from concentrations of 0 to more than 8 mg/l. The Scenario A numbers, however, are not in any way indicative of the actual dissolved oxygen content of the tailwaters of the dam under existing conditions. This is because highly efficient gas transfer and turbulent re-aeration now occurs at Mahoning Creek Dam. Because of this turbulent re-aeration, the discharge from the dam is consistently circumsaturated with dissolved oxygen, regardless of the quality of the intake waters. The USACE has never recorded a dissolved concentration of less than 7.0 mg/l from the tailwaters of Mahoning Creek Dam. Gas transfer in turbine discharges, on the other hand, can not approach this level of efficiency. Therefore, unless specific steps are taken to increase dissolved oxygen concentrations of turbine discharges; their dissolved oxygen concentrations will usually more closely approximate the concentration of the waters of the reservoir withdrawal zone.

Both lake chemical stratification patterns and the elevation of the of the withdrawal zone are modified by Scenario B operations. While the dissolved oxygen concentrations of the withdrawal zone waters never fall to zero in the Scenario B model simulation, it is nonetheless consistently depressed by this hydropower operation. This suggests that the licensee would likely experience problems achieving minimum outflow dissolved oxygen standards with the operation. Of the 160 day simulation period (30 April to 7 October), the model predicts that the turbine discharge would be in violation of the Pennsylvania Department of Environmental Resources' minimum daily dissolved oxygen criteria of 4.0 mg/l for 96 days, and in violation of their daily average criteria of 5.0 mg/l for 126 days. The minimum dissolved oxygen concentration criteria of 6.0 mg/l mandated by the Federal Energy Regulatory Commission (Article 405) in 1990 for a previous license would be violated on 143 days. The project would fail to achieve the U.S. Environmental Protection Agency's non-degradation criteria (based on negligible negative impact to warm water fisheries) of 6.5 mg/l dissolved oxygen for 149 days of the 160 day long period.

The above analysis represents an absolutely worst case situation which could/would be improved by a number of potential mitigating actions, or combinations of actions, such as mixing of the anoxia summer season turbine discharges with oxygen saturated flows bypassed through the dam, by turbine venting, air injection, or other means of re-aeration. Also, the characterizations of the previous paragraph are representative of turbine discharges at their exit point, and do not consider subsequent gas transfer that may be induced by other adjacent hydraulic structures, such as the 17.5 feet high weir at the end of the stilling basin. The plunge angle of this weir is sharp and the downstream scour pool is relatively deep. The head and design of this end weir should contribute substantially to a high re-aeration potential that could be important if MCHC selects powerhouse location A, which would discharge to Mahoning Creek upstream of the stilling basin end weir. The re-aeration potential of the end weir might be additionally enhanced by flow concentration actions such as weir notching. A notch in the stilling basin end weir at nearby Conemaugh Dam was incised to create a low flow fish attraction current near a fisherman accessible location. Other possible considerations, if found to be feasible and acceptable to the USACE, might be installation of seasonal flash boards on the crest of the weir during low summer flow periods, to increase head and concentrate flows for re-aeration benefits or the addition of water impingement blocks or rocks on the face and base of the weir.

In summary, it is likely that the short retention time and dynamic advective processes observed at the Mahoning Creek Lake project would stress the limits of any model used for predicting changes in chemical stratification patterns and outflow dissolved oxygen concentrations, especially during September and October portions of the simulations. Therefore, conclusions about the model predictions must be qualified by inadequacies apparent in the Scenario A calibration runs. The calibration demonstrated that the model tended to seasonally underestimate hypolimnetic dissolved oxygen depletion in the lake. The degree to which depletion was underestimated became progressively more significant as summer stratification progressed. This continued until early autumn, after which hypolimnetic dissolved oxygen depletion problems were overestimated and exaggerated by the model. While CE-QUAL –R1 is a state-of-the-art model, uncertainties with its application to the highly dynamic Mahoning Creek Lake project must be considered when evaluating its results and predictions. Nonetheless, while very exact and precise model outputs might be problematic, the effort clearly demonstrates that withdrawal through the penstocks would tend to prolong summer season retention times within a deep layer of the impoundment below elevation 1050.5 feet NGVD, where oxygen depletion and probably also metal accumulation rates would intensify. Relative to the total area and volume of the reservoir, affected storage would not be great, while retention times would tend to increase in the larger portion of the lake. More significantly, the model demonstrated that penstock discharge operations during a significant period of each summer season would withdrawal from layers of the impoundment with dissolved oxygen concentrations which are not sufficient to maintain the high quality of the outflow, and subsequently that MCHC will have to develop a mitigation plan to address this discharge dissolved oxygen issue.

6.0 SUMMARY

A study of water quality conditions in Mahoning Creek Lake and the outflow of Mahoning Creek Dam were conducted by the Mahoning Creek Hydroelectric Company (MCHC) during the summer stratification season of 2007. This investigation was performed according to a Federal Energy Regulatory Commission (FERC) reviewed and approved plan, Water Quality Work Plan, Appendix C of the Revised Study Plan, Mahoning Creek Hydroelectric Project, Armstrong County, Pennsylvania, FERC Project No. P-12555, September 2006. The primary goal of the study was to assess the effects of a proposed retrofit hydroelectric generation facility on water quality in the impoundment in the area of the proposed intake structure (Station SA 6), in the stilling basin downstream of the dam (Station SA 1), and in Mahoning Creek downstream of the stilling basin (Station SA 2). The study plan was designed to be responsive to observations and concerns presented in a previous 1993 U.S. Army Corps of Engineers (USACE) study, Mahoning Creek Lake, Reservoir Limnology, Aquatic Life, and Water Quality Report. The USACE study included calibration of a CE-QUAL-R1 model to examine the impacts of retrofit hydropower on water quality at the project. This model predicted changes in patterns of summer season thermal and chemical stratification from hydropower development at Mahoning Creek Dam. The 2007 study was recommended to obtain more current lake and stream data. In accordance with the FERC approved plan, if the results of the USACE model results were still shown to be predictive, then potential water quality impacts from MCHC's proposed operating conditions could be assessed using the CE-QUAL-R1 model outputs.

Field measurements and water samples for laboratory analyses were collected from the project during two sampling events, 11-12 July and 27-29 August 2007. Both surveys included vertical profiling of the lake and diurnal monitoring at the outflow stations. These surveys captured wide extremes of summer season antecedent precipitation and flow conditions in the Mahoning Creek drainage basin for comparison with historical data collected by the USACE. The July 2007 survey was representative of very low flow conditions, and the August 2007 survey relatively wet summer season conditions.

Moderate thermal stratification patterns in the lake were evident during both 2007 summer season surveys. The vertical thermal gradient was 4.1°C in July and 4.6°C in August. While reservoir water temperature and thermal gradients were very similar during both surveys, the vertical distribution of other parameters within the lake suggests that convective limnology processes were important during the July antecedent low flow survey, and that advective processes were more dominant during the August antecedent higher flow survey. July dissolved oxygen concentrations ranged from a maximum of 9.5 mg/l at a depth of 10 feet down to a minimum of 0.7 mg/l at a depth of 65 feet. In August, the dissolved oxygen concentration at the surface of the lake was 8.8 mg/l and 6.5 mg/l near the bottom, with a minimum concentration of 5.9 mg/l at a depth of 45 feet. The weak and unstable water temperature and dissolved oxygen stratification patterns observed in 2007 are consistent with historical patterns, and demonstrate that the impoundment is very sensitive and responsive to hydrometeorological conditions. Vertical profiles of the concentrations of various metals in the lake demonstrated a tendency for total iron, total manganese, and total aluminum concentrations to increase with depth during the summer season. The 2007 concentrations of iron, manganese, and aluminum fall within the range of historical project conditions, and generally again confirm the USACE observations that chemical stratification patterns within the lake are weak and unstable, metal concentrations in general are low, and the quality of project waters could be characterized as excellent.

While withdrawal zone dissolved oxygen concentrations in the lake were depressed to varying degrees, the concentration of dissolved oxygen in the stilling basin downstream of the dam was consistently circumsaturated, and stilling basin total dissolved gas concentrations were consistently supersaturated. These observations again confirm that Mahoning Creek Dam discharges are very effectively re aerated at their point of discharge from the dam. Because the waters of the stilling basin downstream of the dam are already dissolved oxygen circumsaturated and at least slightly total dissolved gas supersaturated, the full potential of the stilling basin end weir to further influence gas exchange processes is obscured. However, the high head, steep plunge angle, and deep scour pool downstream of the weir should make it an efficient hydraulic re aeration structure, and even further elevation of the concentrations of both dissolved oxygen and total dissolved gases was consistently observed downstream of the stilling basin end weir during the 2007 surveys. There were only very minor variations in these parameters at the outflow stations over the diurnal sampling periods, indicating that hydraulic re aeration, rather than diurnally sensitive photosynthetic and microbial respiratory activities, is the dominate local influence on these parameters.

Conditions which were built into the USACE's CE-QUAL-R1 model application to Mahoning Creek Lake have not changed in any significant manner. The hydrology of the drainage basin, the morphology and storage capacity of the reservoir, structural features of the dam and outlet works, and the USACE operation of the project remain essentially identical. Therefore, hydrometeorological variations during the period of summer stratification would continue to drive variations in the model output. While vertical stratification patterns within the impoundment are responsive to these hydrometeorology variations, no apparent change in the nature or degree of this responsiveness were demonstrated from the results of the 2007 study, and the USACE model should still be a useful predictive tool.

Five CE-QUAL-R1 scenarios were simulated for Mahoning Creek Lake; (A) existing conditions, (B) all discharge through the penstocks, (C) a 35.3 cfs bypass through the USACE's outlets, (D) a minimum 30 cfs through the USACE's outlets and a minimum 60 cfs through the penstocks, and (E) a minimum 60 cfs through the USACE's outlets and a minimum 60 cfs through the penstocks. These model simulations show that raising the elevation of the withdrawal zone would result in a layer of cooler water persisting through the summer season below the elevation of the penstock intakes, invert elevation 1050.5 feet NGVD or 47.5 feet below minimum summer pool elevation. Warmer and less dense summer inflows would tend to advectively short circuit the impoundment by over and inter-flowing the lake to the penstock intakes. Bypass flows through the existing and deeper USACE's outlets would moderate the impact.

Plate 7 also provides the calculated worst case conditions for downstream water temperature as if all flow went through the power house under Scenario B and shows an impact of no greater than 0.5°C. Thus the water temperature under Scenario D will have minimum impact on downstream water temperature.

Dissolved oxygen concentrations would be depleted from the isolated deeper strata to a greater degree and extent than is now occurring during the period of summer stratification. Presumably, the increased degree and extent of reservoir hypolimnetic oxygen depletion that results from the higher elevation penstock withdrawal would also lead to greater accumulations of hypolimnetic iron, manganese, aluminum, and reduced nitrogen and sulfur compounds in the deep layer during the summer season. However, the isolated storage strata would only occupy a deep band around the steep thalweg of the lake for a distance of about 1.5 miles upstream of the dam. Longer hydraulic retention times in this very deep layer below the elevation of the penstock intakes, which would tend to increase localized hypolimnetic oxygen depletion and metal accumulation rates, would also conversely decrease hydraulic retention times and hypolimnetic oxygen depletion and metal accumulation rates over a much greater portion of the impoundment.

The highest potential water quality impacts of proposed hydropower development at Mahoning Creek Dam identified by the model simulations were related to maintenance of discharge dissolved oxygen concentrations during the period of summer stratification. Of the 160 day simulation period (30 April to 7 October), under worst case Scenario B, the model predicts that the licensee would likely experience problems achieving the Pennsylvania Department of Environmental Resources' minimum daily dissolved oxygen criteria of 4.0 mg/l for 96 days, and be in violation of their daily average criteria of 5.0 mg/l for 126 days. The minimum dissolved oxygen concentration criteria of 6.0 mg/l mandated by FERC in 1990 for a previous license would be violated on 143 days.

The above analysis represents a situation which could/would be improved by a number of potential mitigating actions, or combinations of actions, such as mixing of the anoxic summer season turbine charges with oxygen saturated flows bypassed through the USACE outlets, by turbine venting, air injection, or other means of re-aeration. Also, the characterizations of the previous paragraph are representative of turbine discharges at their exit point, and do not consider subsequent gas transfer induced by other hydraulic structures, such as the 17.5 feet high weir at the end of the stilling basin. To mitigate identified potentially adverse impacts to the project, MCHC will prepare a Water Quality Technical Memorandum, which will contain an evaluation of the feasibility and impact of a flexible operational mode and/or aeration facility to maintain desirable downstream dissolved oxygen concentrations and address other identified water quality issues.

The prior license carried a condition in its Article 403 which matches the investigated Scenario D above. Article 405 also imposed the minimum of 6.0 mg/l as an operating condition and required that a plan be submitted by the licensee describing how this would be maintained. This report demonstrates that conditions at the project site have not changed in any material way since the prior license; therefore that license provides considerable precedence for the current application.

TABLES

TABLE 1 MAHONING CREEK LAKE STATION SA 6, RESULTS OF WATER QUALITY SURVEY OF 11 JULY 2007, FIELD PARAMETERS.

Depth (feet)	**Water Temperature** (C°)	**Dissolved Oxygen** (mg/l)	**Conductivity** (µmhos/cm)	**pH** (units)	**Turbidity** (NTU)	**Differential Gas Pressure** (ΔP)	**Hydrogen Sulfide** (mg/l)
0	26.7	9.14	389	8.38	0.1	16	0.0
5	26.5	9.18	391	8.43	0.3	12	0.0
10	25.8	9.49	388	8.44	0.3	12	0.0
15	24.8	9.13	384	8.17	0.1	12	0.0
20	24.4	6.71	386	7.51	0.5	-2	0.0
25	24.1	3.72	387	7.16	0.5	-32	0.0
30	23.5	1.84	389	7.03	0.5	-49	0.0
35	23.4	1.23	388	6.98	0.6	-61	0.0
40	23.2	0.88	394	6.98	0.9	-62	0.0
45	23.1	0.92	394	6.98	1.1	-64	0.0
50	22.9	1.06	389	6.97	1.2	-61	0.0
55	22.8	1.28	390	6.98	1.2	-68	0.0
60	22.7	1.08	396	6.98	1.5	-66	0.0
65	22.6	0.67	410	6.99	2.0	-65	0.0

TABLE 2 MAHONING CREEK LAKE STATION SA 6, RESULTS OF WATER QUALITY SURVEY OF 27 AUGUST 2007, FIELD PARAMETERS.

Depth (feet)	**Water Temperature** (C°)	**Dissolved Oxygen** (mg/l)	**Conductivity** (µmhos/cm)	**pH** (units)	**Turbidity** (NTU)	**Differential Gas Pressure** (ΔP)	**Hydrogen Sulfide** (mg/l)
0	25.72	8.82	428	8.52	0.3	4	0.0
5	24.91	8.65	428	8.57	0.7	3	0.0
10	24.59	8.45	427	8.51	0.3	5	0.0
15	23.91	6.67	416	8.17	0.9	-9	0.0
20	23.34	5.99	402	7.90	3.3	-23	0.0
25	22.98	6.26	365	7.78	6.6	-18	0.0
30	22.81	6.34	367	7.67	9.9	-15	0.0
35	22.68	6.13	390	7.56	4.3	-18	0.0
40	22.58	5.93	392	7.46	1.3	-16	0.0
45	22.40	5.90	395	7.43	1.9	-30	0.0
50	22.23	6.01	390	7.44	1.9	-27	0.0
55	22.14	6.10	403	7.42	4.3	-22	0.0
60	21.87	6.62	351	7.42	9.7	-18	0.0
65	21.53	6.98	296	7.46	23.9	-12	0.0
70	21.44	7.02	294	7.38	29.7	-18	0.0
75	21.07	6.49	307	7.46	25.2	-26	0.0

TABLE 3 MAHONING CREEK LAKE STATION SA 6, RESULTS OF WATER QUALITY SURVEY OF 11 JULY 2007, LABORATORY PARAMETERS.

Depth (feet)	**Total Iron** (mg/l)	**Ferrous Iron** (mg/l)	**Total Manganese** (mg/l)	**Total Aluminum** (mg/l)	**Total Copper** (mg/l)	**Total Nickel** (mg/l)	**Hardness** (mg/l as CaCO3)
0	0.04	L 0.05	0.02	L 0.10	L 0.01	L 0.01	141
5	0.03	L 0.05	0.02	L 0.10	L 0.01	L 0.01	145
10	0.03	L 0.05	0.02	L 0.10	L 0.01	L 0.01	145
15	0.03	L 0.05	0.02	L 0.10	L 0.01	L 0.01	143
20	0.04	L 0.05	0.05	L 0.10	L 0.01	L 0.01	144
25	0.04	L 0.05	0.13	L 0.10	L 0.01	L 0.01	148
30	0.04	L 0.05	0.11	L 0.10	L 0.01	L 0.01	145
35	0.06	L 0.05	0.27	L 0.10	L 0.01	L 0.01	145
40	0.08	L 0.05	0.29	L 0.10	L 0.01	L 0.01	149
45	0.08	L 0.05	0.16	L 0.10	L 0.01	L 0.01	146
50	0.08	L 0.05	0.19	L 0.10	L 0.01	L 0.01	155
55	0.11	L 0.05	0.47	L 0.10	L 0.01	L 0.01	147
60	0.16	L 0.05	0.60	L 0.10	L 0.01	L 0.01	150
65	0.31	L 0.05	0.46	0.12	L 0.01	L 0.01	148

TABLE 4 MAHONING CREEK LAKE STATION SA 6, RESULTS OF WATER QUALITY SURVEY OF 27 AUGUST 2007, LABORATORY PARAMETERS.

Depth (feet)	**Total Iron** (mg/l)	**Ferrous Iron** (mg/l)	**Total Manganese** (mg/l)	**Total Aluminum** (mg/l)	**Total Copper** (mg/l)	**Total Nickel** (mg/l)	**Hardness** (mg/l as CaCO3)
0	0.02	L 0.05	0.02	L 0.10	L 0.01	L 0.01	144
5	0.02	L 0.05	0.02	L 0.10	L 0.01	L 0.01	146
10	0.02	L 0.05	0.02	L 0.10	L 0.01	L 0.01	144
20	0.07	L 0.05	0.02	L 0.10	L 0.01	L 0.01	125
30	0.28	0.11	0.03	0.16	L 0.01	L 0.01	123
40	0.19	0.08	0.03	L 0.10	L 0.01	L 0.01	129
45	0.14	L 0.05	0.04	L 0.10	L 0.01	L 0.01	132
50	0.47	0.06	0.05	0.25	L 0.01	L 0.01	102
55	0.41	0.08	0.05	0.28	L 0.01	L 0.01	119
60	0.14	0.14	0.04	L 0.10	L 0.01	L 0.01	123
65	0.72	0.12	0.06	0.58	L 0.01	L 0.01	102
70	0.96	0.17	0.08	0.71	L 0.01	L 0.01	88.9
75	0.84	0.15	0.21	0.52	L 0.01	L 0.01	90.3

TABLE 5 MAHONING CREEK DAM STILLING BASIN STATION SA 1, RESULTS OF THE WATER QUALITY SURVEY OF 11-12 JULY 2007.

Parameters	11 July at 1130 hours		11 July at 1730 hours		11July at 2100 hours		12 July at 0200 hours		12 July at 0600 hours	
	0 feet	*5 feet*	*0 feet*	*5 feet*	*0 feet*	*5 feet*	*0 feet*	*5 feet*	*0 feet*	*5 feet*
Water Temperature (C°)	22.6	22.5	22.6	22.5	22.6	22.5	21.9	21.1	21.4	21.9
Dissolved Oxygen (mg/)	8.51	8.84	8.61	8.27	8.26	8.20	8.16	8.19	8.19	8.21
Conductivity (µmhos/cm)	395	395	393	393	392	394	390	391	386	389
pH (units)	7.62	7.61	7.62	7.61	7.62	7.63	7.64	7.65	7.76	7.66
Turbidity (NTU)	3.2	3.4	3	3.7	2.2	3.3	2.3	2.8	2.2	2.4
Total Dissolved Gas (%)	100.4		100.1		100.7		101.1		101.4	
Hydrogen Sulfide (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Iron (mg/l)	0.24									
Ferrous Iron (mg/l)	0.05									
Total Manganese (mg/)	0.96									
Total Aluminum (mg/l)	L 0.10									
Total Copper (mg/l)	L 0.01									
Total Nickel (mg/l)	L 0.01									
Hardness (mg/l as CaCO3)	154									

TABLE 6 MAHONING CREEK DAM STILLING BASIN STATION SA 1, RESULTS OF THE WATER QUALITY SURVEY OF 27-29 AUGUST 2007.

Parameters	27 Aug at 1030 hours		27 Aug at 1630 hours		27 Aug at 2045hours		28 Aug at 0200 hours		28 Aug at 0600 hours	
	0 feet	*5 feet*	*0 feet*	*5 feet*	*0 feet*	*5 feet*	*0 feet*	*5 feet*	*0 feet*	*5 feet*
Water Temperature (C°)	21.39	21.40	21.60	21.61	21.61	21.60	21.79	21.80	21.86	21.88
Dissolved Oxygen (mg/)	8.54	8.51	9.12	9.11	8.53	8.65	8.87	8.87	8.71	8.71
Conductivity (µmhos/cm)	314	311	318	317	320	322	328	327	320	319
pH (units)	7.75	8.00	7.94	7.91	8.03	8.05	8.06	8.03	8.09	8.04
Turbidity (NTU)	27.0	25.6	17.4	19.4	17.2	20.9	16.3	15.4	14.8	15.0
Total Dissolved Gas (%)	101.1	101.2	100.5	100.8	102.0	102.1	101.6	101.9	102.4	102.6
Hydrogen Sulfide (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Iron (mg/l)	0.69	0.92								
Ferrous Iron (mg/l)	0.17	0.17								
Total Manganese (mg/)	0.11	0.47								

Total Aluminum (mg/l)	0.41	0.50								
Total Copper (mg/l)	L 0.01	L 0.01								
Total Nickel (mg/l)	L 0.01	L 0.01								
Hardness (mg/l as CaCO3)	95.2	95								

TABLE 7 MAHONING CREEK DAM, RIFFLE BELOW STILLING BASIN SCOUR POOL, STATION SA 2, RESULTS OF THE WATER QUALITY SURVEY OF 11-12 JULY, 2007.

Parameter	11July at 1100 hrs	11July at 1700 hrs	11 July at 2130 hrs	12 July at 0230 hrs	12 July at 0630 hrs
Water Temperature (C°)	22.6	22.7	22.5	22.0	21.7
Dissolved Oxygen (mg/l)	8.66	8.80	8.53	8.56	8.53
Conductivity (µmhos/cm)	394	395	392	390	386
pH (units)	7.73	7.79	7.76	7.76	7.75
Turbidity (NTU)	2.3	2.8	2.4	3.1	3.2
Barometric Pressure (mm Hg)	734	735	735	737	737
Total Dissolved Gas (%)	100.3	100.3	100.9	101.4	101.6
Hydrogen Sulfide (mg/l)	0.0				
Total Iron (mg/l)	0.58				
Ferrous Iron (mg/l)	L 0.05				
Total Manganese (mg/l)	1.35				
Total Aluminum (mg/l)	0.16				
Total Copper (mg/l)	L 0.01				
Total Nickel (mg/l)	L 0.01				
Hardness (mg/l as CaCO3)	151				

TABLE 8 MAHONING CREEK DAM, RIFFLE BELOW STILLING BASIN SCOUR POOL, STATION SA 2, RESULTS OF THE WATER QUALITY SURVEY OF27-28 AUGUST 2007.

Parameter	27 Aug at 1100 hrs	27 Aug at 1615 hrs	27 Aug at 2115 hrs	28 Aug at 0215 hrs	28 Aug at 0615 hrs
Water Temperature (C°)	21.40	21.60	21.62	21.83	21.91
Dissolved Oxygen (mg/l)	8.74	9.38	9.10	9.33	9.41
Conductivity (µmhos/cm)	311	317	319	326	318
pH (units)	7.96	7.93	7.85	7.92	8.05
Turbidity (NTU)	34.5	20.6	17.6	16.2	14.8
Barometric Pressure (mm Hg)	742.6	745.7	743.4	744.4	744.3
Total Dissolved Gas (%)	102.1	101.7	102.3	103.9	104.3
Hydrogen Sulfide (mg/l)	0.0	0.0	0.0	0.0	0.0
Total Iron (mg/l)	0.61				
Ferrous Iron (mg/l)	0.15				
Total Manganese (mg/l)	0.12				
Total Aluminum (mg/l)	0.31				

Total Copper (mg/l)	L 0.01				
Total Nickel (mg/l)	L 0.01				
Hardness (mg/l as CaCO3)	97.4				

TABLE 9 MAHONING CREEK LAKE STATION SA 6, COMPARISON OF RECENT (2007) AND HISTORICAL SUMMER SEASON DISSOLVED OXYGEN VERTICAL PROFILES.

Depth (feet)	1-Jul 1985 JD 182	2-Aug 1985 JD 214	5-Sep 1985 JD 248	10-Jul 2003 JD 191	13-Aug 2003 JD 225	24-Sep 2003 JD 267	3-Jul 2006 JD 184	19-Jul 2006 JD 200	11-Jul 2007 JD 192	27-Aug 2007 JD 239
0	8.55	8.0	7.0	8.77	9.68	8.55	10.13	8.99	9.14	8.82
5	8.4	7.8	6.8	8.86	10.28	8.34	10.26	9.31	9.18	8.65
10	8.4	7.8	6.6	8.87	10.53	8.03		9.77	9.49	8.45
15	8.4	7.7	3.5	8.91	9.07	7.82	5.04	11.16	9.13	6.67
20	8.1	6.3	3.3	9.14	5.50	7.41	4.52	10.14	6.71	5.99
25	7.0	4.8	3.5	9.10	4.36	6.31	4.41	7.58	3.72	6.26
30	6.1	3.8	4.2	8.27	5.02	6.78		6.41	1.84	6.34
35	5.6	3.7	4.4	6.27	6.37	7.25	5.12	5.23	1.23	6.13
40	5.0	3.1	4.5	5.87	7.70	7.71	5.68	4.40	0.88	5.93
45	4.3	2.6	4.5	6.48	7.59	8.06	6.37	4.35	0.92	5.90
50	4.2	2.7	4.6	5.97	7.66	8.12		4.41	1.06	6.01
55	4.5	2.9	4.6	5.43	7.78	8.30	7.02	4.55	1.28	6.10
60	4.6	3.0	4.5	4.67	7.75	8.41		4.98	1.08	6.62
65	4.0	1.4	4.3	4.69	7.64	8.42	7.22	4.87	0.67	6.98
70	3.4	1.5	3.4	4.71	7.38	8.48		4.00		7.02
75	3.2	1.4		1.81		8.23	7.27	2.96		6.49
80							7.24			
85							7.02			
Max WT (C°)	23.4	24.4	24.4	24.49	24.42	18.91	23.96	28.02	26.7	25.72
Min WT (C°)	18.7	22.0	20.3	21.41	19.86	17.39	17.70	20.40	22.6	21.07
Gradient (C°)	4.7	2.4	4.1	3.1	4.6	1.5	6.3	7.6	4.1	4.6

TABLE 10 MAHONING CREEK LAKE STATION SA 6, COMPARISON OF RECENT (2007) AND HISTORICAL SUMMER SEASON CONCENTRATIONS OF METALS (mg/l) AT NEAR SURFACE, MID-DEPTH, AND BOTTOM DEPTHS.

Depth (feet)	Total Al	Total Cu	Total Fe	Total Mn	Total Ni
6-Jun-85					
3	0.060	0.053	L 0.100	L 0.010	L 0.005
35	0.150	0.024	0.100	0.040	L 0.005
75	0.340	0.021	0.500	0.320	L 0.005
1-Jul-85					
3	0.090	0.032	L 0.100	0.020	L 0.005
40	0.100	0.019	L 0.100	0.240	L 0.005
75	0.300	0.021	0.700	1.260	0.008
2-Aug-85					
3	0.070	0.014	L 0,100	0.020	L 0.005
20	0.070	0.010	L 0,100	0.050	L 0.005
75	0.380		1.000	2.040	L 0.005
5-Sep-85					
3	0.100	0.022	L 0.100	0.030	L 0.005
30	0.160	0.024	0.200	0.160	L 0.005
70	0.160	0.012	0.400	0.410	L 0.005
10-Jul-03					
3	L 0.050	L 0.005	L 0.030	0.006	L 0.010
40	L 0.050	L 0.005	0.080	0.083	L 0.010
75	0.400	L 0.005	0.960	0.315	L 0.010
13-Aug-03					
3	L 0.050	L 0.005	L 0.030	0.009	L 0.010
45	0.370	0.008	0.580	0.162	L 0.010
78	1.540	L 0.005	2.810	0.508	L 0.010
24-Sep-03					
3	L 0.050	L 0.010	0.120	0.049	L 0.010
50	0.120	L 0.010	0.390	0.190	L 0.010
80	0.480	L 0.010	1.170	0.347	L 0.010
11-Jul-07					
0	L 0.100	L 0.010	0.040	0.020	L 0.010
35	L 0.100	L 0.010	0.060	0.270	L 0.010
65	0.120	L 0.010	0.310	0.460	L 0.010
27-Aug-07					
0	L 0.100	L 0.010	0.020	0.020	L 0.010
40	L 0.100	L 0.010	0.190	0.030	L 0.010
70	0.710	L 0.010	0.960	0.080	L 0.010

PLATES

PLATE 1 PROJECT SITE LOCATION

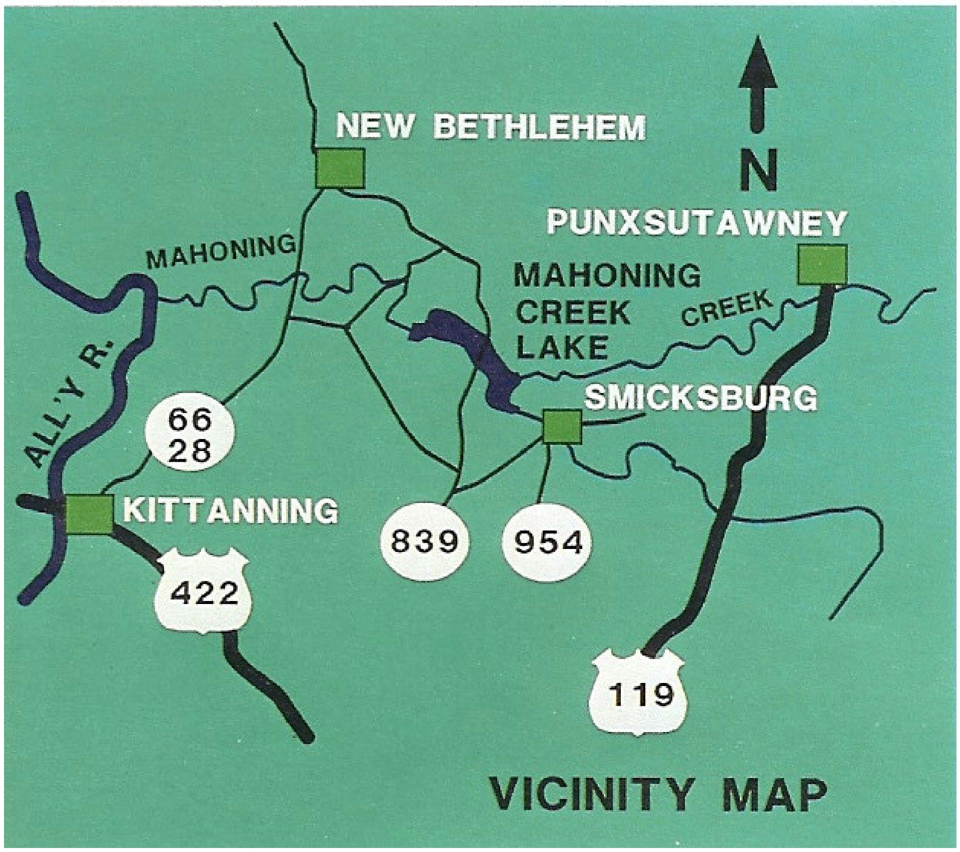


PLATE 2 MAP SHOWING WATER QUALITY MONITORING STATION LOCATIONS, MAHONING CREEK LAKE PROJECT, ARMSTRONG COUNTY, PENNSYLVANIA

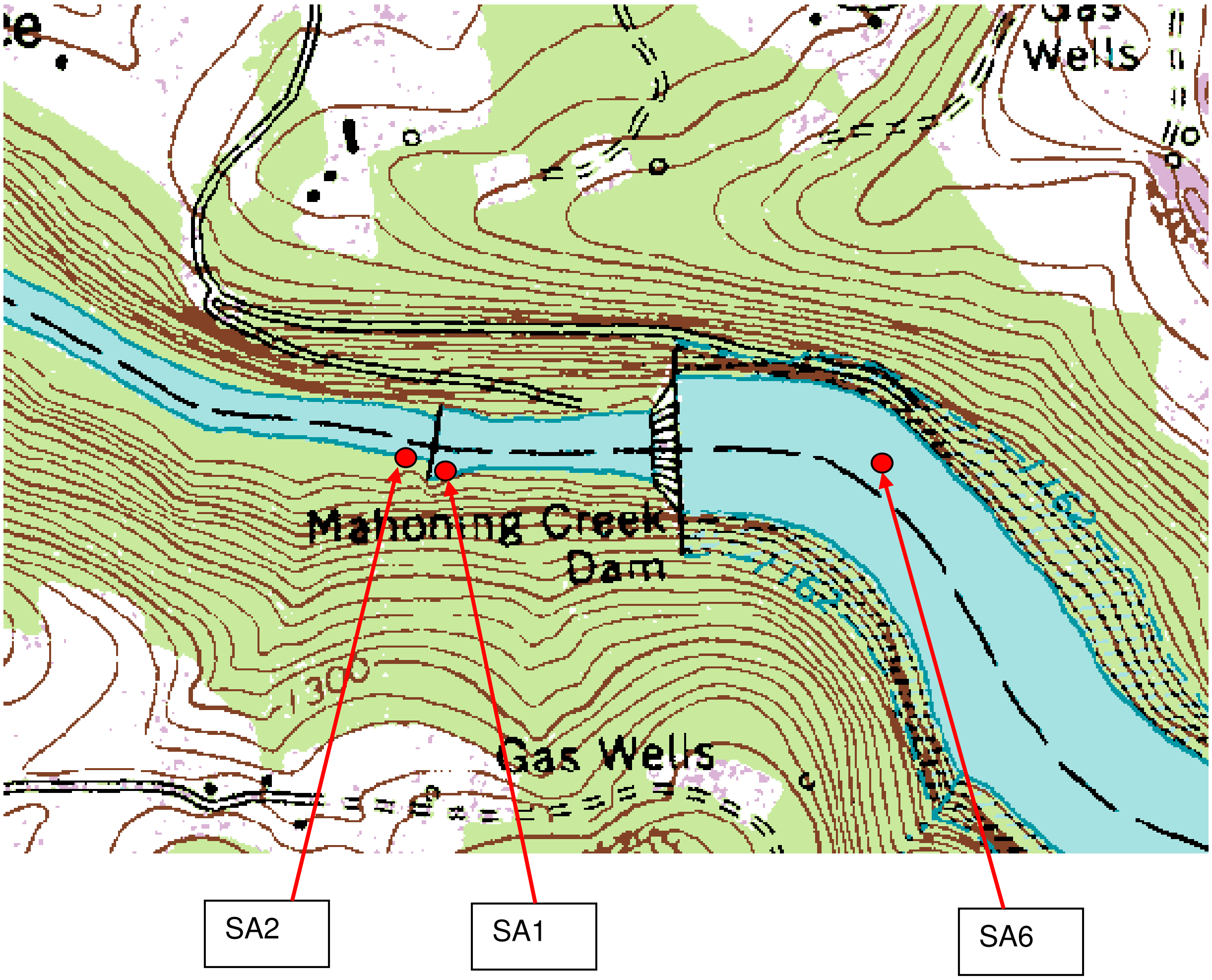


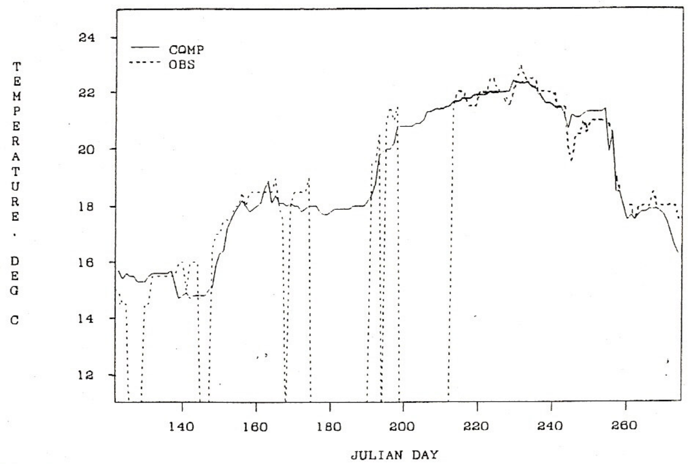
PLATE 3 MAHONING CREEK LAKE STATION SA 6

PLATE 4 MAHONING DAM STILLING BASIN STATION SA 2

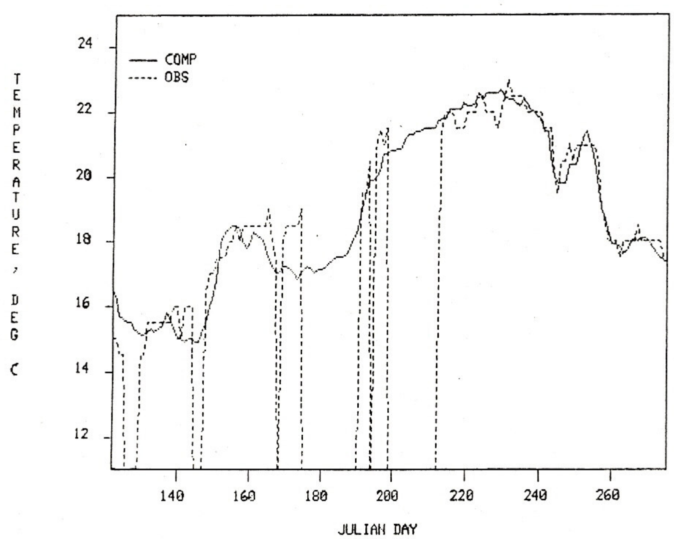
PLATE 5 MAHONING DAM OUTFLOW STATION SA 1, LOOKING UPSTREAM

PLATE 6 MAHONING DAM OUTFLOW STATION SA 1, LOOKING DOWNSTREAM

MAHONING CREEK LAKE, CE-QUAL-R1 OUTFLOW WATER TEMPERATURE SIMULATIONS FOR 1985, COMPUTED AND OBSERVED FOR SCENARIO A AND SCENARIO B



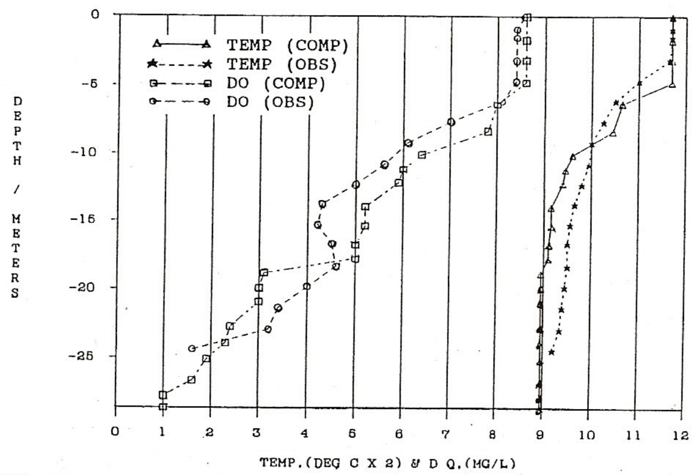
SCENARIO A Existing conditions to compare computed and observed 1985 data for the purpose of model calibration.



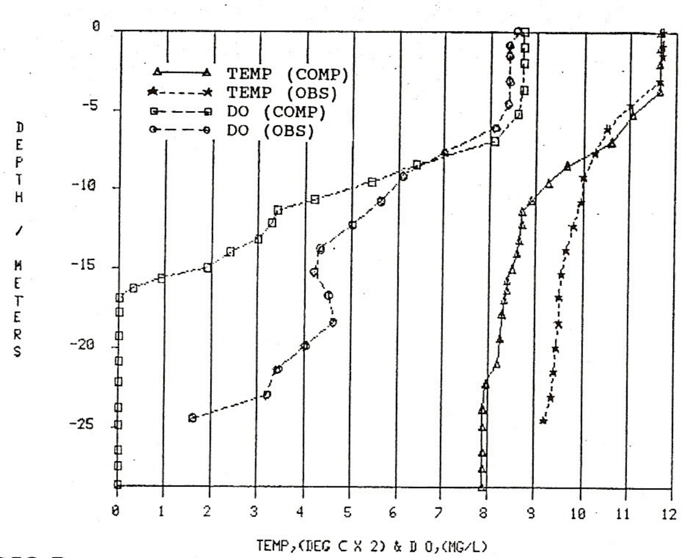
SCENARIO B All 1985 discharge from Mahoning Creek Dam through the hydropower penstocks, and zero discharge through the existing Corps of Engineers' outlets.

PLATE 7

MAHONING CREEK LAKE, CE-QUAL-R1 VERTICAL WATER TEMPERATURE AND DISSOLVED OXYGEN GRADIENT SIMULATIONS FOR JULIAN DAY 182 IN 1985, COMPUTED AND OBSERVED FOR SCENARIO A AND SCENARIO B



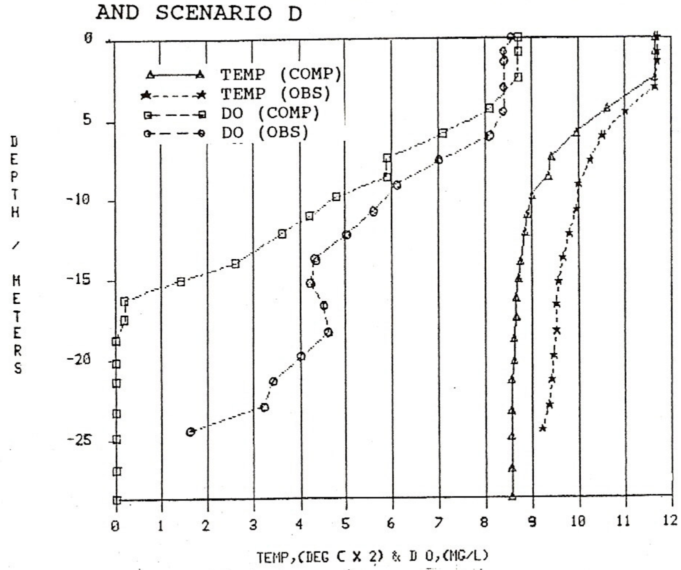
SCENARIO A Existing conditions to compare computed and observed 1985 data for the purpose of model calibration.



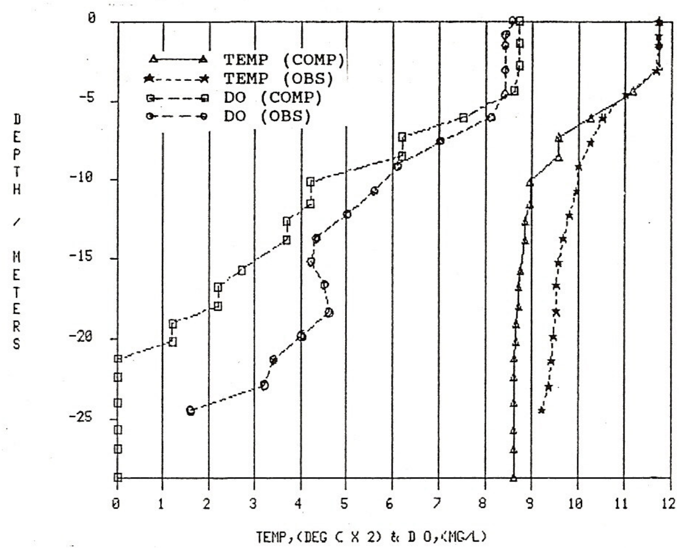
SCENARIO B All 1985 discharge from Mahoning Creek Dam through the hydropower penstocks, and zero discharge through the existing Corps of Engineers' outlets.

PLATE 8

MAHONING CREEK LAKE, CE-QUAL-R1 VERTICAL WATER TEMPERATURE AND DISSOLVED OXYGEN GRADIENT SIMULATIONS FOR JULIAN DAY 182 IN 1985, COMPUTED AND OBSERVED FOR SCENARIO C AND SCENARIO D



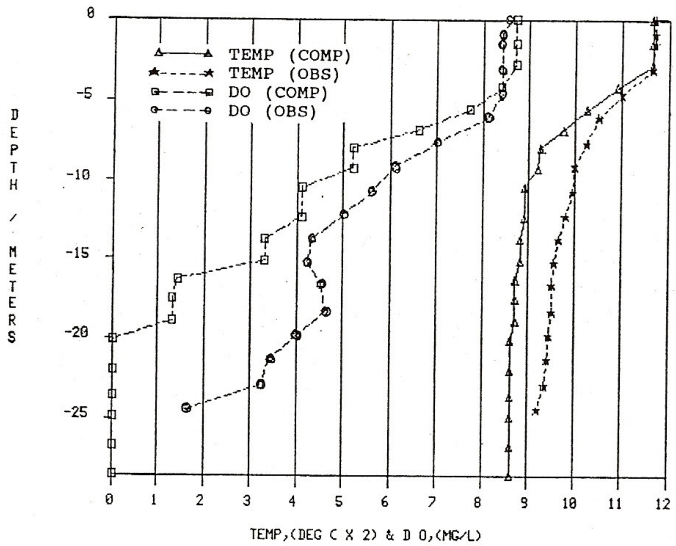
SCENARIO C A one cubic meter per second (35.3 cfs) bypass through the existing Corps of Engineers' outlets, the remainder through the hydropower penstocks and turbine.



SCENARIO D A 0.85 cubic meter per second (30 cfs) minimum bypass through the existing Corps of Engineers' outlets, and a minimum 1.7 cubic meters per second (60.0 cfs) discharge through the hydropower and hydropower turbine.

PLATE 9

MAHONING CREEK LAKE, CE-QUAL-R1 VERTICAL WATER TEMPERATURE AND DISSOLVED OXYGEN GRADIENT SIMULATIONS FOR JULIAN DAY 182 IN 1985, COMPUTED AND OBSERVED FOR SCENARIO E

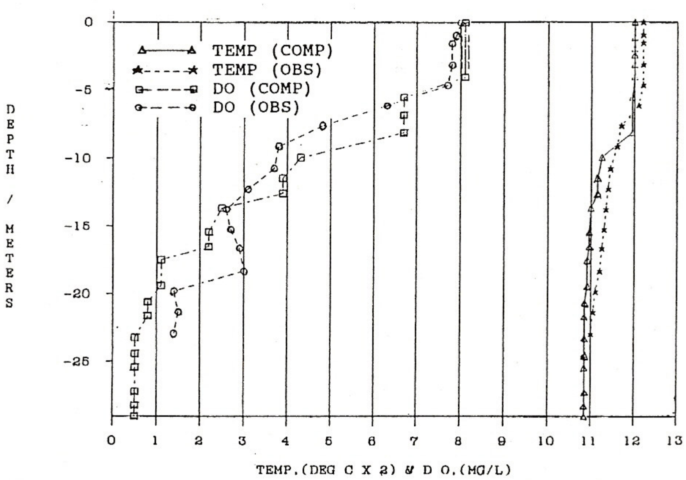


SCENARIO E A 1.7 cubic meter per second (60.0 cfs) minimum bypass through the existing Corps of Engineers' outlets, and a minimum 1.7 cubic meter per second (60.0 cfs) discharge through the hydropower and hydropower turbine.

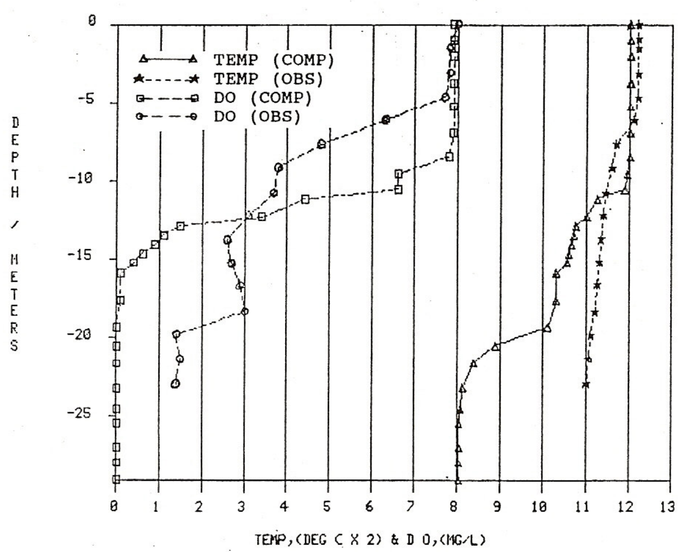
PLATE 10

PLATE 11

MAHONING CREEK LAKE, CE-QUAL-R1 VERTICAL WATER TEMPERATURE AND DISSOLVED OXYGEN GRADIENT SIMULATIONS FOR JULIAN DAY 214 IN 1985, COMPUTED AND OBSERVED FOR SCENARIO A AND SCENARIO B



SCENARIO A Existing conditions to compare computed and observed 1985 data for the purpose of model calibration.

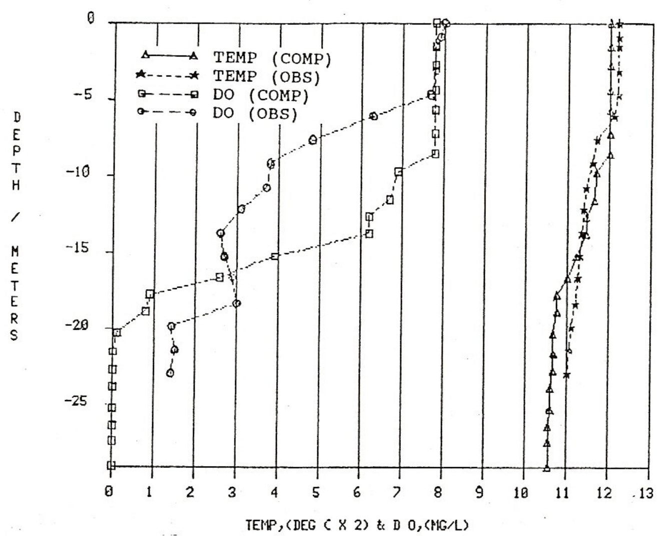


SCENARIO B All 1985 discharge from Mahoning Creek Dam through the hydropower penstocks, and zero discharge through the existing Corps of Engineers' outlets.

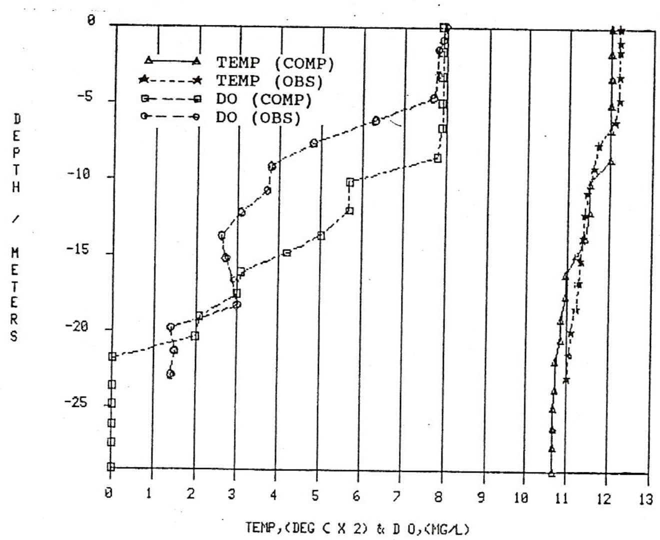
PLATE 11

PLATE 12

MAHONING CREEK LAKE, CE-QUAL-R1 VERTICAL WATER TEMPERATURE AND DISSOLVED OXYGEN GRADIENT SIMULATIONS FOR JULIAN DAY 214 IN 1985, COMPUTED AND OBSERVED FOR SCENARIO C AND SCENARIO D



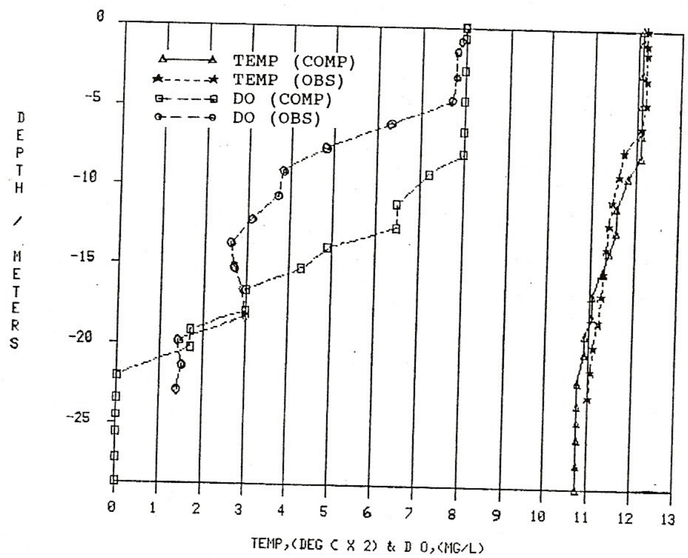
SCENARIO C A one cubic meter per second (35.3 cfs) bypass through the existing Corps of Engineers' outlets, the remainder through the hydropower penstocks and turbine.



SCENARIO D A 0.85 cubic meter per second (30 cfs) minimum bypass through the existing Corps of Engineers' outlets, and a minimum 1.7 cubic meters per second (60.0 cfs) discharge through the hydropower and hydropower turbine.

PLATE 12

MAHONING CREEK LAKE, CE-QUAL-R1 VERTICAL WATER TEMPERATURE AND DISSOLVED OXYGEN GRADIENT SIMULATIONS FOR JULIAN DAY 214 IN 1985, COMPUTED AND OBSERVED FOR SCENARIO E

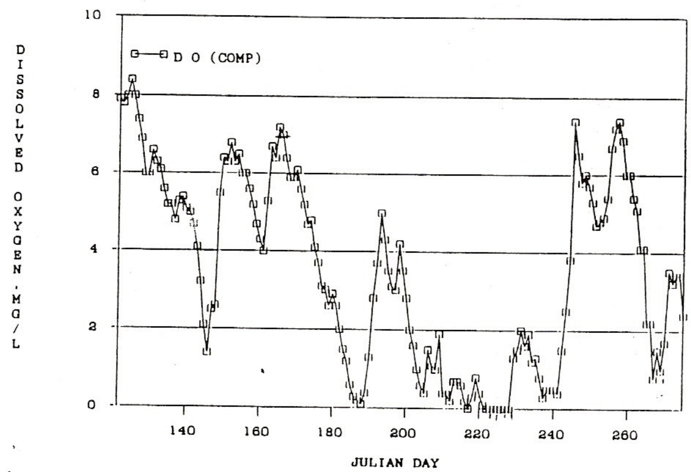


SCENARIO E

A 1.7 cubic meter per second (60.0 cfs) minimum bypass through the existing Corps of Engineers' outlets, and a minimum 1.7 cubic meter per second (60.0 cfs) discharge through the hydropower and hydropower turbine.

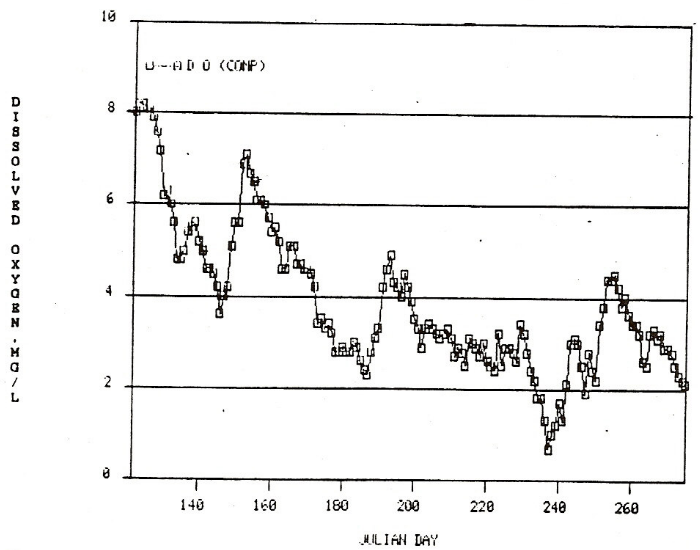
PLATE 13

MAHONING CREEK LAKE, CE-QUAL-R1 WITHDRAWAL ZONE DISSOLVED OXYGEN CONCENTRATION SIMULATIONS FOR 1985, COMPUTED FOR SCENARIO A AND SCENARIO B



SCENARIO A

Existing conditions to compare computed and observed 1985 data for the purpose of model calibration.



SCENARIO B

All 1985 discharge from Mahoning Creek Dam through the hydropower penstocks, and zero discharge through the existing Corps of Engineers' outlets.

PLATE 14