Conowingo Pond Management Plan

Publication No. 242

June 2006

SUSQUEHANNA RIVER BASIN COMMISSION

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of basin water resources among the public and private sectors.

**Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).*

This report is available on our website (www.srbc.net) by selecting Public Information/Technical Reports. For a CD Rom or for a hard copy, contact the Susquehanna River Basin Commission, 1721 N. Front Street, Harrisburg, Pa. 17102-2391, (717) 238-0423, FAX (717) 238-2436, E-mail: srbc@srbc.net.

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

Cover Photo (courtesy of Exelon Generation, Inc.): Looking north at Conowingo dam with the pond in the upper portion of the photo.

ACKNOWLEDGEMENTS

The Conowingo Pond Workgroup members were instrumental in the successful development of the selected management plan for the pond and preparation of the Workgroup's report, which served as the basis for this report by the Susquehanna River Basin Commission. The actively involved members, whose efforts were both important and appreciated, are listed below.

Chester Water Authority – Brian MacEwen, Pat Stabler
City of Baltimore – Sam Grant, Ed Huff; Frank Donaldson and Tom DiLego (Patton, Harris, Rust & Associates)
City of Havre de Grace – Donna Costango
Conectiv Mid Merit, LLC – Stu Widom
Exelon Generation, Inc. – Al Ryan, Tracy Siglin
Harford County – Jackie Ludwig
Lancaster County – Mary Frey
Maryland Department of the Environment –Mat Pajerowski*, John Smith
Maryland Department of Natural Resources – Rich McLean, Steve Schreiner (Versar, Inc.)
Pennsylvania Department of Environmental Protection – Bill Gast
Pennsylvania Fish and Boat Commission – Mike Hendricks
PPL Corporation – Chris Porse
Safe Harbor Water Power Corporation – Dick Johnson
Susquehanna Electric – Don Baldwin, Ron Smith
Susquehanna River Basin Commission – Tom Beauduy, Drew Dehoff, Dave Ladd
U.S. Army Corps of Engineers – Bill Haines
U.S. Fish and Wildlife Service – Dick St. Pierre
York County – John Seitz

*Served as chairman of the Workgroup.

The Susquehanna River Basin Commission retained the services of HydroLogics, Inc. of Columbia, Maryland, for assistance in the technical, water management, and policy aspects of the study that served as the basis for this report. The efforts of Dan Sheer and Dean Randall were critical to the success of the Workgroup, and their contributions to the process and to this report were invaluable.

EXECUTIVE SUMMARY

In 2002, the Susquehanna River Basin Commission (the Commission) convened the Conowingo Pond Workgroup (the Workgroup) to develop a management plan for the Conowingo pond. The primary purpose of this four-year planning effort was for the Workgroup to evaluate operational alternatives for the pond and to recommend to the Commission a management plan that best meets the management needs identified by the Workgroup. Additionally, the Workgroup was tasked with identifying management actions that the Commission should incorporate into its regulatory and water resource management programs. The Workgroup completed their report in March 2006, and it has served as the basis for this report by the Commission on the Conowingo Pond Management Plan.

The Workgroup, which was chaired by the Maryland Department of the Environment, was intended to represent the interests of key stakeholders in the operation and use of the pond. The membership was comprised of representatives from federal and state agencies, local jurisdictions, operators of the lower Susquehanna hydroelectric facilities and Peach Bottom Atomic Power Station, local water utilities, and the Commission. The Workgroup met several times a year and provided direction, oversight, input, and review for the planning effort and its results.

There is a wide range of interests, problems, and potential conflicts related to the resources, uses, and operation of the Conowingo pond. Effective management of the Conowingo pond during low flow conditions is critical for economic, environmental, and human welfare needs in the area. During low flow conditions on the Susquehanna River, there is the potential for conflicts in management objectives to arise to the point where difficult economic and environmental decisions need to be made.

The Conowingo pond, created by the construction of the Conowingo dam, is an interstate body of water with approximately 8 miles of the pond in Pennsylvania and 6 miles in Maryland. The dam was completed in 1928 to provide hydroelectric power generation for the Conowingo Hydroelectric Station. Operation of the dam by Exelon Generation, Inc. (Exelon) is subject to the requirements of the Federal Energy Regulatory Commission (FERC). These requirements include provisions related to minimum flow releases and maintenance of recreational pond levels. Current minimum flows, which vary by season, were established to provide protection for fishery resources, with highest minimum flows required during the anadromous fish migratory period in spring, and intermittent flows permitted only during the winter, when fish populations are limited. By virtue of the pond, a stable source of water storage for other purposes was also provided. The Muddy Run Pumped Storage Hydroelectric Facility, built in 1968, cycles water back and forth from the pond for additional power generation. The water in the Conowingo pond is also used for public water supply by the City of Baltimore and Chester Water Authority, and for industrial cooling by the Peach Bottom Atomic Power Station. Finally, the pond provides a valuable recreational, fish, and wildlife resource.

Under normal and slightly below average flow conditions, there is generally ample water in the lower Susquehanna River to maintain hydroelectric operations; support water supply demands; sustain recreational, fish, and wildlife activities; and meet required flows to downstream river reaches and the upper Chesapeake Bay. However, during more severe low flow conditions, the available water becomes insufficient to meet all prescribed uses and required needs. During such periods, as Exelon operates the Conowingo dam in accordance with its FERC license requirements, storage levels in the Conowingo and Muddy Run facilities begin to decline. Declining pond levels pose a threat to Peach Bottom's cooling water intake, Muddy Run's intake, the use of recreation facilities, shore habitat, and maintenance of downstream flows. In response to declining pond levels and worsening conditions, FERC has authorized Exelon on four occasions to temporarily include water leaking through closed wicket gates toward meeting the dam's daily minimum flow release requirement. A 1988 settlement agreement specifically excludes that water from the minimum release calculation, but FERC has overridden the exclusion during the four events.

In order to investigate and recommend a management plan for the Conowingo pond, it was important that the members of the Workgroup provide insights to the diversified interests related to the pond's resources. These interests include hydroelectric power generation, public water supply, water use upstream of the Conowingo pond, minimum flow release requirements, minimum dissolved oxygen requirements, summertime minimum recreational pond levels, multipurpose benefits, anadromous fish migration, upstream reservoir storage, environmental resources, and cooperative management. The Workgroup collectively assessed the interests and identified problems and conflicts that needed to be addressed. They were:

1. Maintaining FERC mandated minimum flow releases from the Conowingo pond can lead to disruption in power production, water supply withdrawal limitations and diminished recreational opportunities during significant low flow events, and depletes storage that might otherwise be available for release during low flow events of extended duration.

2. Temporary waivers to allow inclusion of gate leakage towards meeting minimum flow releases have been authorized by FERC four times (1999, 2001, 2002, and 2005) during recent droughts, but only under emergency or near-emergency conditions when time is critical and serious impacts are developing with no projected improvement.

3. Increased salinity levels in the Susquehanna River downstream of the Conowingo dam during low flow conditions can negatively impact the water supply for Havre de Grace.

4. Consumptive water use in the Susquehanna River Basin, from and upstream of the Conowingo pond, is increasing and could eventually impact negatively on the pond and those who rely on its water.

5. Commission-owned water supply storage at two federal reservoirs in the upper basin is managed under operating rules that were developed for water supply users elsewhere in the Susquehanna River Basin. Releases from these reservoirs are not mandated by FERC license requirements and may not provide optimum and timely benefits to the Conowingo pond during low flow conditions.

6. Increasing public water supply needs for Baltimore City, Harford County, Chester Water Authority, and the areas of Pennsylvania and Maryland surrounding the Conowingo pond are expected to lead to requests for greater withdrawals from the pond or the Susquehanna River just upstream.

7. Increased consumptive water use needs (i.e., cooling water for a new thermoelectric power plant) could require additional withdrawals from the pond.

A valuable tool used during the planning study was the Commission's OASIS computer model. This daily flow model incorporated more than 70 years of hydrologic record throughout the basin and was used to measure the impacts of various operation parameters on the pond and flow conditions downstream. In addition to hydrologic flow records, the model included representations of the operation of large public water supply withdrawals, power plants, and reservoirs in the Susquehanna River Basin, and incorporated basinwide estimates of existing and future consumptive water uses. Comparative output displays of Conowingo pond levels and dam releases allowed the Workgroup to evaluate numerous operation alternatives and make recommendations for the management of the pond.

Using the hydrologic model, baseline conditions (i.e., existing operations) were established and a series of 32 initial alternatives was evaluated. Key parameters identified for the evaluation included minimum downstream flow requirements, credit for leakage of water at the dam, water supply withdrawals under normal and low flow conditions, consumptive water use in the basin above the Conowingo pond, and the use of Commission-owned storage at two upstream reservoirs to augment low flows. Details on these alternatives are included in Appendix 3 of the main report. Computer-aided negotiations (CAN) were used to perform efficient evaluations of the long-term implications of changes in operating policies and facility configurations. The iterative process embodied in the CAN sessions served to inform the Workgroup members about the pros and cons of many alternatives on a consistent and balanced basis.

After review of the initial 32 alternatives, the Workgroup developed 6 final alternatives for closer analysis leading up to the selection of a preferred operating plan. The alternatives differed mainly in operating rules for release requirements from the Conowingo dam during times of low flow. Parameters such as demand for water supply, water withdrawal operations, and upstream consumptive use were kept constant to allow for direct comparison between alternatives. The alternatives were: (1) Baseline; (2) Automatic Credit; (3) Critical Level; (4) System Deficit; (5) Stepped Waiver; and (6) Minimum Flow. Details on these alternatives are included in Section V of the main report. A thorough evaluation of the six preferred alternatives led to the selected plan, which contains favorable elements of several of the final alternatives.

Based on results of the modeled scenarios, the Workgroup identified the leakage and the minimum release requirement as the most critical parameters in managing low flows and enabling the Conowingo pond to remain viable during droughts. While water conservation measures and the release of augmenting flow from upstream reservoir storage were deemed reasonable measures worthy of consideration, the supplemental volume of water they provide was found to be small relative to the daily fluctuations of the pond, and simply did not offer substantial drought mitigation. Therefore, the selected Conowingo Pond Management Plan was based on establishing a formal protocol to implement a credit for leakage, and to specifying the hydrologic conditions under which the credit is warranted.

The selected plan, "Automatic Q-FERC + 1,000," includes initiation of an automatic credit for leakage of up to 800 cubic feet per second (cfs), when the flow conditions at the Marietta gage decline to a flow of 1,000 cfs greater than the seasonal flow thresholds ("Q-FERC") established by FERC. The Marietta flow threshold is 5,000 cfs between June 1 and September 14, and decreases to 3,500 cfs on September 15 through the end of November.

Modeled simulation runs of operating the resource under the recommended guideline produced favorable results. They demonstrated the most favorable balance for preserving adequate levels in the pond, ensuring reliable multipurpose use of the pond, and meeting the requirements for the quantity of water released to the downstream reaches of the Susquehanna River and the Chesapeake Bay. To further avoid potential negative impacts, the Workgroup conditioned the recommendation of "Automatic Q-FERC + 1,000" with restrictions that prohibit Exelon from automatically taking a credit for leakage during the spring spawning season (April 1 – June 30) and limit the credit to only the portion of the 800 cfs that is absolutely necessary to maintain viable pond levels.

Implementation of the selected plan will require that Exelon successfully petition FERC for an amendment to the existing license to include the altered disposition of the gate leakage during drought conditions. The thorough planning effort of the Workgroup over the past four years and formal support of the proposed license amendment by the agencies involved are expected to be positive input to the approval process. The Workgroup will convene annually to review project operations, assess the potential for hydrologic conditions to develop into drought, and conduct a drought operations exercise. The hydrologic model used to develop the management plan is to be kept up to date by the Commission for the Workgroup's use, and will accurately reflect current water withdrawals in both the pond and the Susquehanna River Basin, as well as current policies and operation protocols. The Workgroup will also be responsible for reviewing and updating, as necessary, the selected management plan on a periodic basis not to exceed five years.

The planning study also identified three related actions beneficial to managing the Conowingo pond that the Commission supports including in its regulatory and water resource management programs. They are:

1. Consideration of the impacts of increasing consumptive water use in the basin on the Conowingo pond and determination of what measures, if any, are necessary to mitigate the impacts.

2. Investigation of the water supply storage owned by the Commission at the federal Cowanesque and Curwensville Lakes projects for alternative operational strategies to

provide more effective low flow augmentation, including benefits to the Conowingo pond and instream resources below the dam.

3. Incorporation of key management principles and tools described in this report, including the use of the annually updated hydrologic model, into the Commission's regulatory and water resource management programs.

To demonstrate its support for implementing the above recommendations, the Commission took action formally adopting the Conowingo Pond Management Plan. As part of that action, the Commission included the plan in its Comprehensive Plan for Management and Development of the Water Resources of the Susquehanna River Basin, noting that the inclusion should not be construed as in any way binding upon the Commission in the approval or disapproval of projects pursuant to its authority under the Susquehanna River Basin Compact (Compact) or the regulations promulgated thereunder.

The report on the Conowingo Pond Management Plan, with its documented thorough analysis, provides valuable information for the Commission, public water suppliers, power companies, and environmental resource agencies in making regulatory and management decisions involving the resources of the lower Susquehanna River. Given the potential for increased water use and future withdrawals in the upstream basin and from the Conowingo pond, the adoption of the Conowingo Pond Management Plan and related actions is intended to ensure sustainable operations and a reliable water source for all needs, from public water supply and power generation to recreation and aquatic habitat, for many years to come. The management plan is accessible by the public via the Commission's website at www.srbc.net.

I. INTRODUCTION

A. Purpose and Objectives

Effective management of the Conowingo pond is critical to economic, environmental, and human welfare needs in the area. As demands on the resource increase, there is the potential during future droughts for inflow into the pond to decrease to the point where difficult economic and environmental decisions will need to be made. There currently is no framework in place to facilitate the dialog and policy development necessary to support those decisions.

The primary purpose of this planning effort was the development of a management plan for Conowingo pond during critical low flow periods. The Conowingo Pond Workgroup (the Workgroup) evaluated operational alternatives for the pond and identified a recommended management plan that best meets the identified needs. In addition, the Workgroup identified actions beneficial for managing the Conowingo pond that the Susquehanna River Basin Commission (the Commission) should consider including in its regulatory and water resources management programs.

The *Conowingo Pond Workgroup Report* was completed in March 2006, and summarizes the efforts of the Workgroup, identifies the issues surrounding operations of the Conowingo pond during low flow conditions, discusses resolution of conflicts and problems through a coordinated planning process, presents the results of analyses of alternative plans, and makes recommendations for actions that should be taken by the Commission. The Workgroup's report served as the basis for this report prepared by the Commission.

The study process, analyses, and results discussed in this report also fulfill a commitment jointly made by the Commission and the City of Baltimore. In 2001, the Commission and the City of Baltimore ratified a settlement agreement to resolve issues relating to Baltimore's withdrawal and diversion of water from the Susquehanna River at the Conowingo pond. Section 7 of the agreement called for development of a Conowingo Pond Operating Plan, including associated modeling and impact studies. In addition to the Commission and the City of Baltimore, a group of stakeholders was identified for possible participation in developing the operating plan. The group consisted of federal and state resource and regulatory agencies, local jurisdictions, and operators of electric power projects.

The following objectives of the Conowingo pond study were established as an initial step:

1. Develop a workgroup dedicated to the comprehensive management of the water resources in the vicinity of the Conowingo pond;
2. Gain an understanding of the factors, both natural and manmade, that affect the water resources of the Conowingo pond;
3. Conduct a study to assess the ability of the available water resources to meet present and future demands;
4. Identify existing constraints and potential conflicts, and evaluate alternative solutions through the use of the detailed Conowingo pond model;

5. Educate the stakeholders and the public regarding the Conowingo pond's demands, constraints, water availability, and management opportunities; and
6. Prepare and implement a long-term management plan.

B. Background of Conowingo Dam and Pond

Construction of the Conowingo dam across the lower Susquehanna River in Maryland began in 1926 and was completed in 1928. The dam created a 14-mile long, 9,000-acre pond having 35 miles of shoreline, a width varying from 0.5 to 1.3 miles, and a maximum depth of 98 feet. The Conowingo pond is an interstate body of water with approximately 8 miles of the pond in Pennsylvania and 6 miles in Maryland. The dam was built to provide hydroelectric power generation, but by virtue of the pond it created, a stable source of water storage for other purposes was also provided. In addition to hydroelectric uses, the water in the Conowingo pond is also used for public water supply, industrial cooling water and recreation, and provides a valuable fish and wildlife resource. The Conowingo dam includes a fish passage feature to facilitate anadromous fish restoration in the Susquehanna River Basin. See Figure I-1 for location of the Conowingo dam and pond.

The Conowingo Hydroelectric Station is operated by Exelon Generation's subsidiary, Susquehanna Electric Company, and is the largest of the four hydroelectric projects on the lower Susquehanna River in terms of generating capacity, dam height, and water storage (i.e., pond area). The other three hydroelectric projects on the river (Holtwood, Safe Harbor, and York Haven) are located upstream of the Conowingo pond in Pennsylvania. Operation of Conowingo dam is subject to the requirements of the Federal Energy Regulatory Commission (FERC), which include minimum flow releases and seasonally prescribed recreation pond levels. Current minimum flows, which vary by season, were established to provide protection for fishery resources, with highest minimum flows required during the anadromous fish migratory period in spring, and intermittent flows permitted only during the winter, when fish populations present are limited.

The Conowingo pond is a source of water for:

1. Conowingo Hydroelectric Station, located in Cecil and Harford Counties, Maryland;
2. Muddy Run Pumped Storage Hydroelectric Facility, Lancaster County, Pennsylvania;
3. Peach Bottom Atomic Power Station, York County, Pennsylvania;
4. City of Baltimore, Maryland, municipal water supply;
5. Harford County, Maryland, public water supply (provided by Baltimore's system);
6. Chester Water Authority water supply utility, serving areas of southeast Pennsylvania and northern Delaware;
7. Recreational uses, including boating and fishing; and
8. Sustained streamflows downstream of the dam.

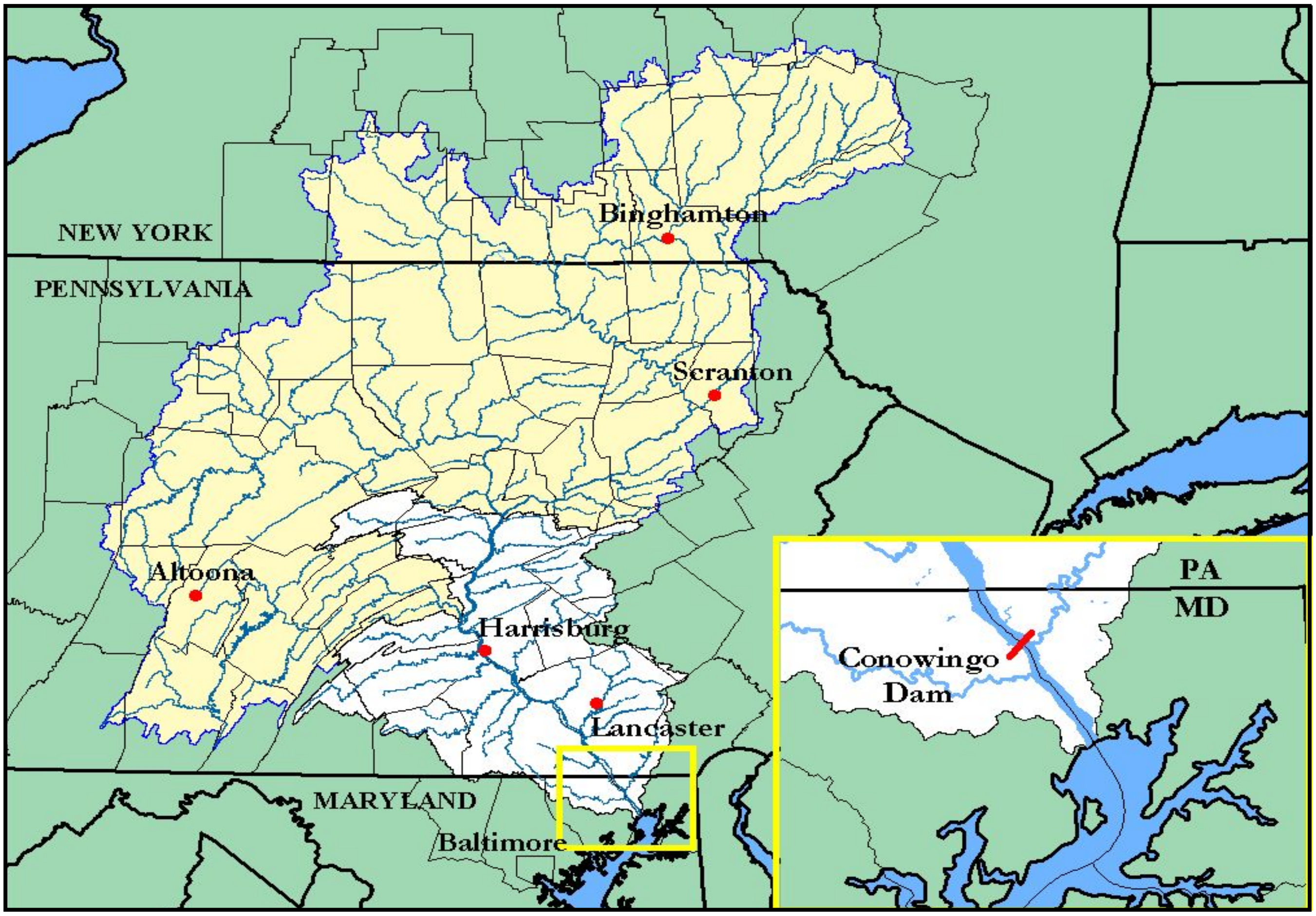


Figure I-1. Location of Conowingo Dam and Pond

Figure I-2 shows the locations of the various facilities at and near the Conowingo pond.

C. Conowingo Pond Workgroup

The Conowingo Pond Workgroup was formed in 2002 by the Commission to both represent the interests of key stakeholders in the operation and use of the pond and to provide direction, oversight, input, and review for the planning effort and its results. The Workgroup met several times per year beginning in April 2002, and was closely involved in the step-by-step development of the Conowingo Pond Management Plan. In addition to their involvement through the periodic meetings, Workgroup members cooperatively provided data and other input upon request by Commission staff. FERC was kept informed of Workgroup progress and results by periodic updates from Commission staff.

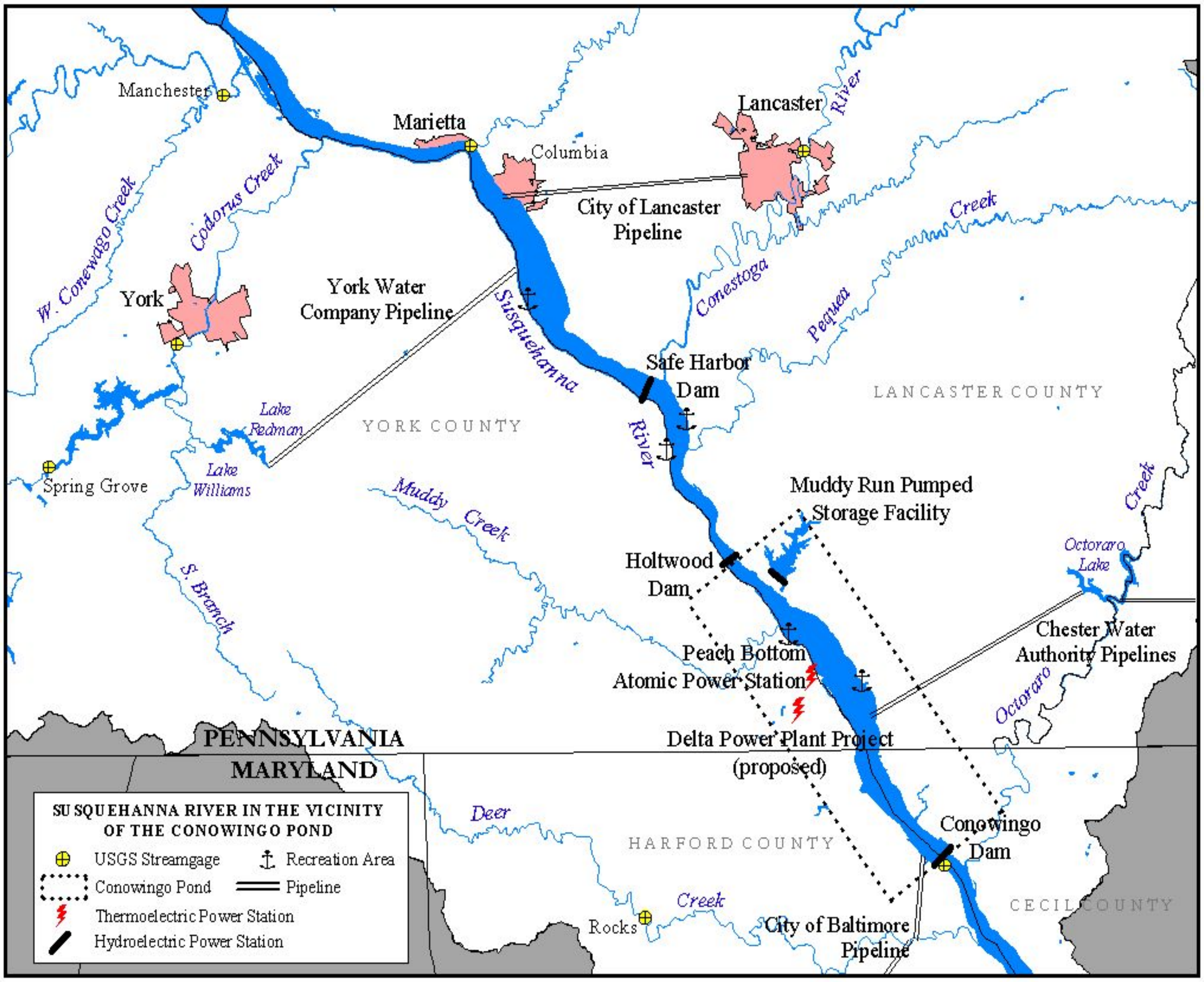


Figure I-2. Facilities in the Vicinity of the Conowingo Pond

Mr. Matthew Pajerowski, Maryland Department of the Environment, served as Chairman of the Workgroup. Commission staff facilitated the meetings by providing study material for information and/or review, setting the meeting agendas, making presentations, leading discussions, and documenting results. Mr. Andrew Dehoff was the project manager for the Commission and had a lead responsibility for Workgroup activities.

Active members of the Workgroup represented a wide variety of interests including power generation, public water supply, natural/environmental resources, regulatory requirements, and balanced water resource planning and management. Participation on the Workgroup was provided by the entities listed below:

1. Maryland Department of the Environment (MDE)
2. Maryland Department of Natural Resources (MDNR)
3. Pennsylvania Department of Environmental Protection (PADEP)
4. Pennsylvania Fish and Boat Commission (PFBC)
5. Susquehanna River Basin Commission
6. U.S. Fish and Wildlife Service (USFWS)
7. U.S. Army Corps of Engineers (USACE)
8. City of Baltimore, Maryland
9. Chester Water Authority
10. City of Havre de Grace, Maryland
11. Operators of the Conowingo, Holtwood, Safe Harbor, Muddy Run, and Peach Bottom projects
12. Conectiv Mid Merit, LLC (Conectiv)
13. Harford County, Maryland
14. Lancaster County, Pennsylvania
15. York County, Pennsylvania

II. THE RESOURCES AND USES OF THE CONOWINGO POND

The Conowingo pond is a multipurpose resource that provides water to meet several needs and to allow water-based opportunities. Summary information on these needs and opportunities are discussed below.

A. Fishery Resources

The 14-mile long Conowingo pond, bounded by the upriver Holtwood dam in Pennsylvania and the Conowingo dam downriver in Maryland, straddles the two states. Reciprocal recreational fishing regulations are in effect in the Conowingo pond, permitting anglers licensed in either Pennsylvania or Maryland to utilize the entire pond. Fishing regulations for the entire Conowingo pond are determined by the Maryland Department of Natural Resources.

The Conowingo pond provides a mixed warm water recreational fishery for largemouth and smallmouth bass, channel catfish, white crappie, bluegill, and to lesser degrees, striped bass, walleye and carp. The most abundant fish in the Conowingo pond is the gizzard shad. Bass fishing tournaments are commonplace during the open season. Steep, wooded slopes and railroad postings limit shoreline and boat access. The heated effluent from Peach Bottom Atomic Power Station attracts game fish during the winter and extends the open-water fishing season.

The seasonal recreational fishery for American and hickory shad below Conowingo dam is one of the best in the world. Catches of more than 100 shad per day are possible. The shad fishery is concentrated along the west shore at two areas: immediately below the dam and at the mouth of Deer Creek. The shad fishery is dominated by shore and wading anglers, since boating in the shallow three-mile section from Conowingo dam to the Town of Port Deposit can be extremely hazardous. Other popular fisheries below Conowingo dam target striped bass, white perch, smallmouth bass, and channel catfish. Gizzard shad entrainment at Conowingo dam provides an intermittent source of forage for predatory fish and birds below Conowingo dam.

B. Hydroelectric Power

Two hydroelectric power facilities use the water of the Conowingo pond as part of their operation. See Figure I-2 for locations of the facilities discussed below.

The Conowingo Hydroelectric Station has 13 turbine generators with a capacity of 549.5 megawatts (MW) and generates an average of 1.8 billion kilowatt-hours of electricity annually. Because water is used to turn the turbines, Conowingo can be used to “jump start” the electric distribution system in the event of a system blackout. The Susquehanna Electric Company, a subsidiary of Exelon Generation, operates the facility.

The Muddy Run Pumped Storage Facility uses water from the Conowingo pond to operate 8 turbine generators with a capacity of 880 MW. The facility is used for electrical demand peaking and load leveling. Water pumped from the pond and stored in the Muddy Run reservoir drops 343 feet vertically through four 25-foot-diameter intake shafts. The shafts then run horizontally for another 525 feet before splitting into eight 14-foot-diameter tunnels that direct the water to the turbines. The facility is operated by the Susquehanna Electric Company and was constructed in 1968.

The hydroelectric facilities do not operate without constraints. As a result of the 1988 settlement agreement between the owners of the Conowingo dam and environmental resource agencies, the dam's FERC license mandates minimum flow requirements and minimum downstream dissolved oxygen requirements to protect downstream aquatic resources. In addition, to promote recreational resources of the Conowingo pond, the license stipulates pond level minimums during summer weekends.

C. Public Water Supply

1. **The City of Baltimore (City) –** The Big-Inch or Susquehanna Project was completed in 1965 to enable the City to make use of the Susquehanna River as a water supply source, and consists of an intake structure of 500 million gallons per day (mgd) capacity above Conowingo dam; a 144-inch and 108-inch tunnel and pipeline with a potential capacity of 500 mgd; the Deer Creek Pumping Station, currently equipped with 3 pumps at a rating of 50 mgd each and expandable to 5 pumps with a combined safe station capacity of 250 mgd; and approximately 35 miles of 108-inch and 96-inch transmission main to the Montebello Filtration Plants in Baltimore City. The transmission main on the discharge side of the pumping station has a design capacity of approximately 250 mgd. Additional right-of-way was acquired at the time of transmission main construction in anticipation of the need to build a parallel conduit at some future date.

   Baltimore has been approved by the Commission to withdraw a maximum of 250 mgd from the Conowingo pond. During low flow periods on the Susquehanna River (i.e., when "Q-FERC" or lower flows occur), the maximum 30-day average withdrawal is reduced to 64 mgd. See Section III-B for an explanation of the Q-FERC values.

   An investigation is currently underway by the City of Baltimore to determine the processes and capacity for the planned Fullerton Filtration Plant, to be located on the Fullerton site at the current location of the City's system interconnection with the Susquehanna project. The Susquehanna River will be the primary raw water source for this future facility.

   Harford County can use up to 20 mgd from the Baltimore system to help meet its water supply needs under an agreement with the City. This amount could increase as Harford County's needs grow, and if a modified agreement is enacted.

2. **Chester Water Authority –** Chester Water Authority has been approved by the Commission to withdraw a maximum of 30 mgd of water supply from the Conowingo pond. Chester Water Authority provides public water supply to areas in

southeast Pennsylvania and northern Delaware. Chester Water Authority's Susquehanna Pumping Station includes a submerged 12-foot-diameter grated intake located about 10 feet below normal pond elevation and a 54-inch pipe that delivers the water from the intake to the sump of the pumping station. Three 15-mgd vertical turbine pumps are used to pump the water through approximately 13 miles of 42- and 36-inch transmission main to the Chester Water Authority Octoraro Treatment Plant for purification. The pumping station capacity with one pump running is approximately 17 mgd and with two pumps running, 30 mgd. The third pump is for backup purposes only.

D. Thermoelectric Power

The Peach Bottom Atomic Power Station, located on the west bank of the Conowingo pond in York County, Pennsylvania (see Figure I-2), is a two-unit nuclear generating facility that uses water from the Conowingo pond for cooling purposes. The two power units are boiling water reactors capable of generating 1,093 MW each. Both units began commercial operation in 1974. The station does not currently use evaporative cooling towers for cooling needs, but evaporates up to 28 mgd through heat transfer via once-through cooling with water withdrawn from Conowingo pond. Peach Bottom is currently co-owned by Exelon Generation and Public Service Electric and Gas of New Jersey. Exelon Nuclear operates Peach Bottom.

E. Recreational

A variety of unique physical features gives the Conowingo pond its special character and provides visitors with a wealth of outdoor recreational experiences. The rugged geology creates a dramatic scene of island formations and shoreline cliffs. The pond's waters and the forested hillsides harbor a broad spectrum of aquatic, animal, and plant habitats.

Fishing is one of the most popular recreational activities on the Conowingo pond. Good fishing areas in the pond are accessible along the shoreline or by boat. There is also fishing access to streams feeding into the pond and to a recreation lake at Muddy Run Park, which is just east of the pond. Stocking programs and fishing tournaments help attract anglers to the pond.

Boating is another favorite recreational pastime for visitors to the pond. The broad expanse of water at the southern portion of the pond is good for waterskiing, sailing, and motor boating. The northern portion of the pond is narrower, includes islands, and is ideal for canoes and small boats.

While fishing and boating are the most popular activities at the Conowingo pond, visitors also enjoy camping, hunting, hiking, swimming, nature observation, and educational facilities. Most visitors enjoy a day trip to the Conowingo pond to participate in recreational activities, but some stay for an entire season.

F. Future Project

A new electric generating facility, having a maximum capacity of 1,100 MW, has been proposed by Conectiv Mid Merit, LLC (Conectiv) for construction in Peach Bottom Township, York County, Pennsylvania. The facility would be located inland approximately 2.5 miles from the Conowingo pond (see Figure I-2 for location), but major water needs for the project would be met by a withdrawal from the Conowingo pond and would include cooling tower makeup water, blowdown makeup, process water for emissions control and fuel conditioning, and fire protection needs. The amount of consumptive water use would vary depending on plant operations, but would not be expected to exceed a maximum daily loss of 8.700 mgd.

III. EXISTING PROBLEMS, ISSUES, AND OPPORTUNITIES

A. Review of Various Interests in Pond's Resources

There are a wide variety of interests related to the resources, use, and operation of the Conowingo pond. The members of the Workgroup provided insights to these diversified interests. The following major interests were identified during development of the management plan. A full listing of input provided by Workgroup members is provided in Appendix 1 of the report. A summary, non-prioritized listing of this information is provided below.

1. **Hydroelectric Power Generation –** There is a widely recognized and critical need to maintain reliable hydroelectric power generation, particularly during low flow conditions in the summer when electrical demand is at its highest level. The Muddy Run Pumped Storage Facility is key to reliable power generation during droughts and the Conowingo Hydroelectric Station plays a lesser role. The Muddy Run facility makes use of the top four feet of Conowingo pond storage to cycle water back and forth for the purpose of hydropower generation. Water is pumped from the Conowingo pond to the Muddy Run reservoir overnight when the cost of electricity is low, and is then released during the day to generate power when demand and prices are higher. The Muddy Run facility moves more water and generates more power, with a capacity of 880 MW, than any of the other hydroelectric facilities on the Susquehanna River. The Conowingo Station's electrical power generation is significantly diminished during low flow conditions because it is dependent on inflow from the Susquehanna River and must release the required downstream minimum flows. During low flows, the Conowingo Station typically produces approximately 4 percent of its operating capacity, or just 22 MW. In view of the operating parameters, maintaining the Muddy Run facility at as high an operating level as feasible should be a primary objective. This can be accomplished by minimizing reductions in the Conowingo pond levels during low flow periods.

2. **Public Water Supply –** Protecting and conserving Conowingo pond as a water source are essential for ensuring sufficient water resources for current and future citizens of the region. As population and water needs increase, reliance on the pond as a water supply source is expected to increase as well. It is vital that the waters flowing to the Conowingo pond be properly managed to ensure adequate flow and the best possible water quality. Water conservation and efficient water use should be recognized as beneficial measures, particularly during low flow conditions.

   Chester Water Authority has a continuing need to withdraw up to 30 mgd from the pond. Increasing water supply demands may lead Chester Water Authority to request an increase in its maximum withdrawal to 40 mgd.

   The City of Baltimore is approved to withdraw a maximum of 250 mgd, but is currently limited by its aggregate pumping capacity with 3 pumps operating to a withdrawal of approximately 137 mgd, depending upon system hydraulics. The City must reduce its 30-day average withdrawal to 64 mgd during critical low conditions on the Susquehanna River, in accordance with the City's water withdrawal approval from the Commission. The river withdrawal is an integral element of Baltimore's raw water supply system and is currently employed either during major drought periods or under emergency operating conditions. Growing demands are expected to increase the City's dependence on the pond as a raw water source, and the planned implementation of the Fullerton Filtration Plant project will result in the withdrawal from the Susquehanna operating year-round. Consequently, the City may request that the allowable maximum day withdrawal during low flow conditions be increased, potentially to as much as 142 mgd.

Harford County depends on the pond for 20 mgd, at present, through water supply provided by Baltimore City's system. The County anticipates needing up to 40 mgd in the future, possibly obtained through a modified agreement with Baltimore City. Cecil County is also potentially interested in water supply from the Susquehanna River to meet its growth objectives. A recent study by Cecil County resulted in recommendations to the County Commissioners that the Susquehanna River be investigated as a source to supplement water supply within Cecil County's growth corridor along U.S. Route 40. A withdrawal to serve Cecil County would likely draw water from an existing intake downstream of the Conowingo dam.

The City of Havre de Grace has a water withdrawal permit for 10 mgd from the Susquehanna River. The City's intake is exposed to tidal influence when the discharge from Conowingo dam is low and the water quality can be impacted by salinity. If severe, the water would be usable only for sanitation purposes, not for drinking. Impacts on the Upper Chesapeake Hospital could be severe and a bottling plant could be shut down.

3. **Consumptive Water Use Upstream of Conowingo Pond –** There is concern that increasing consumptive water use in the Susquehanna River Basin will result in more frequent low flow periods impacting the pond. The impacts of changing hydrologic conditions and increasing consumptive use and water withdrawals must be accommodated. Adequate storage of water in the basin, including water supply reservoirs, is vital in order to lessen impacts to streamflows during low flow conditions.

4. **Minimum Flow Release Requirements –** Extended low flow conditions can adversely affect the ability of the pond to both provide mandated flow releases to the lower Susquehanna River and concurrently maintain critical pond levels. Maintaining sufficient flow and quality for waters entering the lower Susquehanna River and the Chesapeake Bay is critical to ensuring the health of the Bay. Sufficient flow is required in order to adequately dilute discharges into the lower Susquehanna River from a number of industrial and other wastewater facilities, and to maintain the health of wetlands in the region surrounding the river.

   A management plan for the pond's operation during low flow conditions must ensure that all essential uses of the pond are protected to the fullest extent practicable. Any proposed modification of the minimum flow releases must be for the purpose of protecting all essential uses and not just to enhance hydropower generation.

5. **Minimum Dissolved Oxygen Requirements –** Extended low flow conditions, in conjunction with high ambient water temperatures, make achieving dissolved oxygen levels downstream of Conowingo dam a challenge.

6. **Summertime Minimum Pond Levels –** Extended low flow conditions can adversely affect the ability of the operators to keep the pond at prescribed levels for recreational use.

7. **Multipurpose Benefits –** The citizens in the surrounding area benefit from recreational activities, fish and wildlife resources, hydroelectric power, and public water supply provided by the pond. Specific interests in these benefit categories are discussed in this section, and effective management of the pond is needed to ensure that it continues to meet these multiple needs. From the Commission's perspective, a primary goal of the Workgroup's effort is the balancing of economic development, environmental protection, and provision of public water supplies.

8. **Anadromous Fish Restoration –** The program for anadromous fish restoration in the Susquehanna River Basin has been very successful and will continue as an important and widely supported effort. Any changes in low flow operations at Conowingo dam and pond must ensure that successful upstream passage of adult shad in the spring and downstream movement of juveniles in the fall continue.

9. **Upstream Reservoirs –** Commission-owned water supply storage at two Army Corps of Engineers' reservoirs in Pennsylvania, Cowanesque and Curwensville Lakes, is available for low flow augmentation. However, the use of that storage is limited to times of severe low flows when Q7-10 events occur (Q7-10 is the low flow expected to occur once in 10 years, on average, for a 7-day duration). There is interest in determining if additional flow releases could be made from the Commission's storage to benefit the Conowingo pond during low flow periods when the more frequent Q-FERC events occur (see Section III-B for discussion of Q-FERC).

10. **Environmental Resources –** Concerns include the general health of living resources in the pond and tailwaters, impacts on downstream resources, and impacts on aquatic resources at water intakes and streamside development.

11. **Cooperative Management –** There was strong support for a cooperative effort by Workgroup members to resolve conflicts and implement an effective management plan.

B. Minimum Releases and the 1988 Settlement Agreement

The minimum flow release requirements for Conowingo dam were established in 1988 as part of a settlement agreement (Docket No. EL80-38-000; Project No. 405-009) approved by FERC. Parties to the agreement were the Philadelphia Electric Power Company and the Susquehanna Power Company (the "licensees") and the "interveners" consisting of the U.S. Fish and Wildlife Service, the State of Maryland (Maryland Department of Natural Resources), the Commonwealth of Pennsylvania (Department of Environmental Resources and the Fish and Boat Commission), the Susquehanna River Basin Commission, the Upper Chesapeake Watershed Association, and the Pennsylvania Federation of Sportsman's Clubs.

The agreement specified that the minimum flow requirement from Conowingo dam be determined by the lesser of two quantities: (1) the natural river flow as measured at the U.S. Geological Survey (USGS) gage at Marietta, Pennsylvania; or (2) the minimum flow requirement from the seasonal schedule developed for the agreement, shown below, and commonly referred to as "Q-FERC." The minimum flows, which vary by season, were established to provide protection for fishery resources, with highest minimum flows required during the anadromous fish migratory period in spring, and intermittent flows permitted only during the winter, when fish populations present are limited. Minimum flows below Conowingo dam during the spring are of particular importance to maintenance of good water quality and the aquatic resources present in that habitat. Under full anadromous fish restoration, the 3-mile river reach below Conowingo dam is expected to host up to 3 million American shad and 15 million river herring, and it is currently utilized by large populations of white perch, gizzard shad, carp, suckers, American eel, striped bass, and other species. Long-term studies demonstrated that intermittent winter flows were sufficient to maintain the wetted surface area needed to maintain macroinvertebrate production, an important fish food resource.

Dates	Minimum Flow (cfs)
March 1 – March 31	3,500
April 1 – April 30	10,000
May 1 – May 31	7,500
June 1 – September 14	5,000
September 15 – November 30	3,500
December 1 – February 28	3,500 [1]

[1] The minimum flow for December 1 – February 28 was left unspecified in the 1988 agreement, pending further study. In order to resolve this issue, the agreement called for MDNR to undertake studies to determine if continuous flows have a detectable impact on benthic populations in the Susquehanna River below Conowingo dam. These studies were completed in 1998 and served as the basis for the minimum intermittent flow of 3,500 cubic feet per second (cfs) or natural river flow, whichever is less. The agreement also allows a maximum of 6 consecutive hours of no flow releases followed by an equal or greater amount of hours of releases of 3,500 cfs or the natural river flow. This policy was formally adopted in 2004.

In practice, during normal conditions when there is ample water available in the Susquehanna River, the dam releases the appropriate minimum Q-FERC flow for the time of year, in accordance with the table above. However, during low flow conditions, when flows measured at the Marietta gage decline below the Q-FERC level, the dam's minimum flow matches the flow recorded at the gage during the previous day.

In addition to prescribing the minimum flow rate from the dam, the license amendment also specifies that the flows must be provided by turbine releases exclusive of leakage from appurtenances of the Conowingo dam, and that discharges from house units shall be included as minimum flows only when such units are operating. In other words, leakage of water through closed wicket gates in the powerhouse cannot be counted towards the dam's required minimum flow release. The leakage has been estimated to be about 800 cfs.

C. Low Flow Operations

Under normal and slightly below average flow conditions, there is generally ample water in the lower Susquehanna River to support water supply demands, serve hydroelectric operations, and maintain adequate flows to downstream river reaches and the upper Chesapeake Bay.

Under current pond operating conditions and in the absence of a management plan, the available water becomes insufficient to meet all prescribed uses and required needs during periods of extreme low flow. Storage levels in the Conowingo and Muddy Run facilities begin to decline as Exelon strives to meet minimum release requirements of the FERC license. In order to avoid violating the minimum flow requirements of the license, Muddy Run operations are at first gradually curtailed, and eventually discontinued in the interest of maintaining required minimum releases.

Declining pond levels threaten Peach Bottom's cooling water intake, recreational use of the Conowingo pond, shore habitat levels, and downstream flows. As drought conditions continue, the operators continue to generate hydroelectricity as much as possible using the water available to them, but it becomes a secondary concern. The primary concern becomes the depletion of storage in the pond and safeguarding the ability of the pond to continue to make adequate releases during low flow events of extended duration. See Figure III-1 for a depiction of important elevations in the pond. The elevations shown on Figure III-1 are based on the Conowingo datum, which is 0.7 feet below the more standard NGVD (National Geodetic Vertical Datum).

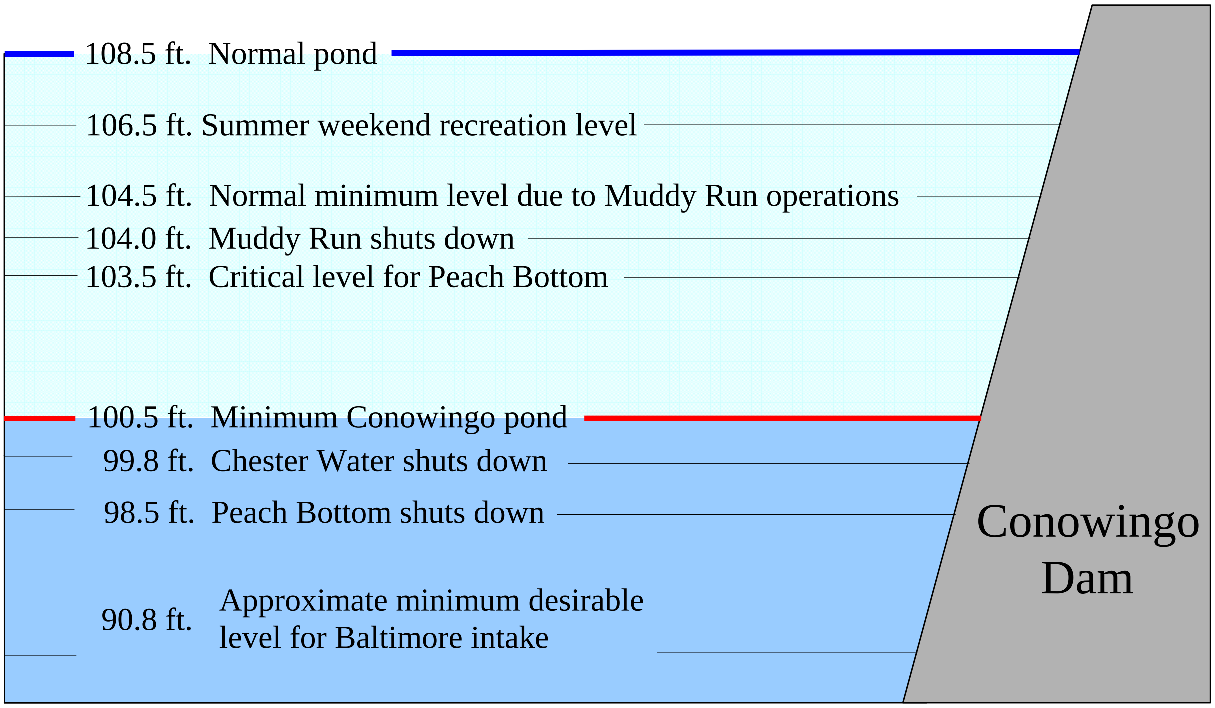


Figure III-1. Important Operating Elevations (Conowingo Datum) of Conowingo Pond

During recent droughts, in response to declining pond levels and worsening conditions, FERC has granted Exelon temporary relief from license requirements on four separate occasions (1999, 2001, 2002, 2005) in order to safeguard the storage remaining in the pond and its availability for multipurpose use. The variances were supported by the Pennsylvania Fish and Boat Commission, Maryland Department of Natural Resources, U.S. Fish and Wildlife Service, and the Susquehanna River Basin Commission in consideration of the importance of preserving storage and preventing the decline of the pond to undesirable levels. The variances were not intended to benefit Exelon hydroelectric operations at the expense of recreational pond levels, minimum downstream releases, or minimum pond elevation requirements.

The basis of the variance in the past has been the quantity of water estimated to leak through non-operating turbines, approximately 800 cfs. Instead of disqualifying that leakage from counting towards minimum release requirements, as stipulated in the 1988 settlement agreement, FERC temporarily allows inclusion of up to 800 cfs, as needed. The variance is valid only so long as drought conditions exist, or as otherwise stipulated by FERC. It should be noted that, in actual implementation of the credit for leakage, Exelon typically uses only the portion of the 800 cfs necessary to stabilize and maintain the pond level, so as to continue releasing as much flow downstream as possible. Also, because of inherent uncertainties in estimating leakage quantities, utilizing only the credit for leakage necessary to maintain and stabilize pond level ensures conservative implementation of the variance when possible.

Because counting leakage toward minimum flows from Conowingo directly contradicts the 1988 settlement agreement, there is an elaborate protocol for implementing the variance. Exelon personnel must carefully document declining flows and deteriorating conditions in the pond, and request the support of the intervening parties to the settlement agreement. Depending on the timing of the request and availability of personnel, concurrence from the four agencies can come as quickly as later the same day, or may not be available for up to a week; there is no definitive duration or deadline. When Exelon has garnered the support of the four agencies, it makes an official request to FERC for a license variance. Again, depending on the circumstances, approval for the variance from FERC, while usually forthcoming, can take several days. The process is intentionally a deliberate one, because it is important that the variance to credit leakage towards the minimum flow requirement is justified. However, the delay between the initiation of the request and the approval can result in a significant loss of critical storage in the Conowingo pond.

Regardless of the severity of drought conditions, availability of water for power plant cooling purposes, or a variance from FERC, neither of the water supply withdrawals from the pond (by the City of Baltimore and Chester Water Authority) is subject to curtailment as a result of decline in pond elevation. In accordance with agreements established between Exelon and the withdrawal operators, daily withdrawals continue even as the pond level declines. This is true regardless of whether the withdrawals have ever been shown to impact Exelon's ability to maintain Conowingo's required stage and release. It is the sole responsibility of Exelon to maintain the pond and releases at levels required in the FERC license.

Although not subject to withdrawal restrictions based on pond elevations, there is a provision in the City of Baltimore's settlement agreement with the Susquehanna River Basin Commission that limits withdrawals during periods when the flow at Marietta is below the thresholds established by FERC. Although approved to take up to 250 mgd, and with a present output totaling 137 mgd (with 3 pumps operating), the City is currently restricted to taking a 30-day average of 64 mgd during FERC triggers. As mentioned above, Chester Water Authority is not subject to such restrictions.

D. Identification of Existing Problems and Issues

For the reasons described above, managing the Conowingo pond during low flow periods on the Susquehanna River is a challenging endeavor. The Conowingo pond is an intensely used, but finite, water resource that serves hydroelectric, thermoelectric, water supply, recreation, and aquatic habitat purposes. The multipurpose operation of the pond, in combination with increasing water demands and naturally recurring low flow conditions, has led to problems and conflicting purposes. As one of its initial tasks, the Workgroup identified the existing and potential problems and issues:

1. Maintaining FERC mandated minimum flow releases from the Conowingo pond can lead to disruption in power production and cause pond levels that are lower than the recreational levels. See Figure III-1 for a depiction of important elevations. The specific problems and issues that can develop are:

    a. Conowingo Hydroelectric Station – The FERC license for the Conowingo plant does not allow the pond to go lower than 100.5 feet.

b. Muddy Run Pumped Storage Hydroelectric Facility – The Muddy Run facility cannot operate its large pumps below 104.0 feet elevation due to concerns about cavitation.

c. Peach Bottom Atomic Power Station – The Peach Bottom station begins experiencing cooling problems when the elevation of the pond drops to 103.5 feet. Due to the nature of nuclear power plants with operational safety concerns, complex shutdown/start-up procedures, and large base-load power outputs, logic dictates that priority must be given to Peach Bottom over other interests, particularly considering that low flow conditions typically occur in the midst of summer when demand for electricity peaks. Faced with declining pond levels and in recognition of the potential serious impacts to the Peach Bottom Station, Exelon expects that prudent and cautious actions would be directed by FERC to help stabilize the pond level in the range of 104.0 to 105.0 feet. The Nuclear Regulatory Commission license for Peach Bottom requires the plant to shut down completely at 98.5 feet.

d. Chester Water Authority – Lowered pond elevations may hinder the Chester Water Authority's withdrawal. The Authority needs a pond elevation of at least 99.8 feet to avoid cavitation problems.

e. City of Baltimore – The City's withdrawal intake is at a deeper location in the pond than the others. The minimum desirable level for operation of the intake is 90.8 feet.

f. Recreation – Lowered pond levels reduce recreational opportunities. The Conowingo pond operating rules stipulate that an elevation of 106.5 feet be maintained on weekends to meet recreational needs.

2. Emergency or near-emergency conditions have existed when temporary waivers to allow inclusion of gate leakage towards meeting minimum flow releases were given at four times (1999, 2001, 2002, 2005) during recent droughts. The process for obtaining a temporary waiver occurs when time is critical and serious impacts are developing with no projected improvement.

3. Increased salinity levels in the Susquehanna River downstream of the dam during low flow conditions can negatively impact the water supply for Havre de Grace.

4. Consumptive water use in the Susquehanna River Basin upstream of the Conowingo pond continues to increase and could negatively impact the pond. Consumptive use is estimated to have increased from 270 mgd in 1970 to 456 mgd in 2000 (a 69 percent increase over 30 years), and is projected to increase to 640 mgd in 2025 (a 40 percent increase over 25 years).

5. Commission-owned water supply storage (30,000 acre-feet) at two federal reservoirs in the upper basin is not available for use to specifically benefit the Conowingo pond due to existing operational rules at the reservoirs.

6. Increasing public water supply needs for the City of Baltimore; Chester Water Authority; utilities in Harford, Lancaster, and York Counties; and possibly other areas are expected to lead to requests for greater withdrawals from the pond or the Susquehanna River just upstream.

7. Increased industrial consumptive water use needs (i.e., cooling water) could require additional withdrawals from the pond.

E. Opportunities for Improvements

Each member of the Workgroup brought a different perspective to the table with regard to drought operations and experience in managing and mitigating droughts. In preliminary discussions about potential management strategies, Workgroup members identified several topics that merited consideration and evaluation, including reducing water demand at the pond through water conservation or other reductions, increasing water supply through release of upstream storage, modifying operations or implementing drought contingency plans, and identifying targeted management thresholds related to flow, downstream salinity, or pond elevation.

A great deal of discussion involved the need to address the shortcomings of issuing the leakage variance on an emergency, ad hoc basis, and the Workgroup agreed that an investigation of a more reliable, predictable, and consistent process was warranted. However, the Workgroup also recognized that a variance to credit leakage towards the minimum release can alter downstream flows and have other consequences, and agreed to consider and evaluate several issues and alternatives, as described below.

1. *There should be clearly defined limitations to the use of a leakage credit.* Workgroup members recognized that the credit is not needed at all times, and can conflict with other objectives, such as downstream biotic habitat and migratory fish passage.

2. *Due consideration should be given to the skimming of peak flows and water conservation before committing to reducing downstream flows (i.e., allowing a leakage credit).* There may be the potential to alleviate low flow conditions by temporarily reducing water demand or shifting withdrawals from the pond to other times of the year when water is more abundant.

3. *Opportunities to augment flows to the pond should be fully investigated, including more frequent releases of Commission storage.* There may be the potential to alleviate low flows by increasing the supply of water entering the pond.

4. *Analyses of a credit for leakage should consider the potential beneficial impacts of more sustainable releases that will likely result from releasing lesser quantities.*

Eliminating the loss of storage during low flow periods may allow the pond to sustain higher downstream flows later into the summer and early autumn.

The Workgroup agreed that close examination of the opportunities described above, through the use of a hydrologic model, would provide information needed to assess the ability of each to mitigate low flow conditions. Use of the model will allow the Workgroup to analyze historic low flow events and evaluate the benefits, impacts, and other consequences of various management strategies.

IV. PLANNING PROCESS AND INITIAL SCREENING

A. Hydrologic Model Development and Verification

The ultimate objective of this effort was to develop a comprehensive set of hydrologic records for use in the Commission's OASIS model by converting gaged flows into inflows at the OASIS nodes. The record was developed from gaging records along the Susquehanna, and is intended to be representative of flows that can reasonably be expected to occur in the future.

1. **Hydrologic Record Development –** Essential to building a useful hydrologic record is the computation of a record of "unimpaired" gaged flows. Gages only show the actual flow in the stream; they have no information about what the flow would have been without human intervention. "Impairments" are modifications of the natural flows due to change in reservoir storage (including evaporation and precipitation on the reservoir surface) and municipal, industrial, or agricultural consumptive withdrawals of water. If water is withdrawn above a gage and returned to the river below the gage, the impairment is the entire withdrawal.

   In order to estimate unimpaired gage records, it was first necessary to develop a time series estimate of historic water uses. Some highly regulated facilities, such as public water supply withdrawals and power plant operations, have detailed records that can be used to recreate historic uses. Most uses, however, have little or no record and thus, must be estimated through the use of statistical techniques and assumed correlations between water use and known water use factors, such as population data.

   a. Use of Gage Records – The hydrologic record runs from 1930 to 2002. The starting date for the record was chosen in order to include the drought of the 1930s and a few antecedent years, and because eight gages were started in 1928 and 1929. Prior to 1928, the paucity of available gauging records makes it difficult to develop a representative reconstruction of all of the gages required to produce the hydrologic records for the model. There are 61 streamflow gages in the Susquehanna basin that are used in this project; these are listed in Table IV-1. Many of the gages have incomplete records; their operation either began after 1930 or ended prior to September 30, 2002. For a description of the methodologies used to recreate missing records, refer to the Model Development and Verification Appendix. Figure IV-1 shows locations of gages used to develop the record.

   b. Development of Hydrologic Record – The availability of gage information and the locational need for flow information in the model do not always coincide. A significant task related to development of the hydrologic record is transferring the non-impaired and extended flow records to the various model nodes and junctions, and computing the inflow, or reach gains, from the intervening drainage area between two or more model nodes. Refer to the Model Development and Verification Appendix for a detailed description of the process.

Table IV-1. Stream Gages Used in Development of the Hydrologic Record

Stream	Location	Stream	Location
Susquehanna River	Colliersville, N.Y.	Bald Eagle Creek	Blanchard, Pa.
Susquehanna River	Unadilla, N.Y.	Blockhouse Creek	English Center, Pa.
Unadilla River	Rockdale, N.Y.	Pine Creek	Waterville, Pa.
Susquehanna River	Conklin, N.Y.	Lycoming Creek	Trout Run, Pa.
Tioughnioga River	Cortland, N.Y.	West Branch Susquehanna River	Williamsport, Pa.
Tioughnioga River	Itaska, N.Y.	Chillisquaque Creek	Washingtonville, Pa.
Chenango River	Chenango Forks, N.Y.	Susquehanna River	Sunbury, Pa.
Susquehanna River	Vestal, N.Y.	Penns Creek	Penns Creek, Pa.
Susquehanna River	Waverly, N.Y.	E Mahantango Creek	Dalmatia, Pa.
Cowanesque River	Lawrenceville, Pa.	Frankstown Branch	Williamsburg, Pa.
Tioga River	Lindley, N.Y.	Juniata River	Huntingdon, Pa.
Tioga River	Erwins, N.Y.	Raystown Branch	Saxton, Pa.
Chemung River	Corning, N.Y.	Raystown Branch	Huntingdon, Pa.
Chemung River	Chemung, N.Y.	Juniata River	Mapleton Depot, Pa.
Susquehanna River	Towanda, Pa.	Aughwick Creek	Three Springs, Pa.
Towanda Creek	Monroeton, Pa.	Juniata River	Newport, Pa.
Susquehanna River	Meshoppen, Pa.	Sherman Creek	Shermans Dale, Pa.
Tunkhannock Creek	Tunkhannock, Pa.	Clarks Creek	Carsonville, Pa.
Lackawanna River	Old Forge, Pa.	Letort Spring Run	Carlisle, Pa.
Susquehanna River	Wilkes Barre, Pa.	Conodoguinet Creek	Hogestown, Pa.
Susquehanna River	Danville, Pa.	Susquehanna River	Harrisburg, Pa.
WBr Susquehanna River	Bower, Pa.	Yellow Breeches Creek	Camp Hill, Pa.
Clearfield Creek	Dimeling, Pa.	Swatara Creek	Harper Tavern, Pa.
WBr Susquehanna River	Karthaus, Pa.	West Conewago Creek	Manchester, Pa.
Driftwood Branch	Sterling Run, Pa.	Codorus Creek	Spring Grove, Pa.
Sinnemahoning Creek	Sinnemahoning, Pa.	Codorus Creek	York, Pa.
First Fork	Stevenson, Pa.	Susquehanna River	Marietta, Pa.
Kettle Creek	Cross Fork, Pa.	Conestoga River	Lancaster, Pa.
West Branch Susquehanna River	Renovo, Pa.	Susquehanna River	Conowingo, Md.
Spring Creek	Axeman, Pa.	Deer Creek	Rocks, Md.
Bald Eagle Creek	Milesburg, Pa.		

c. Flow Routing – There are 15 stream reaches between model nodes where flow routing was deemed important due to either extensive travel distance or hydrologic complexity. The Muskingum routing methodology was used to develop routing coefficients; see Section 5 of the Model Development and Verification Appendix for a description of the process used.

2. **Model Coverage –** Although the focus of the planning study is on the conditions in and below the Conowingo pond, the Workgroup recognized that upstream conditions play a role significant enough to merit their inclusion in the model. Specifically, operations at the dam during low flow conditions are driven by conditions at the USGS stream gage located at Marietta, Pennsylvania, and reliable modeling capabilities at that location on the Susquehanna River are, thus, essential to successful analysis. Further, conditions at Marietta are, in turn, driven by hydrologic conditions in the 25,990 square miles of upstream drainage. See Figure IV-2 for a depiction of the extent of basin coverage by the model.

Figure IV-1. Locations of Stream Gages Used in Development of Hydrologic Record

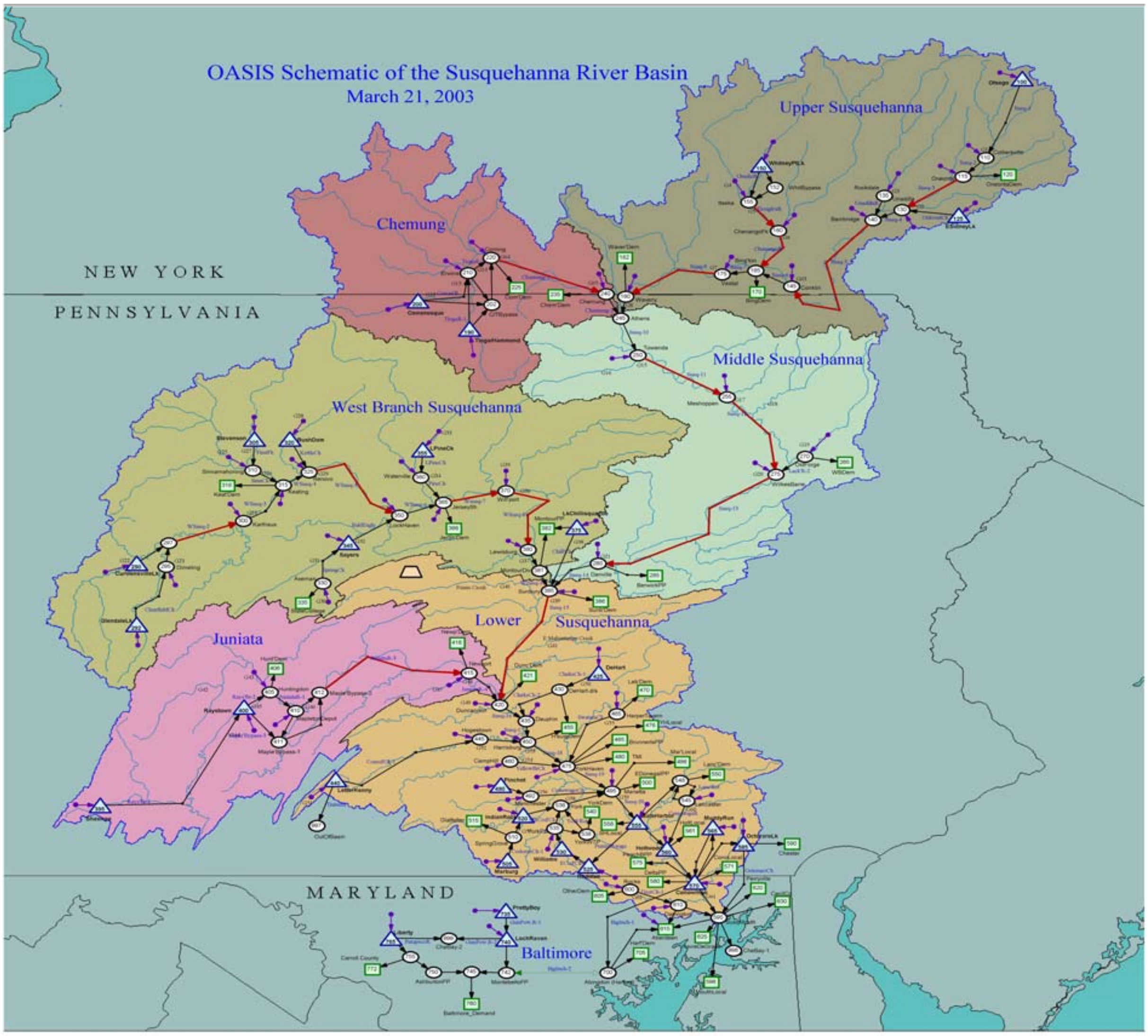


Figure IV-2. Schematic of Hydrologic Model Coverage

a. <u>Upper Susquehanna Basin</u> – Model coverage upstream of Marietta is less detailed and intensive compared to coverage between the gage at Marietta and the mouth of the Susquehanna River at Havre de Grace, Maryland. Nevertheless, it contains several major stream nodes in each subbasin, and a general coverage of consumptive use demands, as well as major individual points of demand such as the power plants at Berwick and Montour.

b. <u>Lower Susquehanna Basin</u> – Demand and flow information in the region downstream of the Marietta gage is much more comprehensive and localized than it is for the upstream drainage. Also, due to the heavy development and more intense human activity as far north as Harrisburg, hydrologic representation of conditions between Marietta and Harrisburg were given more dedicated attention.

Figure IV-3 shows a detailed schematic of the model coverage for the Lower Susquehanna basin.

c. Baltimore City System – Although the entire service area of the Baltimore City water system is wholly outside the Susquehanna River Basin and does not impact the Conowingo pond after the initial diversion occurs, it is nevertheless prudent to include at least a rudimentary representation of the City system. Because the withdrawal is significant and is driven, at least partly, by conditions in the City's reservoir system, there is utility in developing basic hydrologic modeling for all the City's supplies. See Figure IV-3. It also is recognized that long-term water withdrawals from the Conowingo pond will, in part, be driven by operation of the planned Fullerton Water Filtration Plant, to be located northeast of the City between the existing Abingdon and Montebello facilities. The modeling of the City system was completed to ensure reasonably accurate representation of water withdrawals, regardless of the specific configuration of treatment facilities and distribution practices currently or in the future.

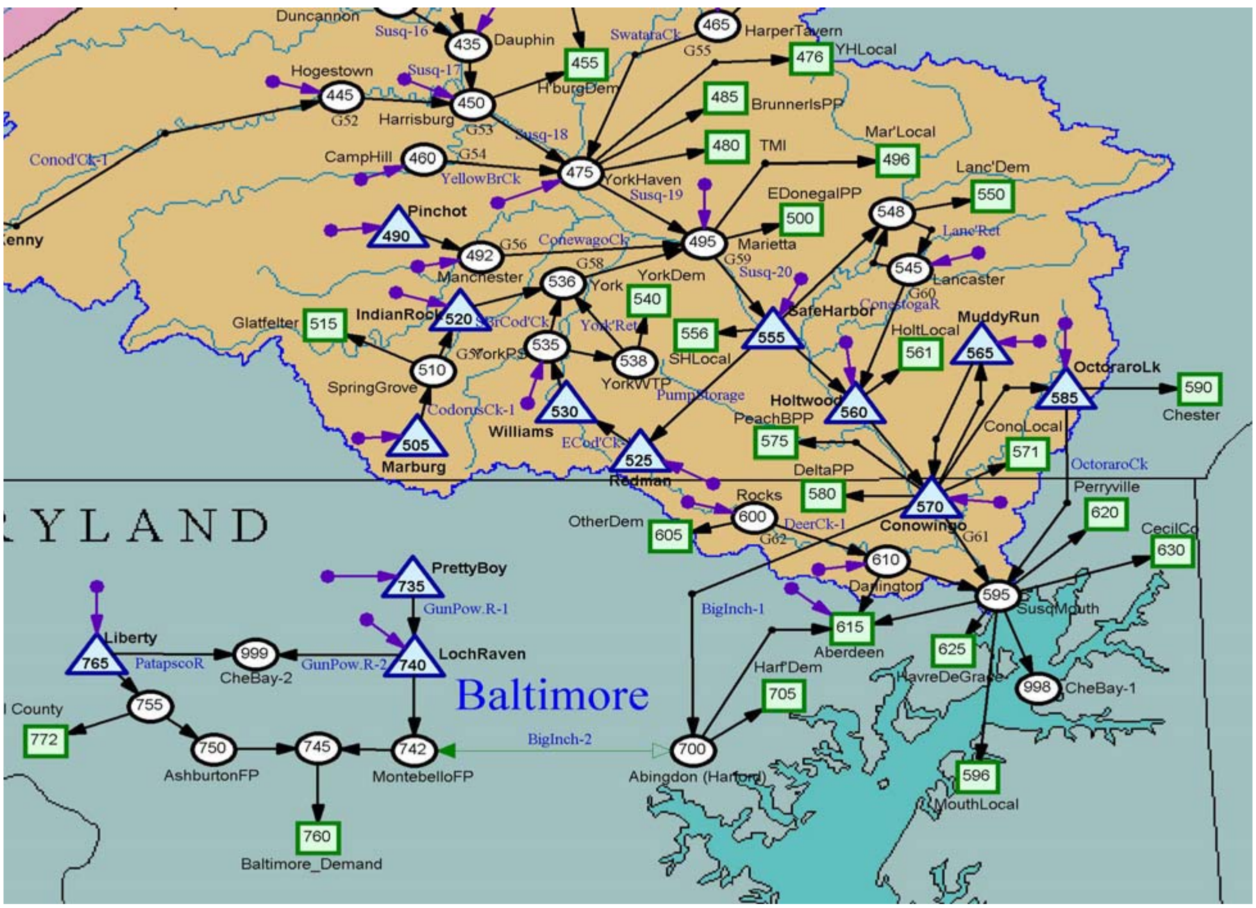


Figure IV-3. Schematic of Detailed Model Coverage in Lower Susquehanna Basin

3. **Operational Rules** – Concerted efforts were made to understand and accurately model the sometimes complex operating rules and management protocols of the various water users in and around the Conowingo pond, particularly reflecting operations during low flow conditions.

   a. Water Supply Reservoirs – Water supply reservoirs have two management aspects in particular that are typically the prevalent rules during low flow conditions: reservoir storage and conservation releases for fish propagation and protection of the downstream aquatic ecosystem. For example, the operators of Baltimore's water supply system rely on rules based on remaining reservoir storage to decide whether and at what quantity to withdraw water from the Susquehanna River. As another example, the requirement that water supply reservoirs maintain conservation releases is a critical element in the yields of reservoirs, and plays a role in the ability of the storage to supply water for the duration of a drought. It is thus very important that operating rules and conservation release requirements are modeled as precisely as possible.

   b. Flood Control Reservoirs – Most of the major flood control reservoirs in the Susquehanna basin do not play a major role in the hydrologic regime during low flow periods, although some USACE reservoirs likely contribute more water through conservation releases than the watershed in its natural state might. Nevertheless, the reservoirs were modeled to be consistent with published operating rules, affording the Workgroup the opportunity to assess the sensitivity of conditions at Marietta and in the Conowingo pond to varied operations at the USACE facilities.

      Of particular interest are operations at the Cowanesque and Curwensville reservoirs, which have a combined storage of 30,000 acre-feet under contract to the Commission for releases under low flow conditions. While the baseline version of the model operates under the release protocols as defined in the agreement between USACE and the Commission, alternate model simulations have been employed using protocols that vary timing and quantity of low flow releases to analyze the potential for these releases to benefit the Conowingo pond.

   c. Hydroelectric Facilities – Operations at the major hydroelectric facilities on the lower Susquehanna River are strictly constrained by the requirements contained in the separate FERC operating licenses. How the dams are operated within those constraints, however, is driven by daily fluctuations in energy demand, supply available in the energy market, available river flow, and pricing. Each dam owner operates competitively to maximize profitability; the details of the factors determining the daily level of operations are proprietary at each facility and, therefore, not available for inclusion in model runs.

      For the purposes of modeling operations at Conowingo dam, it was assumed that the operators would first and foremost meet minimum release requirements, and then strive to maximize storage within the license constraints. While perhaps not an exact replication of realistic operations, prioritization tools available in the modeling software ensure that the water is dedicated to the same purposes that the operators would likely choose, particularly during low flow operations.

d. Interconnected Supplies – Several components of the hydrologic model, such as Chester Water Authority, the City of Baltimore, and Harford County, maintain multiple sources of water supply. Each has guidelines, ranging from formally adopted plans to general rules of thumb, that govern which source is being used and at what level of service. The modeling logic was developed in accordance with rules provided by the various stakeholders to replicate as closely as possible the balancing of sources routinely undertaken, particularly during low flow conditions. Where necessary, pipelines were modeled with the capability to transport water in reversed directions.

e. Pumped Storage Facilities – The Muddy Run Pumped Storage Facility enables the operators of Conowingo dam to store energy in the form of water storage for use during peak demand periods. The facility was modeled using protocols suggested by Exelon personnel, and conditioned in such a way that higher priorities, such as meeting minimum release requirements and maintaining pond level in accordance with FERC licensing, take precedence over the pumping or holding of storage in Muddy Run.

f. Drought Operations/Requirements – Special conditions for operating during low flow conditions are typically included in the general operating guidelines for each water user. Actions such as reduction in withdrawals, maintenance of minimum releases, or balancing water taking between sources were developed in the model as appropriate for each stakeholder.

g. Commission Storage – As previously mentioned, the Commission, by contract with USACE, owns a combined 30,000 acre-feet of water at two federal facilities: the Cowanesque and Curwensville reservoirs. The baseline model was developed to reflect precisely the release protocols agreed to upon adoption of the respective contracts. For purposes of sensitivity analysis and furthering discussion, alternative models were developed that dictated different timing and quantity protocols for the release of Commission storage.

4. **Model Calibration and Verification** – Models generated using the OASIS software are not calibrated in the traditional fashion, such as is done with water quality models, for example. It is not the intent of the programmers to develop a hydrologic record that matches the published record precisely on a daily basis. By virtue of the methodology used to develop the hydrologic time series, the generated record and the published record will match each other on a monthly average basis, within a few percent. The resulting hydrologic time series, while not exactly reproducing the measured data, give a very reasonable representation of a range of flow conditions that could be expected to occur in the Susquehanna River Basin. It is worth noting

that the streamflow measurements made and published by the USGS are themselves subject to precision errors and are affected by withdrawals and discharges.

Although the model is not subject to standard calibration techniques, there is value in verifying that the results of the model are reasonable with respect to observed conditions. Because the timing of the model development coincided with the drought of 2002, hydrologic conditions during the drought were used to verify that the model was producing reasonable results. Operational rules and parameters in place during the summer of 2002 were simulated in the model and run with the hydrology generated for the year. Model results were compared to observed conditions in various areas of interest, such as streamflows, reservoir levels, and hydroelectric releases. The Workgroup concluded that the model was producing reasonable results and was, therefore, a useful and credible tool for examining alternative operating scenarios in the Susquehanna River Basin. Some of the comparative plots used in the verification are displayed below on Figures IV-4, IV-5, and IV-6.

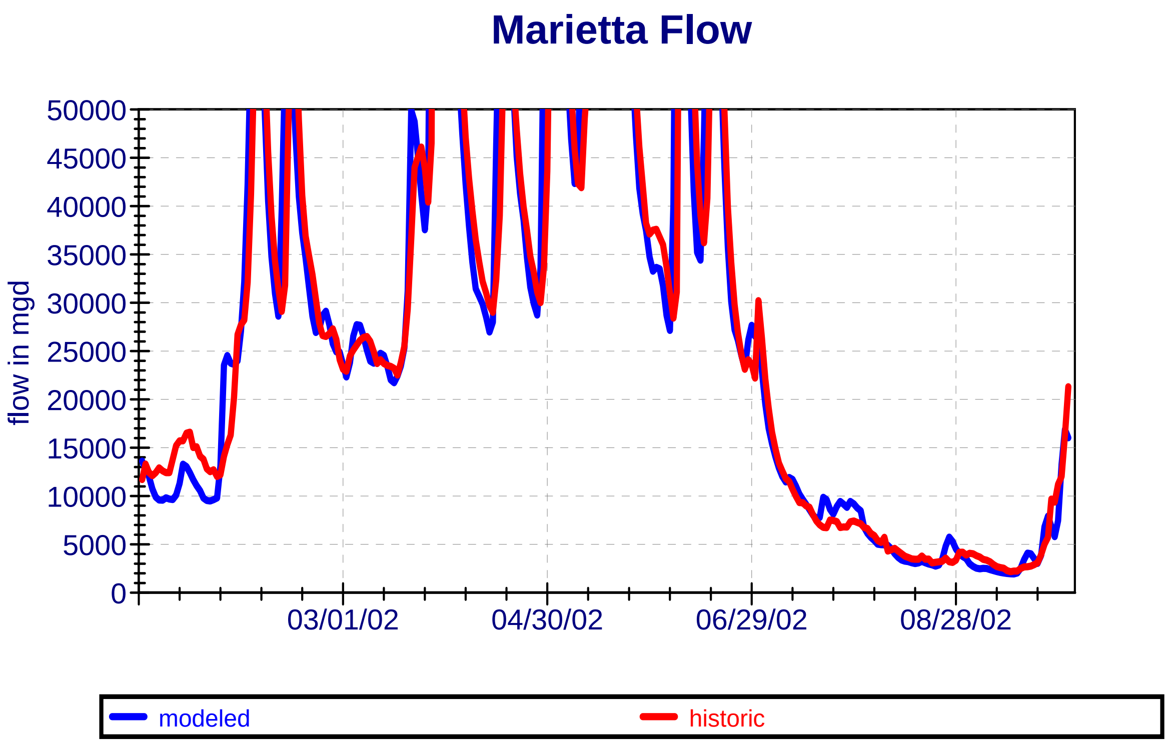


Figure IV-4. Modeled vs. Historic Marietta Flow in 2002

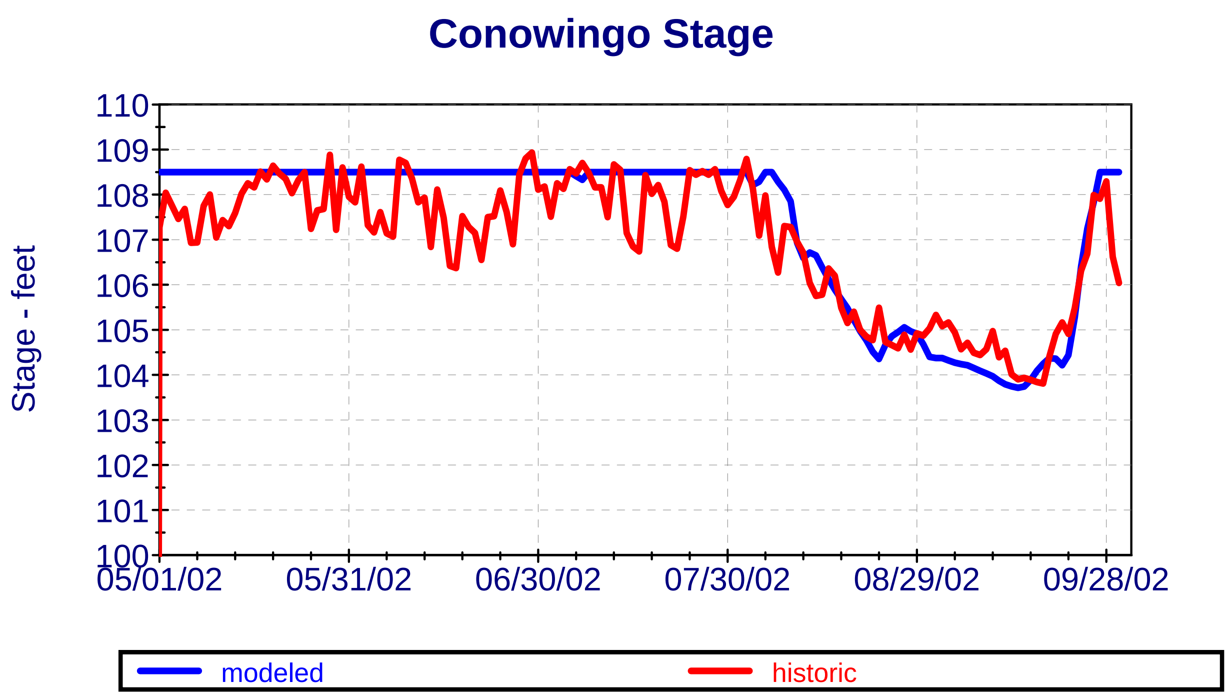


Figure IV-5. Modeled vs. Historic Conowingo Pond Stages in 2002

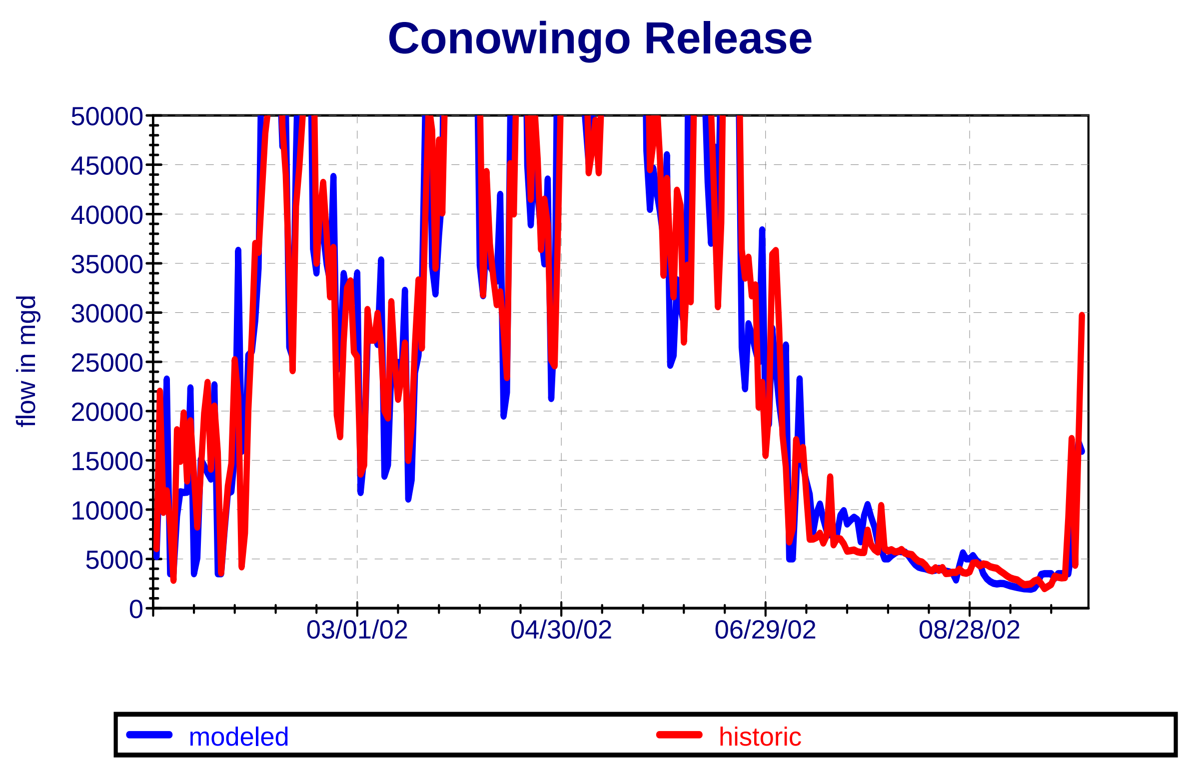


Figure IV-6. Modeled vs. Historic Conowingo Dam Flow Releases in 2002

B. Performance Measures

Performance measures are simply displays that show particular results of an evaluation of an alternative. Performance measures were developed by the Workgroup to assess how well a given management plan alternative does with regard to one or more management objectives, such as maintaining minimum pond releases or minimum pond elevation. Each performance measure is designed to allow one or more stakeholder with an interest in operations of the pond to determine whether one alternative is better than another with respect to the objective(s) that is important to them. There are numerous objectives for managing the Conowingo pond, so many performance measures were developed.

Performance measures can be the same as management objectives, but often they represent surrogates rather than the management objective directly. For example, one of the performance measures used low flows below the Conowingo dam as a surrogate for periods of high salinity in the Havre de Grace area. The assumption is that there is a correlation between historic low flow events and historical periods of high salinity, and it was the task of the stakeholders to interpret the simulation results accordingly.

Each stakeholder in the Workgroup had an interest in one or more of the performance measures. At the same time, it is likely that no stakeholder had direct interest in all of the performance measures. To develop a consensus management alternative, all stakeholders were able to understand how differences among alternatives affect other stakeholders. That information was helpful in developing alternatives that are satisfactory to all parties.

Performance measures present information based on a technical evaluation of a particular alternative. They do not, in and of themselves, differentiate between good and bad or better and worse. Each stakeholder makes that determination individually when they interpret the performance measure displays for alternatives, individually and collectively. To the extent possible, performance measures are value neutral.

Initially, 26 performance measures were identified. These measures are discussed in Appendix 3, *Performance Measures Report*. After further consideration by the Workgroup, the smaller set of performance measures discussed below were used for detailed analyses.

1. **Basic Time Series Output Measures –** Basic time series outputs for all flows, water deliveries, and reservoir levels were made available in the form of both plots and tables. In addition, the time series of "natural" or "unimpaired" flows was available for comparison. Displays were developed to show these time series individually and side-by-side for comparison of values from a single run of the hydrologic model or across multiple runs.

2. **Conowingo Pond Level-Based Performance Measures**:

    a. Probability of Pond Level – Plots of the probability that the pond will fall below a given level allowed stakeholders to quickly ascertain how often low pond levels will impact them.

b. Events Below Threshold Levels – A tabular output was prepared for comparing alternatives that showed data on events, including number of days and years, which resulted in pond stages below selected thresholds of interest.

3. **Conditions Below Conowingo Pond** – In addition to time traces of flow releases from the Conowingo pond, there was interest in salinity intrusion and turbidity in the Susquehanna River below the dam. The problem of turbidity is not understood well enough for a credible index display to be prepared. There was also substantial interest in maintaining adequate flow below the dam for fish habitat and to support fish migration.

   a. Salinity – It was not possible to develop flow/salinity relationships for this reach of the river. As a surrogate, modeled flows for historical periods of high salinity were graphed alongside historical flows for the same period. The graphs were annotated with available information as to historical salinity in the reach.

   b. Flows to Support Fish Habitat and Migration – Plots of the probability that releases from the dam meet or fall short of the Q-FERC values were prepared to assist in evaluating potential fisheries and aquatic habitat impacts.

4. **Water Supply** – In the Lower Susquehanna basin, water use restrictions are based on two flow indices: the Q7-10 (the low flow expected to occur over a 7-day period once in 10 years) and the Q-FERC minimum flow at Marietta. The frequency of these flows may be influenced by releases from upstream reservoirs and/or the growth of upstream water supply uses. In addition, stakeholders' water use restrictions can be imposed based on levels in local storage reservoirs. Performance measure output included information tabulated to show water use restrictions data, including number of events, days, and years when restrictions were in place, and total water not delivered to users. The total amount of water not delivered was shown for each utility, including the City of Baltimore. The data also included the number of days of Marietta flow below 5,000 cfs as a surrogate for hydropower impacts.

5. **Hydropower** – Hydropower generation at Conowingo dam is largely a peaking operation; water is held in the Conowingo pond at night and over the weekends, then discharged when demand for energy is high. Low flow requirements force minimum night and weekend releases, which may leave less water available for power generation at Muddy Run. The performance measure developed was the reduction of water available for pumping to the Muddy Run pond.

C. Baseline Conditions

Before investigation of operating alternatives can be considered, a benchmark for comparison must be established. The Workgroup decided that a representation of conditions as they existed at the time the study was conducted – the "Baseline Condition" – should be developed and used as the basis for comparison. Incorporated into the Baseline Condition was as accurate a representation as possible of operating rules and physical characteristics of all components of the Conowingo pond system and the Susquehanna basin upstream of Marietta. Those components include reservoirs, pipes, water treatment and movement capacities, operating rules and regulations, license requirements, and typical operating priorities. Information for developing the Baseline Condition was supplied by the stakeholders, who were then given the opportunity to verify that the parameters built into model served as reasonable representations of actual existing conditions.

It was also important to capture accurate estimates of the withdrawal and consumptive uses of water currently occurring in the basin. Stakeholders supplied operating records, which were combined with general water use estimates made by USGS and the Commission, to build a complete database of water use throughout the basin.

D. Operational Alternatives Considered

The Workgroup identified a total of 32 alternative operational plans for consideration at the Conowingo pond. Initially, all alternatives were given equal consideration. Key variable parameters were established to distinguish differences in the alternatives. The parameters used and alternative plans are discussed below. A summary table displaying the 32 alternatives and parameters is contained in Appendix 3. The results of the analysis of the plans are discussed in Section IV-D(3).

1. **Parameters Used**:

   a. <u>Q-FERC Requirements Met</u> – Does the alternative meet (Yes) or not meet (No) the minimum downstream flow releases required by the 1988 settlement agreement (see Section IV-B)?

   b. <u>Credit for Leakage Allowed</u> – Is a credit for gate leakage at Conowingo dam allowed toward meeting the minimum flow requirements notwithstanding the prohibition against this in the settlement agreement?

   c. <u>Baltimore Withdrawal, Maximum/Low Flow</u> – Defines the maximum water supply withdrawal allowed under normal and low flows into the Conowingo pond, respectively. Currently, Baltimore has an approved maximum withdrawal of 250 mgd, a maximum output of 137 mgd, and a reduced 30-day withdrawal rate of 64 mgd during low flow periods.

   d. <u>Chester Water Authority Withdrawal</u> – Defines the maximum water supply withdrawal allowed from the Conowingo pond by Chester Water Authority. Currently, Chester Water Authority has an approved maximum withdrawal of 30 mgd.

   e. <u>Consumptive Use in the Basin</u> – The amount of consumptive water use in the Susquehanna River Basin, upstream of the Conowingo pond, based on estimates of daily averages for peak monthly use in 2000 and a similar projection for 2025, and an assumed increase of 30 percent in the 2025 daily averages as an estimate for the maximum peak daily use. These consumptive uses are 456, 640, and 830 mgd, respectively.

f. Commission Reservoir Storage Trigger – The Commission-owned water supply storage at Cowanesque and Curwensville Lakes in the upper basin is used to augment low flows when trigger levels are reached at one of several key stream gages. Under current rules, the trigger level is Q7-10, which is defined as the consecutive 7-day low flow values having a frequency of occurrence of 10 percent in a given year (commonly referred to as once in 10 years). An alternative trigger value considered for the purpose of this analysis is Q-FERC. This is defined as the comparable flow at key upstream gages that correspond to the minimum flow release requirements at the Conowingo pond as established in the 1988 settlement agreement (see Section IV-B).

2. **Alternative Operational Plans**:

   a. **"_SimBase" Options** (five options) – Represents baseline conditions with existing operations in place and four other modified baseline options as defined by varying parameters for leakage credit, Baltimore's maximum water withdrawal, and consumptive water use in the basin. If a credit for leakage was included, its implementation was triggered on the condition of the pond declining below the critical elevation of 104.5 feet, at which continued operation of Muddy Run is threatened. At that time, a credit of 800 cfs for gate leakage was allowed.

   b. **"AutoWaiver" Options** (seven options) – Includes an automatic credit allowance for gate leakage toward the required minimum flow releases. The time period for the credit is either year-round, from July–March or June 16–March 31. Other parameters are changed for several alternatives, including Baltimore's and Chester's maximum water withdrawals, consumptive water use in the basin, and the low flow trigger for releasing water from Commission-owned storage in two upstream federal reservoirs.

   c. **"Stepped_Waiver" Options** (two options) – Includes an automatic flow credit for gate leakage, but the credit is allowed in increments of 250, 500, and 750 cfs, as needed, to maintain a stable Conowingo pond level. A second option increases Baltimore's maximum water withdrawal.

   d. **"Level_Storage" Options** (five options) – This set of alternatives includes a minimum operability level in the pond of 104.5 feet to maintain both Muddy Run storage transfers into/from the Conowingo pond and reliable Peach Bottom operations. Minimum flow releases from Conowingo dam, Baltimore's maximum water withdrawal, and consumptive water use in the basin were varied to distinguish options.

e. **Other Alternatives –** Thirteen other initial alternatives were considered by varying the parameters in different combinations.

3. **Results of Analysis of Alternatives –** The Workgroup analyzed the set of 32 alternatives by reviewing performance measures to determine which options warranted further consideration. The key performance measures used included: (1) probability of critical pond levels being reached; (2) minimum pond levels reached; (3) minimum and average flow releases from the pond; (4) impacts to established recreation pond levels; and (5) impacts to hydroelectric power generation. After careful consideration of the alternatives, it was determined that 14 of them had sufficient merit to be carried forward for further analysis. See Section IV-E for further discussion of these alternatives. Conversely, 18 alternatives failed to produce positive results and were dropped from further consideration.

E. Computer-Aided Negotiations

After the full set of possible operational alternatives was initially evaluated, the next key step in the development of the Conowingo Management Plan involved the use of computer-aided negotiations (CAN). At several Workgroup meetings, CAN sessions involved the use of a computer to perform efficient evaluations of the long-term implications of changes in operating policies and facility configurations over the course of day-long sessions. The computer modeling results of several alternative operations and facility scenarios were prepared in advance and distributed at the beginning of the meetings. Stakeholders reviewed results of the alternatives and critiqued both the positive aspects and problems presented by the alternatives. The Workgroup identified other alternatives to mitigate the problems identified. Further evaluations followed, continuing an iterative process of building towards consensus on a small number of preferred alternatives. The iterative process embodied in the CAN sessions served to inform the Workgroup members about the positive and negative aspects of many alternatives on a consistent and balanced basis so that informed decisions resulted.

During the CAN sessions, alternatives were evaluated using the OASIS-based Susquehanna River Basin simulation model. See Section V-A for discussion of the OASIS model. The initial outputs of the model were defined as performance measures by the Workgroup prior to the CAN sessions, but new measures were often suggested at the CAN sessions. The outputs were generally long-term plots of storage in reservoirs and flows at critical points and summaries of impacts, such as the number of days that flows fall below critical threshold values. In order to familiarize the group with the variables and introduce them to the system's sensitivity to various parameters and changes, sample outputs were provided. Following discussion of the results at the CAN sessions, the group offered suggestions for further modifications that were programmed and demonstrated "live," as time permitted.

Table IV-2 presents a summary of the alternative plans that were evaluated by the Workgroup during several CAN sessions. The explanation of the alternatives and the variable parameters used can be found in Section IV-D. The numbering system used for the alternatives in Table IV-2 is based on the initial list of 32 alternatives discussed in Section IV-D and Appendix 3.

Table IV-2. Alternative Operational Plans Evaluated During Computer-Aided Negotiations

Plan No. **(1)**	Alternative Plan	Threshold for Leakage Credit	Upstream Consumptive Use Level	Commission Reservoir Storage Release Trigger	Baltimore Maximum Withdrawal	Chester Maximum Withdrawal	Other Pond Consumptive Use
1	**_SimBase**	Pond < 104.5'	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
3	**Future_Baseline**	Pond < 104.5'	Year 2025	Q7-10	137/64 mgd	30 mgd	Year 2025
4	**SimBase_Plus**	Always	Year 2000	Q7-10	137/100 mgd	30 mgd	Year 2000
5	**Future_Plus**	Always	Year 2025	Q7-10	137/100 mgd	30 mgd	Year 2025
6	**AutoWaiver**	Always	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
7	**FutureMax_AW**	Always	Year 2025	Q7-10	250/100 mgd	40 mgd	Year 2025
13	**Stepped_Waiver**	**(2)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
15	**Level_Storage**	Always **(3)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
23	**Balt-84mgd**	Pond < 104.5'	Year 2000	Q7-10	137/84 mgd	30 mgd	Year 2000
24	**SRBC_FERC_trig**	Pond < 104.5'	Year 2000	Q-FERC	137/64 mgd	30 mgd	Year 2000
27	**Fictional_Lake**	Pond < 104.5'	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
28	**FERC_Passthru**	Local inflow **(4)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
29	**Storage_Waiver**	**(5)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
30	**Salinity4500**	Always **(6)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000

(1) See Appendix 3 for complete listing of plans.
(2) The credit for leakage increases from 250 cfs to 500 cfs to 750 cfs as conditions worsen in the pond.
(3) Total release must exceed 3,000 cfs.
(4) Conowingo dam must pass the lesser of the leakage estimate (800 cfs) or the incremental inflow between the Marietta gage and the Conowingo pond (estimated by drainage area relationships).
(5) The credit for leakage is dependent on storage deficit in Muddy Run and the Conowingo pond.
(6) Leakage is credited at all times, unless the 30-day average outflow decreases to 4,500 cfs or below.

F. Model Results

The results of the CAN sessions served to demonstrate positive and negative aspects of the various scenarios, and allowed the Workgroup to eliminate operating parameters that do not offer desirable outcomes. Evaluation of results also allowed the Workgroup to focus on operating parameters that meet the objectives of the planning effort. Because many of the alternatives involved variations in other aspects of the system, such as water demands or storage releases, examination of the results provided a sensitivity analysis for the system; the Workgroup was, thus, able to discern those parameters that deserved the most scrutiny during selection of the final alternative.

1. **Water Demand –** The Workgroup felt it was important to evaluate the impact of water withdrawals and upstream consumptive water uses on the ability of the Conowingo pond to remain viable during droughts. In addition to running the scenarios with estimates of current water demands in the Susquehanna River Basin, scenarios were run using demands increased to 2025 levels, and 2025 demands with a peaking factor to estimate maximum short-term water use. Various levels of water use were also investigated for specific water users such as Chester Water Authority and the City of Baltimore. Also, new anticipated water uses were incorporated into the total demands. The results showed that, although water demand from the pond and the upstream basin was projected to increase by as much as 59 percent, the impact of varying water demands on the resource (pond stage and minimum dam releases) was not significant. Dam releases were generally not affected and pond stages were diminished by less than one foot. Although still deemed important to incorporate accurate estimates of future water demand, it was not anticipated to have significant impacts on the pond resource and thus, the Workgroup's efforts were focused more on other aspects of planning.

   The Workgroup also considered the role water conservation might play in mitigating low flow conditions on the Conowingo pond. Estimates were made about potential reductions obtainable through conservation. Even using optimistic reductions of 10 to 20 percent basinwide, maximum water savings are relatively small compared to river flows, and would offer limited drought relief. Therefore, while conservation measures are to be encouraged and are a vital component of sound drought management, they do not offer the mitigation needed to sustain the Conowingo pond.

2. **Water Releases to Augment Low Flows –** The water storage owned by the Commission at two federal reservoirs in the upper basin is currently dedicated to offsetting specific consumptive uses during droughts in the vicinity of Wilkes Barre and Harrisburg, Pennsylvania. Certainly it can be argued that any water released will eventually supplement flows into the Conowingo pond. However, that storage has not been a factor in pond management during recent droughts because none of the storage was used to offset the identified consumptive uses during that time. Under the contractual agreement between the Commission and the USACE, release of the storage is predicated on flow conditions of Q7-10 at either the Harrisburg or Wilkes Barre stream gages. That condition was not met in recent low flow years.

To gain an understanding of the potential for large storage projects to mitigate drought conditions at the Conowingo pond, different operating conditions were investigated. For example, because much of the operations at Conowingo dam are dictated by flow conditions at the Marietta gage relative to the Q-FERC values, model runs were performed using Q-FERC values as the criterion for the release of augmenting flow from Commission-owned storage. Results showed that excess inflow can be demonstrated at the pond, but the benefit is not significant, particularly when compared to the leakage flow of 800 cfs from Conowingo dam. The ability of the storage to improve conditions at the pond is limited due to the relative size of the storage with respect to the daily fluctuations typically observed in the pond. The Commission owns 30,000 acre-feet of storage collectively at the two projects, which is equivalent to roughly 4 feet of water in the pond.

Releasing a quantity of storage that is of significant use to the pond would deplete the Commission's storage in a matter of days; conversely, releasing the storage at a rate sustainable over a summer-long drought (75 – 125 cfs) would contribute minimal extra inflow to the pond on a daily basis. While further study may demonstrate unrealized potential for drought mitigation from Commission storage, the Workgroup decided it is beyond the scope of this effort, and it was not pursued as a management objective.

3. **Implementation of Leakage Credit –** The single variable that most directly and measurably impacted the pond is the credit for including leakage in meeting minimum flows. The quantity of credit and the timing of its use proved to be very influential in the ability of the pond to remain viable for multipurpose use during low flows. As such, much of the Workgroup's subsequent effort was focused on evaluating implementation strategies for the credit, discussing the need for restrictions on use of the credit, and assessing the potential for the credit to offer benefits and impart adverse impacts to the pond and the river downstream of the dam.

V. PREFERRED OPERATION ALTERNATIVES

Following completion of the CAN and evaluation of the model results, the Workgroup selected the scenarios described below for closer analysis and, eventually, final selection of a preferred operating alternative. They differ mainly in operating rules for release requirements from Conowingo dam during times of low flow. Parameters such as demand for water supply and water withdrawal operations were kept consistent in the scenarios to best allow for direct comparison between them. Consumptive use in the Susquehanna basin and withdrawal demands from the Conowingo pond were set at projected levels for 2025, as agreed upon by the Workgroup.

A. Description of Preferred Alternatives

1. **Baseline –** The model was configured to represent as closely as possible the existing operations in the Conowingo pond, using the previous "SimBase" model as a basis. In contrast to the "SimBase" alternatives, in which the credit for leakage was conditioned solely on the pond level declining below 104.5 feet, Exelon personnel assisted Commission staff in crafting a rule for implementation of ad hoc leakage credits that served as a reasonable approximation of the historic occurrences of such a waiver by FERC. The rule based the implementation of a credit for leakage on the storage in the pond and the time of year. Otherwise, the release requirements contained in the FERC license, which do not include a consideration for leakage estimates, were followed. For example, if the matching release is 4,000 cfs, the volume of the pond was reduced by 4,000 cfs plus an additional 800 cfs that is estimated to be leaking through the gates.

   Similarly, all other operations (e.g., control of Commission-owned storage in upstream reservoirs and operation of other water supply reservoirs and flood control dams) were modeled to reflect, as closely as possible, currently existing rules or requirements. Results of this scenario represented the "baseline" for comparison and served to demonstrate to the Workgroup the long-term conditions that can be expected in the pond if no action is taken to modify existing protocols.

2. **Automatic Credit –** Under this scenario, the full 800 cfs leakage was recognized and credited towards satisfying minimum dam releases at all times, regardless of flow conditions at Marietta. Although minimum flow releases made from Conowingo dam were still dependent on flow conditions at the Marietta gage, as required by the existing FERC settlement agreement, their magnitude was automatically reduced by 800 cfs to account for leakage. This outcome was true whether the flow at Marietta was greater or less than the FERC identified flow (i.e., Q-FERC) for a particular day.

   For example, during June, the dam is required under the settlement agreement to release 5,000 cfs if Marietta flow is at least that much. Including the 800 cfs leakage, a total of 5,800 cfs actually passes downstream. Under the Automatic Credit scenario, 800 cfs for leakage is discounted from the required release of 5,000 cfs, leaving a release of 4,200 cfs. That release, combined with the 800 cfs leakage, totals a quantity passing the dam of 5,000 cfs.

On the other hand, if the flow at Marietta is below the threshold of 5,000 cfs in June, the settlement agreement stipulates that the dam match the Marietta flow. Under the settlement agreement, if 4,000 cfs is measured at Marietta, the dam must release 4,000 cfs in addition to the 800 cfs that leaks through, for a total of 4,800 cfs passing the dam. Under the Automatic Credit scenario, 800 cfs is credited toward the required matching release (4,000 cfs in this example), and only 3,200 cfs is released from the dam. Combined with the 800 cfs leakage, a total of 4,000 cfs passes the dam.

The only exception to the full-time inclusion of the leakage credit in meeting release requirements arose out of concern for passage of spawning anadromous species; the credit for leakage was never available in April, May, or June.

3. **Critical Level –** The full credit of 800 cfs for uncontrolled leakage was allowed under this scenario, but only when the elevation of the Conowingo pond dropped below a pre-defined critical stage (104.5 feet, Conowingo datum) due to extreme low flow conditions. That stage was selected because it is a reasonable indication of conditions at which continued operations at Peach Bottom and Muddy Run lose sustainability. Above that stage, no consideration was given for estimated leakage. Below that stage, the dam could count all 800 cfs of estimated leakage toward meeting the FERC-required minimum release. As in scenario No. 2, the credit for leakage was never available in April, May, or June, regardless of the pond elevation, out of concern for fish migration.

4. **System Deficit –** Rather than linking a credit for leakage to the flow past Marietta as in scenario No. 2, or to a critical stage of the Conowingo pond as in scenario No. 3, the rules of this alternative defined a minimum operability level for the combined pond and Muddy Run system, and allowed a leakage credit (up to 800 cfs, as needed), to maintain that minimum operability level. In other words, the scenario was structured such that enough water would always be held in the combined ponds of the Conowingo pond and the Muddy Run facility, such that when Muddy Run is full, the Conowingo pond would not be below an identified threshold. After some deliberation, the Workgroup established a threshold of 106.5 feet (Conowingo datum) for the pond.

   Under typical operating conditions, there is sufficient water so that both Muddy Run and the pond can be held full; however, during low flow conditions, the total combined storage between the two can begin to trend downward when the operators act according to license requirements. The threshold of 106.5 feet was chosen because it represents a condition in which some of the operational capacity of Muddy Run has been lost, but operations at Peach Bottom are still fully sustainable.

An example of the application of the System Deficit alternative follows: if flows into the pond are sufficiently low so that the designated amount of storage can be maintained only through the allowance of a credit for 300 cfs of the leakage, then a credit of 300 cfs is allowed. Unlike scenario Nos. 2 and 3, the operators are prohibited from taking a credit for the remaining 500 cfs in leakage for the purpose of maintaining pond level above 106.5 feet. Only when river flows naturally provide sufficient water can the pond level be restored to 108.5 feet. As in the above scenarios, the credit for leakage was never available in April, May, or June, regardless of the situation in the pond.

5. **Stepped Waiver –** The introduction of a leakage credit was applied incrementally in this alternative, based on conditions in and around the Conowingo pond. There were two basic criteria: (1) the flow at Marietta dropping below the specified threshold levels (5,000 or 3,500 cfs, seasonally); and (2) the estimated local inflow (downstream of Marietta) into the pond being less than the estimated 2025 combined public water supply (for Baltimore and Chester withdrawals) and thermal power generation consumptive water use (for Peach Bottom and new Conectiv project) from the pond. If either of the two basic criteria was met, a credit for up to 250 cfs of the estimated leakage was granted. Intermediately, if both criteria were met, the credit was additive and granted up to 500 cfs. If the pond continued to trend downward in spite of the credit for leakage and reached a pre-defined critical stage (104.5 feet, Conowingo datum), the maximum credit of the full 800 cfs was allowed.

   As in the above scenarios, the credit for leakage was never available in April, May, or June, regardless of conditions in and around the pond.

6. **Minimum Flow –** Under this scenario, the flow thresholds established by Conowingo's FERC license (5,000 and 3,500 cfs, seasonally) were adopted as absolute minimum release criteria, even during times when Marietta flows were below these thresholds. In consideration of the dam striving to meet those minimum releases at all times, the estimated leakage of 800 cfs was always fully counted toward that goal. From the perspective of having the credit available under any conditions, this scenario resembles No. 2, Automatic Waiver. However, the mandated minimum release of 3,500 or 5,000 cfs was unique to this alternative.

   The only circumstance under which no credit for leakage was given was during the months of April, May, and June, as in the above scenarios.

B. Evaluation of Preferred Alternatives

Based on an evaluation of results for the six preferred alternatives, the Workgroup was able to identify positive and negative aspects of each option. The Workgroup was able to eliminate certain options from consideration because they were unable to meet various objectives for the plan, the most important being sustained viability of the Conowingo pond.

1. **Baseline –** The Baseline alternative was developed only with the intent to serve as being representative of existing conditions for comparison purposes, and not as a proposal for recommended operations. Instead, the goal of the Workgroup was to modify existing conditions, as warranted, for improved management of the pond.

2. **Automatic Credit –** The Automatic Credit option was very successful at protecting the level of the pond during droughts, and was deemed worthy of further evaluation. However, the Workgroup was concerned about allowing the variance for leakage even during times when the dam can be operated at full capacity without the credit. The intent behind formalizing the credit for leakage was to ensure reliability of the pond during droughts, and not to enhance operations of the hydroelectric facility. The results of the Automatic Credit option indicated that there are times during moderately low flows where usage of a leakage credit could noticeably alter the dam's outflow as a result of intra-day peaking. Implementing a permanent, full-time credit for leakage runs counter to the settlement agreement negotiated in 1988 to protect downstream habitat, and affords more flexibility to the dam at the expense of downstream flows than is warranted. Nevertheless, the Automatic Credit option consistently provided reliability to the storage in the Conowingo pond, and the Workgroup recognized the potential benefits.

3. **Critical Level –** The Critical Level option quickly proved to be inadequate in ensuring sustainability of the pond. By restricting the leakage credit until the pond was at a level of 104.5 feet, the opportunity to maintain flexibility necessary to withstand droughts was generally lost. In other words, the variance simply came too late. Further, by tying the variance to the pond level, which is a parameter entirely within the control of the dam operators, the Workgroup expressed concern that the public would perceive the potential for a conflict of interest.

4. **System Deficit –** Although the results for the System Deficit option were very favorable in terms of timing of the variance and success in sustaining pond operations, concern was expressed that the implementation of the variance was overly complicated and potentially restrictive of operational flexibility at the dam. It is not the intent of the plan to dictate operations to Exelon. Also, the variance relied on conditions in the pond that are not always readily available to the public, or even to members of the Workgroup, and might under certain circumstances be considered proprietary and confidential by Exelon. Nevertheless, the alternative was viewed favorably overall, as it was successful at providing the credit for leakage when it was truly needed, and allowed the pond to remain viable. At the same time, the conditions required for the credit ensured that the waiver does not benefit hydroelectric operations at the expense of downstream habitat. As such, the System Deficit alternative was recommended for further consideration and possible selection as the final recommended alternative.

5. **Stepped Waiver –** In contrast to the criteria associated with System Deficit, the criteria under the Stepped Waiver option are readily available to the public and members of the Workgroup. However, daily assessment of withdrawals, pond level,

and inflow estimates was deemed overly complicated and in opposition to the goal of a more direct and straightforward protocol for implementing the leakage credit. Further, despite several overlapping criteria for the variance, the option was not able to, in all cases, ensure pond viability during drought conditions.

6. **Minimum Flow –** Finally, the Minimum Flow alternative demonstrated that the pond is simply unable to meet sustained releases of 5,000 and 3,500 cfs under drought conditions, even with the advantage of a full-time credit for leakage. The results reinforced the rationale implicit in the 1988 settlement agreement, tying required releases to the conditions at the Marietta stream gage. Adoption of the Minimum Flow alternative would have run contrary to that negotiated agreement, and would not have met the goals of the Conowingo Pond Management Plan.

C. Conclusions and Refinement of Alternatives

Having evaluated the six preferred alternatives, the Workgroup identified two as having favorable results in terms of meeting the objectives of sustainable operations during low flows: Automatic Credit and System Deficit. However, despite generally favorable results, both alternatives exhibited flaws that prompted the Workgroup to continue discussing the options and deliberating implementation of the leakage credit. As discussed above, Automatic Credit is too permissive, allowing the leakage credit at times when it is not warranted; and System Deficit, while reasonably seeking to limit the credit to occasions when it is truly needed, employs a triggering mechanism that is complex and difficult to monitor.

The Workgroup decided to evaluate a new alternative based on a variation of the Automatic Credit concept, but establishing more stringent, yet simple to track, requirements for the credit. Following review of preliminary results, the Workgroup chose to develop and evaluate the implementation of the credit based upon the flow conditions at Marietta. Called Automatic Q-FERC + 1,000, the alternative was designed to initiate a credit for leakage, up to 800 cfs, any time the measured flow at the Marietta stream gage declines to a flow 1,000 cfs above the seasonal FERC flow, which is required to be released from Conowingo dam (either 5,000 cfs or 3,500 cfs, depending on the time of year). The credit allowance would remain in effect until the flow at Marietta exceeds Q-FERC + 1,000 cfs. The Workgroup agreed to evaluate the results of the Automatic Q-FERC + 1,000 alternative in comparison to the Baseline and System Deficit alternatives, as well as a No Action alternative that was designed to demonstrate expected results if no modifications (e.g., no credit for leakage) are made to the Conowingo pond operations during low flows. The No Action alternative differs from the Baseline alternative, in that a credit for leakage is never allowed under No Action, whereas the rules in Baseline approximate the ad hoc implementation of the leakage credit based on the resource conditions reported during its historic implementation.

In conducting a final evaluation of the four alternatives (No Action, Baseline, Automatic Q-FERC + 1,000, and System Deficit), the Workgroup considered parameters such as minimum pond elevation, minimum and average flows from the dam, frequency of the pond being unable to meet required recreation levels, and impact to hydroelectric generating capacity. A similar set of data were used to evaluate the initial set of six preferred operation alternatives discussed earlier in this section of the report. As shown in Table V-1, the Automatic Q-FERC + 1,000 clearly showed the most promising results. Table V-1 displays selected key parameters that were especially useful in evaluating the alternatives, but several others were also considered. The entire table is displayed in Appendix 3, Model Results.

Some of the results displayed in Table V-1 are compiled from the entire 73-year simulation, while others are specific to the year 2002. At the time the analyses were conducted, the drought of 2002 was the most recent widespread drought in the basin, and there were good records and institutional knowledge available for use in evaluating the performance of the alternatives. The drought of 2002 was defined by extreme precipitation deficits through late spring and summer, causing the Conowingo pond to begin declining in July. By mid-August, the pond level had declined severely enough that FERC granted Exelon a credit for leakage. The credit remained in place until late September, when heavy rains associated with Hurricane Isabel provided enough rain and river flow to ease drought conditions.

Table V-1. Selected Results of the Final Four Alternatives

	No Action	Baseline	Automatic Q-FERC + 1,000	System Deficit
Minimum Elevation (feet)	100.5	101.8	103.1	101.8
Minimum Elevation in 2002 (feet)	100.5	104.5	104.5	104.5
Average Release in September 2002 (cfs)	3,359	3,516	3,633	3,636
Unmet Recreation Days	15.0	13.5	12.2	12.7
Generating Capacity (percent)	81.5	91.5	92.6	92.0

<u>Minimum Elevation</u>: The table shows the minimum daily pond elevation reached in the Conowingo pond for each alternative through the entire 73-year period of record. The timely usage of leakage credit under the Automatic Q-FERC + 1,000 scenario allowed the pond the most reliability in terms of maintaining adequate levels. The results clearly show that the Automatic Q-FERC + 1,000 alternative provides the most reliability; two of the other three options declined below 102 feet, and the third remaining alternative allowed the pond to decline to the minimum allowable level specified in the FERC license, several feet below optimum minimum conditions.

During the drought of 2002, each of the options – Baseline, Automatic Q-FERC + 1,000, and System Deficit – maintained a minimum pond level of 104.5 feet by implementing a credit for leakage in different ways. The No Action option, however, not only was unable to maintain 104.5 feet in the pond, but also demonstrated that the pond level would have declined to the extreme minimum of 100.5 feet without the benefit of a credit for leakage. That result serves to reinforce the importance of the credit in keeping the Conowingo pond at reliable levels during droughts.

When looking at the level of the Conowingo pond over the entire 73-year record, a period of 26,663 days, on only 53 days (0.2 percent) did the pond level decline below 104.5 feet under the selected alternative. The No Action, Baseline, and System Deficit alternatives demonstrated pond levels below 104.5 on 1,200 days (4.5 percent), 267 days (1 percent), and 106 days (0.4 percent), respectively.

Average Release: The Workgroup looked at simulated releases from Conowingo during several droughts, including 2002. The differences in results of the four alternatives are attributable to the implementation (both timing and quantity) of the leakage credit. Any credit taken will reduce by that same quantity the water that is released downstream. On average during September 2002, the dam released about 3,630 cfs under the Automatic Q-FERC + 1,000 and System Deficit scenarios, while releasing 3,516 cfs under the Baseline scenario and 3,359 cfs under the No Action alternative. It seems counterintuitive that higher releases are shown by the alternatives that apply the leakage credit more liberally, but their ability to do so is ensured by the higher stages of the pond. When the drought conditions eased in mid-September 2002, the dam was able to return to normal conditions more quickly under those alternatives, while it needed to retain more flow for refilling under No Action and Baseline conditions.

For comparison purposes, it is useful to also consider average releases during August 2002, before flows increased above drought conditions. During that month, the dam released the least water (4,479 cfs) under the System Deficit scenario, followed closely by 4,495 cfs under the Automatic Q-FERC + 1,000 scenario. The Baseline and No Action alternatives allowed releases of 4,616 cfs and 5,055 cfs, respectively. While there is significant difference in those results, the higher releases under the No Action scenario came at the expense of lower pond levels, as described above. Although providing less flow downstream during the month of August 2002, the Workgroup is satisfied that, based on available information, the releases under the Automatic Q-FERC + 1,000 and System Deficit alternatives are no more harmful to aquatic habitat than the releases under the No Action and Baseline scenarios.

Unmet Recreation Days: It is expected that allowing a credit for leakage will increase the reliability of the Conowingo pond to provide adequate levels for recreation. Because the FERC license stipulates maintenance of a recreational pond level of 106.5 feet only on weekends between Memorial Day weekend and the end of September, recreation usage is concentrated during that time, which is roughly 55 to 60 days spread over 18 to 20 weekends. Results show that, over the 73-year record, there are fewer days of unmet recreation levels (on an average annual basis) under the Automatic Q-FERC + 1,000 and System Deficit scenarios, at 12.2 and 12.7 days, respectively. Conversely, an average of 13.5 days (Baseline) and 15 days (No Action) fail to meet recreation needs under the other alternatives. In terms of the total days available for recreation (up to 60), the range of unmet days ranges from about 20 to 25 percent. The results, therefore, show that Automatic Q-FERC + 1,000 and System Deficit operations provided the equivalent of one additional weekend of optimum recreational opportunities (pond level at 106.5 feet) in an average summer. The results also suggest that when impacts do occur to recreation, they are less severe and of shorter duration under the chosen alternative.

Generating Capacity: Although the purpose of establishing management objectives for the Conowingo pond is not to provide the means for sustained or increased hydroelectric generation, reliable power generation is nevertheless a vital multipurpose use of the Conowingo pond. Thus, the generating capacity retained through drought periods is a useful indicator of whether or not the alternatives have provided more sustainable and reliable operations. Results show that the water available for generation at Muddy Run during the July through September timeframe can support about 92 percent of capacity under the Baseline, Automatic Q-FERC + 1,000, and System Deficit alternatives. However, the No Action option can sustain only about 81.5 percent of capacity. The period July through September is particularly useful for evaluation because it is the juxtaposition of the time that low flows are most likely to occur and the typical occurrence of peaks in power demand.

The evaluation of preferred alternatives showed that Automatic Q-FERC + 1,000 provided the best overall results for key parameters to include minimum pond elevation, minimum and average flows from the dam, frequency of the pond being unable to meet required recreation levels, and impact to hydroelectric generating capacity. Thus, Automatic Q-FERC + 1,000 was carried forward as the best alternative.

VI. DISCUSSION OF SELECTED ALTERNATIVE

Finally, the best alternative, Automatic Q-FERC + 1,000, was evaluated with respect to the important issues defined by the Workgroup at the outset of the study (see Section III-E):

1. **Issue:** *There should be clearly defined limitations to the use of a leakage credit.*

   The Workgroup decided that a year-round permanent credit is not justified and established clearly defined limitations. Leakage credit will be allowed only during low flow events when flow at the Marietta gage falls to a level of Q-FERC + 1,000 cfs or less. Over the 75 years of flow records considered, Q-FERC + 1,000 cfs has occurred in 56 of those years. Nearly 90 percent of those events have occurred in July through September, with the remainder occurring in late June and October.

   A critical factor in the Workgroup's decision was the change or impact to the aquatic habitat downstream of the dam, the protection of which was the basis for the 1988 settlement agreement that first established minimum release requirements at Conowingo. The Workgroup believes there will be no discernible adverse habitat impacts likely to result from a license amendment to allow a periodic credit for leakage, and recognized that none were reported in the four instances the variance has been granted by FERC. Nevertheless, in order to further safeguard against negative impacts, the Workgroup conditioned its findings with a restriction that limits the credit to only that portion of the 800 cfs that is necessary to maintain viable pond levels.

   Another important restriction prohibits Exelon from automatically taking any credit for leakage during the spring spawning season (April 1 – June 30).

   Members of the Workgroup also concluded that, if the Automatic Q-FERC + 1,000 alternative is implemented, the existing protocol for operations during the fall out-migration of shad should remain intact. This protocol includes the operation of a large Conowingo unit to allow out-migration of juvenile American shad while minimizing mortality rates. The decision to operate the larger unit would be made based on American shad juvenile population data, existing flow and hydrologic conditions, and discussions between Susquehanna Electric and the Susquehanna River Fisheries Coordinator at U.S. Fish and Wildlife Service. At no time would FERC-licensed minimum flow (on a daily basis) or dissolved oxygen requirements be violated.

2. **Issue:** *Due consideration should be given to the skimming of peak flows and water conservation before committing to reducing downstream flows (i.e., allowing a leakage credit).*

   Both actions were considered by the Workgroup early in the process, but found to have very limited effect on management of the pond. Skimming of peak flows to provide water supply to Baltimore was done in early 2002, before developing drought conditions became critical. This action helped preserve some of Baltimore's local reservoir storage for the short term, but did not obviate the need to continue to withdraw from the pond as the drought worsened. Similarly, skimming operations for Chester Water Authority would not be expected to reduce their withdrawal during droughts.

Voluntary water conservation is an option available for local jurisdictions and state government to request. Mandatory conservation will not be required or imposed in Maryland until a drought emergency declaration is made by the state. Pennsylvania could impose mandatory conservation on Chester Water Authority, if feasible. However, assuming a 10 percent reduction in demand due to water conservation by both Baltimore and Chester Water Authority, the net effect is to save the equivalent of approximately 15 cfs of flow. This "savings" represents only 2 percent of the potential leakage credit of 800 cfs, and would have negligible effect on the pond and downstream resources.

While the Automatic Q-FERC + 1,000 alternative does not directly address peak flow skimming or mandatory water conservation, those techniques were fully evaluated. They are recognized as responsible and reasonable water supply management practices, and should be encouraged along with the implementation of a credit for leakage.

3. **Issue:** *Opportunities to augment flows to the pond should be fully investigated, including more frequent releases of Commission storage.*

   Again, as with peak flow skimming and water conservation, the selected alternative does not address flow augmentation, but it was considered with a focus on alternative use of Commission-owned storage at Cowanesque and Curwensville Lakes. Analyses were made of triggering low flow releases from the reservoirs at different gages and for alternate flow conditions to benefit the Conowingo pond.

   Existing operational rules at the two lakes cannot be changed without a separate in-depth study and revised water supply agreements with USACE. FERC has no purview over releases from Commission-owned water supply storage as they relate to operation of the Conowingo facility. For these reasons, alternate operations of Commission-owned storage was not included as part of the selected management plan for the Conowingo pond. The Workgroup did support an action for the Commission and USACE to continue the process to investigate alternate release strategies at Cowanesque and Curwensville Lakes. See Section VII-D for more information on this recommended action.

4. **Issue:** *Analyses of a credit for leakage should consider the potential beneficial impacts of more sustainable releases that will likely result from releasing lesser quantities.*

The downstream impact of changing flow releases from Conowingo dam was a critical element in assessing management alternatives. Operation under the selected management plan was compared to the established operating baseline condition over the 73 years of modeled record to measure impacts expected. It was determined that there was essentially no difference in the two operating modes for downstream flow parameters to include days below Q-FERC, days below salinity thresholds in the Susquehanna River at Havre de Grace, and average and minimum flow releases from Conowingo dam.

More specifically, the release of lesser quantities due to implementation of a leakage credit was not found to dramatically increase incidences of low flow complications below the dam during drought periods. Moreover, close examination of model results shows that alternatives that allow a leakage credit and thus, preserve storage in Conowingo pond during droughts, ultimately deliver more water downstream for several weeks after river flows rebound above critical low levels. These higher releases are the result of the pond being able to return to normal operations more quickly if storage was preserved. Alternately, if significant drawdown of the pond is allowed to occur during a drought, the dam will need to retain as much inflow as possible to rebuild storage, thus limiting the water available for downstream release.

Because the Automatic Q-FERC + 1,000 alternative met the objectives of the Workgroup in terms of a reasonable modification of existing protocols for implementation of the leakage credit, and did not conflict with the four issues discussed above, the Workgroup recommended that this alternative serve as the basis for the recommended Conowingo Pond Management Plan. The Commission concurred with this recommendation.

VII. CONOWINGO POND MANAGEMENT PLAN

A. Description of the Conowingo Pond Management Plan

Based on results of numerous modeled alternative operating scenarios, the Workgroup identified the leakage and the minimum release requirement as the most critical parameters in managing low flows and enabling the Conowingo pond to remain viable during droughts. While water conservation measures and the release of augmenting flow from upstream reservoir storage were deemed reasonable measures worthy of consideration, the supplemental volume of water they provide was found to be small relative to the daily fluctuations of the pond, and by themselves offered limited drought mitigation. Therefore, the selected Conowingo Pond Management Plan was based on establishing a formal protocol for implementing a license variance related to leakage, and specifying the hydrologic conditions under which the variance is warranted.

The simulated results of operating the resource under the selected plan, "Automatic Q-FERC + 1,000," demonstrated the most favorable balance between preserving adequate levels in the pond, ensuring reliable multipurpose use of the pond, and meeting the requirements for the quantity of water released to the downstream reaches of the Susquehanna River and the Chesapeake Bay. The plan includes initiation of an automatic credit for leakage of up to 800 cfs, as necessary, when the flow conditions at the Marietta gage decline to a flow of 1,000 cfs greater than the seasonal flow thresholds ("Q-FERC") established by FERC. The credit for leakage would remain in effect until the flow at Marietta increases to a level greater than 1,000 cfs above the Q-FERC conditions.

Under the plan, the credit for leakage is never automatically given during the spring shad spawning season, from April 1 through June 30, regardless of flow conditions at Marietta. The plan also stipulates that a credit for leakage does not obviate Exelon from its responsibility to operate in accordance with certain existing guidelines. The guidelines, which are consistent with operating conditions included in the four previous variances issued by FERC, are listed in Section VII-C.

If a severe drought should occur early in the year and cause conditions in the pond to become critical during the spring spawning season, Exelon may decide it is necessary to request a temporary variance to allow leakage credit during some or all of the period of April 1 through June 30. It will need to clearly demonstrate the need for the variance to FERC and the resource agencies, who will evaluate the request at that time.

B. Implementation of the Management Plan

The Conowingo Pond Management Plan is expected to have the support of the Workgroup and the Commission due to Conowingo pond's interstate characteristics and importance to low flow conditions in the lower Susquehanna River and upper Chesapeake Bay. Implementation of the plan will then require that Exelon successfully petition FERC for an amendment to the existing license to include the proposed credit of the gate leakage during drought conditions. The thorough planning effort of the Workgroup over the past four years and formal support of the proposed license amendment by the agencies involved are expected to be positive input to the approval process. The participation and support of the Commission and key resource agencies, including the U.S. Fish and Wildlife Service, Pennsylvania Fish and Boat Commission, Pennsylvania Department of Environmental Protection, and the Maryland Department of Natural Resources, will be essential during the FERC approval process.

Following FERC approval, it is expected that Exelon will adopt the new operating protocols, in accordance with any conditions imposed by FERC in the license amendment. Exelon and the Commission will coordinate to keep the Workgroup apprised of progress of the license amendment as it is subject to the approval process at FERC, and to provide information on the implementation of amended license requirements as appropriate.

A complete relicensing of the Conowingo Hydroelectric Station is scheduled for 2014. Depending upon the implementation date of the recommended license amendment, there could be up to five years of empirical data available (assumes the period 2007-2012 for data collection and analysis since the relicensing application is due in 2012) to assess the results of the leakage credit protocol. The information should prove useful for considering the appropriateness of continuing the leakage credit under the full relicensing process. In addition, the minimum flow release requirements established in the 1988 settlement agreement are subject to review and possible revision during the relicensing process. It is fully expected that the Commission and key resource agencies will be actively involved in the relicensing process.

C. Operation of the Management Plan

The long-term effectiveness of the Conowingo Pond Management Plan requires that its operational aspects be successfully accomplished. There are two components of the plan's operation: (1) the continuous project operations for the hydroelectric power facilities involving certain water resources; and (2) oversight by the Workgroup of project operations during low flow conditions.

The Susquehanna Electric Company will be responsible for operating the Conowingo Hydroelectric Station during low flow periods in accordance with the amended FERC license, as recommended in the Conowingo Pond Management Plan. Operation of the hydroelectric facilities includes monitoring the Susquehanna River flows at the Marietta stream gage and releasing the required flows from Conowingo dam. When the credit for leakage becomes effective, the controlled flow releases can be reduced accordingly. Incorporation of the leakage credit is a tool that will be used only to the extent needed in order to maintain viable pond levels while still meeting the minimum downstream flow requirements established in the 1988 settlement agreement. The leakage credit will not be used to store additional water for the purpose of increasing hydroelectric power production.

The selected management plan addresses only implementation of the leakage credit. It is not intended that other existing protocols or precautionary measures be modified or discontinued. Specifically, the Workgroup recommended, and the Commission concurred, that the operation of Conowingo remain subject to the following requirements, as it is currently:

1. When implementing the credit for leakage, dam personnel should record and periodically report flows measured at the Marietta stream gage;

2. Dam personnel should monitor conditions downstream of the dam for potentially adverse impacts to the aquatic habitat as a result of flow reductions related to the leakage credit;

3. When operating under the variance, dam personnel should record and periodically report facility operations, specifically the estimated discharge through the turbines and estimated total outflow; and

4. Discussion and deliberation between dam personnel and resource agencies should remain available as a means of coordinating the optimum management of the resource to balance needs both in the pond and downstream of the dam.

The Workgroup will continue to function as a body to provide oversight of project operations during low flow periods as related to river inflow, pond levels, and downstream flow releases. Those members of the Workgroup that are directly involved with or responsible for water withdrawals, flow measurements, hydroelectric operations, or other actions with the potential to impact conditions in and below the Conowingo pond will provide routine overview and updates to ensure project operations are in accordance with the management plan. Other Workgroup members will be included in the oversight capacity if they so desire. As was the case for the development of the management plan, Workgroup participation will be voluntary and collaborative.

In addition to providing oversight during low flow events, it is anticipated that the Workgroup also meet annually, most likely in May, in order to review project operations and assess the developing hydrologic conditions as they pertain to the potential for significant low flow periods later in the year. Special meetings can be called at any time, if needed, due to developing drought conditions. The hydrologic model used to develop the management plan is to be kept up to date for the Workgroup's use and it will accurately reflect current water withdrawals in both the pond and the Susquehanna River Basin, as well as current policies and operation protocols. The Commission will be responsible for maintaining the model in an active and up-to-date status. Review of the model and plan in future years will allow for the investigation of modified operations at all the hydroelectric facilities under future or amended licenses. It will also enable evaluation of other large-scale projects throughout the basin and the use of proposed releases from the hydroelectric ponds for the purpose of mitigation for consumptive water use at steam facilities such as Brunner Island and Peach Bottom.

It is also planned that the Workgroup will hold an annual drought operation exercise, possibly as part of their meeting discussed above. The Commission will utilize the hydrologic model during the operations exercise with the Workgroup, particularly when conditions indicate that a drought situation may transpire. To the extent available, forecasts should be incorporated into the exercises. The exercise should also make use of actual initial hydrologic conditions and up-to-date estimates of consumptive water use in the basin, and should perform position analyses. Water supply and hydroelectric facility operators should be prepared to share relevant information and prepare ahead of time contingency operating strategies for investigation at the exercise. Effective communications during drought conditions will be stressed as an important facet of the exercise.

The Workgroup will also be responsible for reviewing and recommending updates to the selected management plan on a periodic basis not to exceed five years. Practical experience gained through operations under the plan will be a key consideration in revising the plan. As one example of a factor to consider, the correlation between low flows and salinity levels in the Susquehanna River at Havre de Grace should be documented and assessed. Other actions that will need to be considered in updating the management plan include the relicensing of the Conowingo Hydroelectric Station (scheduled for 2014), the proposed expansion at PPL's Holtwood project (scheduled for 2010), and the Commission's consideration of approval for continuation of withdrawals from Conowingo pond by the Peach Bottom Atomic Power Station (current approval expires in 2011).

D. Related Actions by the Susquehanna River Basin Commission

As discussed in Section I-A, the Workgroup was tasked with identifying actions beneficial for managing the Conowingo pond that the Commission should consider including in its regulatory and water resources programs. The Workgroup considered several items that are not part of the Conowingo Pond Management Plan per se, but can be taken as related actions. Three specific recommendations for Commission action resulted and are discussed below. The Commission supports each recommendation and plans to take action on each item.

1. **Workgroup Recommendation**: The Commission should consider the impacts of increasing consumptive water use in the basin on the Conowingo pond and develop measures to mitigate the impacts, if needed.

   Discussion: Several management alternatives were investigated for the purpose of discerning the potential for increased consumptive water use upstream of the pond to impact the operations of the dam and the facilities located on or downstream of the pond. Results showed that greater upstream consumptive water use can cause more frequent low flow conditions in the pond vicinity. In order to fully assess the potential for aggravating future droughts, the Commission should undertake a study to characterize upstream consumptive water use and to quantify future consumptive water use needs. The study should assess the potential impact of future needs and address the need for any mitigation efforts to offset the impacts.

   The Commission plans to undertake this study as resources allow.

2. **Workgroup Recommendation**: The water supply storage owned by the Commission at the federal Cowanesque and Curwensville Lakes projects should be investigated for alternative operational strategies to provide more effective, multipurpose low flow augmentation, including benefits to the Conowingo pond and instream resources below the dam.

Discussion: The Workgroup identified the difference between Q7-10 and Q-FERC levels as a hindrance to the potential for Commission storage to provide relief for downstream drought conditions. Q7-10 flows occur much less frequently than Q-FERC flows, so Commission storage is often unused while conditions in the pond and downstream deteriorate. Deeper investigation into the capability of the Commission storage to provide relief should be undertaken, and operating policies developed to use that storage to respond to demonstrated downstream needs rather than the infrequent Q7-10 conditions at two locations in the basin (Harrisburg and Wilkes Barre, Pennsylvania).

The Commission plans to undertake this investigation as resources allow. A scope of work has been prepared by the Commission and USACE.

3. **Workgroup Recommendation**: The Commission should incorporate key management principles and tools described in the Workgroup report, including the use of the annually updated hydrologic model, into the Commission's regulatory and water resource management programs.

   Discussion: The hydrologic model developed by the Commission and used by the Workgroup is a useful and valuable tool, with extensive applicability to management of the water resources of the Susquehanna basin. The Commission should maintain the model with current data and should update water use information annually for use in regulatory and management decisions. Likewise, the management principles identified by the Workgroup should be incorporated into the Commission's regulatory and water management programs.

   The Commission has incorporated use of the hydrologic model and the management principles into its water resources management program.

To demonstrate its support for implementing the above recommendations, the Commission took action formally adopting the Conowingo Pond Management Plan. As part of that action, the Commission included the plan in its Comprehensive Plan for Management and Development of the Water Resources of the Susquehanna River Basin, noting that the inclusion should not be construed as in any way binding upon the Commission in the approval or disapproval of projects pursuant to its authority under the Compact or the regulations promulgated thereunder.

E. Long-Term Benefits

The preceding report and the thorough analysis that it documents provide valuable information for the Commission, public water suppliers, power companies, and environmental resource agencies in making regulatory and management decisions involving the resources of the lower Susquehanna River. Given the potential for increased water use and future withdrawals in the upstream basin and from the Conowingo pond, adoption of the Conowingo Pond Management Plan and related recommendations is intended to ensure sustainable operations and a reliable water source for all needs, from public water supply and power generation to recreation and aquatic habitat, for many years to come.

VIII. SUMMARY OF CONCLUSIONS AND ACTIONS

The Workgroup concluded that the preferred alternative, "Automatic Q-FERC + 1,000," provides the best basis for sound management of the Conowingo pond during low flow conditions. This plan demonstrated the most favorable balance between preserving adequate levels in the pond, ensuring reliable multipurpose use of the pond, and meeting the requirements for the quantity of water released to the downstream reach of the Susquehanna River and the Chesapeake Bay. The Workgroup also concluded that it should remain active in an oversight and review capacity of pond operations during low flow conditions, and that the Commission should take several related actions to potentially benefit the Conowingo pond. The Commission fully supports the Workgroup's conclusions.

The Commission also supports the following actions recommended by the Workgroup:

1. Implementation of "Automatic Q-FERC + 1,000" by Exelon, to include the operational features and protocols described in this report, after FERC approval through the license amendment process;

2. Continuance of the Workgroup as an active body to provide oversight and review of pond operations during low flow events, to hold drought exercises, and to periodically review and update the management plan;

3. Consideration by the Commission of the impacts of increasing consumptive water use in the Susquehanna River Basin on the Conowingo pond and development of measures to mitigate the impacts, if needed;

4. Investigation of the water supply storage owned by the Commission at Cowanesque and Curwensville Lakes for alternative operational strategies to provide more effective, multipurpose low flow augmentation, including benefits to the Conowingo pond and instream resources below the dam; and

5. Incorporation of key management principles and tools described in the Workgroup report, including the use of the annually updated hydrologic model, into the Commission's regulatory and water resource management programs.

APPENDIX 1

Conowingo Pond Workgroup Input

Appendix 1

Conowingo Pond Workgroup Input

This appendix contains information on the Conowingo Pond Workgroup (the Workgroup) and the important role played by its members. The Workgroup was formed in 2002, at the request of the Susquehanna River Basin Commission (the Commission), to both represent the interests of key stakeholders in the operation and use of the pond and to provide direction, oversight, input, and review for the planning effort and its results. Workgroup members represented federal and state agencies, local jurisdictions, power companies, public water supply purveyors, special interest groups, and the Commission.

Many members of the Workgroup were active in the planning effort. The Workgroup met 17 times from April 2002 to January 2006. These meetings provided the participants opportunities to be actively involved in the complete planning process, including technical analyses, resolution of issues, development and evaluation of alternative management measures, selection of the recommended plan, and preparation of the Workgroup report. Attendance at the 17 meetings by members representing the diverse groups on the Workgroup was consistently good, as shown in the summary of meeting attendance presented below.

In addition to participating in Workgroup meetings, the members were requested to review and comment on planning results, initial drafts of the Workgroup report, and other material provided by the Commission. Members were also requested to provide data and other input needed to accomplish technical analyses and evaluation of alternative plans. An input item provided was a discussion of Workgroup members' particular interests in the resources, use, and operation of the Conowingo pond. The discussion of interests follows the listing of meeting attendance below and a summary of the interests, by topic, is included in Section III-A of the main report.

Finally, Workgroup members were requested by the Commission to provide letters of support for the recommended management plan, Automatic Q-FERC + 1,000. The Commission's letter of request, dated November 1, 2005, which was sent to all Workgroup members, and responses received are included at the end of this appendix. At the January 26, 2006, Workgroup meeting, the members in attendance reaffirmed their support for Automatic Q-FERC + 1,000.

The *Conowingo Pond Workgroup Report* was finalized in March 2006, and documents the analyses and results produced under the general oversight of the Workgroup. The Workgroup's report then served as the basis for the Commission's report on the Conowingo Pond Management Plan.

Conowingo Pool Workgroup Meeting Attendance Summary

Organization	2002				2003				2004			2005					2006
	4/16	6/4	10/1	12/4	3/4	6/3	8/19	11/6	1/6	6/23	9/16	1/20	4/6	5/24	7/12	10/11	1/26
Audubon PA				*X*													
Cecil County		*X*															
Chester Water Authority	*X*	*X*		*X*	*X*	*X*	*X*	*X*	*X*					*X*			
City of Baltimore	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
City of Havre de Grace		*X*	*X*	*X*	*X*	*X*	*X*	*X*		*X*		*X*	*X*			*X*	
City of Lancaster																	
Conectiv Mid Merit	*X*	*X*							*X*	*X*			*X*		*X*		
Exelon/Susquehanna Electric	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
FERC	*X*	*X*															
Harford County	*X*	*X*	*X*	*X*			*X*	*X*	*X*	*X*		*X*	*X*	*X*		*X*	*X*
Lancaster County	*X*	*X*	*X*	*X*	*X*	*X*		*X*						*X*			
Lower Susquehanna Heritage Greenway	*X*																
MDE	*X*	*X*	*X*	*X*			*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
MDNR	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
NYSDEC																	
PADEP	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
PFBC	*X*									*X*		*X*	*X*	*X*	*X*	*X*	
PPL Generation	*X*		*X*	*X*	*X*	*X*		*X*	*X*		*X*	*X*	*X*	*X*			*X*
Safe Harbor Water Power	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
SRBC	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Town of Perryville																	
USFWS										*X*	*X*			*X*		*X*	
USACE		*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
USEPA																	
USGS	*X*					*X*											
York County	*X*	*X*	*X*	*X*	*X*	*X*	*X*		*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
York Water Co.	*X*			*X*	*X*	*X*											

Workgroup Interests

1. **Cecil County, Maryland –** The Board of County Commissioners of Cecil County is interested in the management of the Conowingo pond. The Board has an interest in securing future water allocations from the Commission and Maryland Department of the Environment to meet the growth objectives as described in the County Comprehensive Plan.

   The Board of County Commissioners appointed a "Water and Wastewater Task Force" in September 2004, to look into the provision of water and wastewater infrastructure in the designated growth area. The Task Force's report and recommendations to the County Commissioners have recently been finalized. Among the report's implementation recommendations is that the Susquehanna River be investigated as a water source through the utilization of intake points at the facilities in Perryville and Perry Point. These sources could supply water in an easterly direction along U.S. Route 40 to supplement water supply within Cecil County's growth corridor.

   The Board of County Commissioners has made the effort to reach out to the municipalities in a spirit of cooperation to secure a supplemental water source for the County's growth corridor. The County is looking towards the establishment of multiple water sources and to establishing interconnections between the existing systems. It is the intention of the Board of County Commissioners to work closely with the Commission and the Maryland Department of the Environment on these initiatives.

2. **Chester Water Authority –** The Chester Water Authority withdraws water from the Conowingo pond to augment its primary Octoraro Reservoir source of supply in times of drought, to dilute elevated nitrate levels or otherwise offset poor water quality conditions in the Octoraro Reservoir, and to satisfy the conditions of Chester Water Authority's allocation permit for withdrawals from the Conowingo pond. The station capacity for transmitting water from the pond with 1 pump running is approximately 17 mgd and with 2 pumps running, 30 mgd. The pumping station is frequently used during off peak (electrical) periods to minimize electrical costs. However, when the station is needed due to poor Octoraro water quality or sustained drought, it is operated continuously.

3. **City of Baltimore –** Although in the past, the Susquehanna River source may have been viewed as an alternative source for two of the City's three reservoirs (Prettyboy and Loch Raven Reservoirs in the Gunpowder River Watershed), the operation of this source, or lack of operation, is not based on availability of water from the river, but rather on water quality and economic considerations. Unlike the City's three raw water reservoir sources that flow to the treatment plants by gravity, the Susquehanna River source requires pumping, at a considerable operating cost. The waters of the river, with turbidity substantially higher than that of the City's Gunpowder reservoirs,

necessitate additional chemical treatment costs and result in water treatment-generated residuals.

It is expected that, in the future, the Susquehanna River source will become more of a primary raw water source for the daily demands of the Baltimore metropolitan region. With recent heightened concern for security, the Susquehanna River source, as well as the existing raw water reservoirs, now must also be viewed as contingent sources to meet water demands during times of national crisis, or resulting effects caused by intentional disruptions to the water supply.

Management of the Conowingo pond resource is a significant and ongoing concern of Baltimore and other jurisdictions that are served. To that end, an equally significant concern is the management of the water resources in the river upstream of the Conowingo pond. As water resources are consumed along the river, there is a direct effect upon the pond. This will require an ever-changing operating plan, if we are to reasonably meet all demands placed on the pond. However, an unstable pond operating plan will, in itself, impact current stakeholders and their long range planning activities.

Toward those ends, the City has become concerned over docket approvals by the Commission for increased withdrawals upstream of the pond. For example, continuous, unabated awarding of increased consumptive use licenses anywhere upstream of the Marietta gage may result in sooner, and more frequent, FERC trigger flow events, during low flow periods.

The Commission faces a challenging, and almost insurmountable, task of balancing the competing demands for the resources of the river. The Commission should look beyond completion of the Conowingo pond Workgroup program, if the resulting pond operating plan is to have a meaningful lifespan. As modeling demonstrates, resources in the pond barely satisfy the needs of the current stakeholders, projected demands, and environmental concerns. As such, the City hopes that the Commission will strive for a basinwide approach to the Conowingo management program.

4. **City of Havre de Grace, Maryland –** The City of Havre de Grace is interested in the management of the Conowingo pond from a number of different perspectives. The Conowingo pond feeds the Susquehanna River which borders Havre de Grace and provides for recreational and commercial boating, fishing, crabbing, and sea plane operations, as well as a water supply for our citizens and surrounding areas. Obviously, the City wants to work together with other stakeholders to protect and preserve this most valuable resource.

   Currently, the City has a water withdrawal permit for 10 mgd from the Susquehanna River. The intake for the City is exposed to a tidal influence when the dam discharge falls below 4,000 cfs. This can impact the water quality through a rise in salinity. If severe, the water would be usable only for sanitation purposes, not for drinking, and would shut down a bottling facility. Low flow through the dam also impacts a local manufacturing facility and its ability to discharge under a National Pollutant Discharge Elimination System (NPDES) permit to the Susquehanna River. Thus, the possibility of closing or reducing operations at two large employment centers can be at risk. Impacts on the Upper Chesapeake Hospital (Harford Memorial) could also be severe.

Storage of water within the basin and in reservoirs within each system is vital to the ability to supply potable water during periods of drought and should be a requirement of systems prior to an increase in allocation being granted.

5. **Exelon Generation –** Periods of drought or extended periods of low flow can adversely affect the ability of the dam to meet minimum flow and summertime pond level minimums. In addition, due to high ambient and water temperatures and low flow, maintaining the minimum dissolved oxygen requirement is also challenging. These situations can further be compounded if the flows coming into the pond as measured at the Marietta gage do not equal the flow outfalls. This not only affects the dam, but also the water supply companies and Peach Bottom Atomic Power Station due to the loss of pond level. Additionally, recreational boating and marina operation becomes severely hampered due to low water levels.

   A hopeful resolution to these issues would be an automatic minimum flow waiver, if drought and/or low flow conditions are experienced, with a leakage allowance. It would also be advantageous to have a better indication or match of actual flow into the pond versus the Marietta gage. This would allow time to preserve the existing pond level and hopefully maintain minimum flow and summertime minimum pond level requirements. This would also serve to preserve continued water use by water suppliers and the Peach Bottom facility.

6. **Harford County, Maryland –** Harford County is interested in the management of the Conowingo pond from a number of different and diverse aspects. The pond borders the northeast boundary of the County. The pond provides recreational activities, fish and wildlife, hydroelectric power, and water supply to the citizens of the County and surrounding areas. The County is interested in working together with other stakeholders in order to protect and provide for adequate water resources now and in the future.

   The Conowingo pond is the present and future to the County with respect to providing a safe and adequate drinking water supply. Currently, the County has an executed agreement with the City of Baltimore to receive up to 20 mgd through its withdrawal from the pond. The County has an option for an additional 10 mgd withdrawal allocation from the City, for a total of 30 mgd, and is hoping to secure this 10 mgd at the conclusion of the Conowingo study. It is expected that the City's additional peak day withdrawal request can be adjusted upward. In addition, the County needs to plan for additional drinking water to Aberdeen Proving Ground – Edgewood Area and to allow future economic development in and around the County's existing development envelope. For the 50-year planning period, the

County anticipates it will require up to a 40 mgd allocation of the City's withdrawal from the Conowingo pond. The pond will become the County's main resource for providing drinking water to the growing County during all seasons, both drought and wet weather times.

Currently, Harford County is unable to secure additional withdrawal allocation from Baltimore City due to the City's limited peak day withdrawal conditions under their existing permit. Hopefully conflicts between existing permits and improved management of all of the basin's resources can be resolved so that Baltimore City can receive an increase withdrawal permit, where in turn the County would be able to secure additional flow.

Managing the pond efficiently and cooperatively between all parties involved should be the number one goal of the Workgroup. Through cooperative management, surrounding areas should be able to overcome existing conflicts.

7. **Lancaster County Planning Commission –** The Lancaster County Planning Commission recognizes the importance of the collaborative planning efforts of the Commission, the states of Maryland and Pennsylvania, the surrounding counties, and the electric and water utilities in developing and implementing the Conowingo Pond Management Plan.

   Lancaster County public water suppliers do not draw from the Conowingo pond; however, both the City of Lancaster and the Columbia Water Company have intakes upstream at Columbia.

   The lower Susquehanna River is an important natural, scenic, and recreation resource for Lancaster County. The recently established Susquehanna River Water Trail – Lower Susquehanna Section extends 53 miles from Harrisburg, Pennsylvania, to the Mason Dixon Line, encompassing the Conowingo pond. The Lancaster County Planning Commission, on behalf of the Lancaster-York Heritage Region, has developed and printed the Susquehanna River Water Trail – Lower Section (Pennsylvania) Map & Guide to facilitate the exploration of this stretch of the Susquehanna River.

   The Holtwood Environmental Preserve is located on the northern end of the Conowingo pond. The Preserve includes a nationally recognized wildflower preserve, museum of Native American artifacts, and networks of hiking trails. The Kelly's Run-Pinnacle Trail and Urey Overlook Trail lead to spectacular scenic vistas overlooking the Susquehanna River.

   The Conowingo pond/Muddy Run area is an Audubon-designated Important Bird Area where 250 species of birds have been identified. The Conowingo pond provides important wildlife, fish, and plant habitat; recreational opportunities such as fishing, boating, and wildlife watching; and hydroelectric power to the residents of Lancaster County and surrounding areas.

The Conowingo Islands below Holtwood dam at the northern end of the Conowingo pond are considered a highly significant area by the Nature Conservancy for maintaining biological diversity in Pennsylvania. There are state-endangered, threatened, and rare species in the Riverside Cliff/Outcrop natural community located here. The islands provide nesting and roosting sites for bald eagles and osprey.

The Lancaster County Planning Commission recognizes the need for all parties involved in the Workgroup to work together to ensure the implementation of the management plan. Managing the pond efficiently and effectively will require the continued cooperation of the key stakeholders in the pond.

8. **Maryland Department of the Environment** – The Maryland Department of Environment (MDE) is the lead environmental regulatory agency in Maryland, and as such is responsible for managing Maryland's water resources, protecting public drinking water supplies, and preserving water quality of the state's water resources. As a result, the Conowingo pond is of significant interest to MDE.

   Deterioration in water quality, caused by either reductions in flow or other factors, can result in serious implications for drinking water. Inferior water quality increases the complexity and cost of water treatment, and can ultimately compromise public health. Maintaining the best possible quality for sources of public drinking water is the primary goal of MDE's Source Water Protection Program and is considered critical to meeting the goals of the federal Safe Drinking Water Act, for which MDE has primacy.

   Discharges from the Conowingo pond comprise about 50 percent of the flows into the Chesapeake Bay. The Bay is North America's largest and most biologically diverse estuary, and contributes significantly to Maryland's economy, in addition to providing irreplaceable recreational opportunities for the state's citizens. Therefore, maintaining sufficient flow and quality for waters entering the Bay is critical to ensuring the health of the Bay and preserving the benefits engendered to the state. MDE is responsible for implementing total maximum daily loads (TMDLs) for Maryland's waterways, an effort that depends on maintaining and/or improving water quality in the tributaries that feed the Bay, including the Susquehanna River. As signatory to the 2000 Chesapeake Bay Agreement, Maryland is committed to restoring water quality in the Bay, and the health of the Susquehanna is critical to this mission.

   Discharges into the Susquehanna River from a number of industrial and other wastewater facilities are regulated by the MDE. Sufficient flow is required in order to adequately dilute these discharges. In addition, the Susquehanna River system is vital to maintaining the health of wetlands in the region surrounding the river, which are regulated under MDE's Wetlands and Waterways Program.

9. **Maryland Department of Natural Resources and Pennsylvania Fish and Boat Commission –** Restoration of American shad and other migratory fishes in the Susquehanna River has been underway for more than 30 years. Fish passage facilities are now in place at all four of the lower Susquehanna River hydroelectric projects. Uses of the Conowingo pond must not compromise the success of upstream passage of adult shad during April through June, and downstream movement of juveniles from September through December. Minimum flows below Conowingo dam during April through June are of particular importance to maintenance of good water quality and the aquatic resources present in that habitat. Under full anadromous fish restoration, the 3-mile river reach below Conowingo dam is expected to host up to 3 million American shad and 15 million river herring, and it is currently utilized by large populations of white perch, gizzard shad, carp, suckers, American eels, striped bass, and other species. Current FERC-ordered minimum flows, which vary by season, were established to provide protection for these fishery resources, with highest minimum flows required during the anadromous fish migratory period in spring, and intermittent flows permitted only during the winter, when fish populations present are limited. Long-term studies demonstrated that intermittent winter flows were sufficient to maintain the wetted surface area needed to maintain macroinvertebrate production. It may be necessary to reassess spring minimum flow requirements when anadromous fish stocks are fully restored to ensure that habitat and water quality (oxygen) are sufficient to meet the needs of those enhanced populations.

10. **Pennsylvania Department of Environmental Protection –** The Pennsylvania Department of Environmental Protection seeks to protect the broad range of multiple uses the Conowingo Pond supports. Protection of all withdrawal and non-withdrawal uses must be balanced. Withdrawal uses include not only existing withdrawals, but also potential future withdrawals, whether they be by new users or increases by existing users. Non-withdrawal uses include existing and projected future aquatic resource needs, recreation and hydropower, in and below the Conowingo Pond. Instream flow protection measures must be adequate to protect aquatic resources below the dam, as well as the seasonal migratory needs of anadromous fish species.

    The needs of all users must be accommodated in a plan that addresses the impacts of changing hydrologic conditions and growing withdrawal and consumptive uses throughout the Susquehanna River Basin. The plan should recognize the benefits of water conservation and efficiency of water use, particularly during periods of low flow in the river. At its core, the plan should provide a streamlined mechanism for protecting all essential uses during critical low flow periods, including, if necessary, a provision for automatic waivers, whereby leakage through the dam could be temporarily credited toward the conservation release requirements. Any such waivers, however, must serve to protect essential uses, rather than to enhance the economic benefits of the operators of the Conowingo hydropower project.

11. **Susquehanna River Basin Commission –** The Commission has the broad authority and responsibility to take a lead role in managing water resources in the Susquehanna

River Basin. Article 3.5 of the Susquehanna River Basin Compact (Compact), enacted in 1971, contains the duties of the Commission. Specifically, Article 3.5.1 states the Commission shall: "Develop and effectuate plans, policies, and projects relating to water resources; adopt, promote, and coordinate policies and standards for water resources conservation, control, utilization, and management; and promote and implement the planning, development, and financing of water resources projects." Article 3.5.3 calls for the Commission to: "Administer, manage, and control water resources in all matters determined by the commission to be interstate in nature or to have a major effect on the water resources and water resources management." The duties cited in both Articles 3.5.1 and 3.5.3 relate to the development of the Conowingo Pond Management Plan.

A critical and long-term part of the Commission's mission, as reflected in the 1971 Compact, is the achievement of a balance between environmental, human, and economic needs in the management of the basin's water resources. The alternatives considered and the recommended management plan formulated by the Workgroup had, as a primary goal, the balancing of economic development, environmental protection, and provision of water supplies. This was achieved by carefully considering sustainability of the resources, protection of existing users, potential adverse environmental impacts and actions to minimize the impacts, protection of high quality water from degradation, and effective interagency coordination.

In view of the duties and mission discussed above and in response to the 2001 settlement agreement with the City of Baltimore (see Section I-A of the main report), the Commission has had a long-term interest in resolving water resource issues at the Conowingo pond. The Commission recognizes the importance of a cooperative effort by the key stakeholders in the pond. Voluntary, long-term participation in the implementation of the Conowingo Pond Management Plan by the stakeholders is the Commission's goal.

12. **U.S. Army Corps of Engineers –** Changes to operational policies at the Conowingo pond along the lower Susquehanna River do not directly affect Corps of Engineers' projects or water control responsibilities. However, the Corps of Engineers does have an interest in how the Conowingo pond system is managed, both seasonally and long term. This interest stems from proposals, by others, to use releases from upstream Federal reservoirs to mitigate the adverse effects of low streamflows on the pond.

    Only two (Cowanesque and Curwensville Lakes) of the Corps of Engineers' 14 reservoirs in the Susquehanna River Basin are presently authorized for water supply storage. Releases from either project may be initiated when flows at key stream gages along the Susquehanna River drop below Q7-10 target values. These target values, though, were established prior to the heightened concern about the Conowingo pond. Currently, neither project is regulated specifically for the purpose of managing the Conowingo pond.

The Commission has proposed an investigation of low flow management throughout the Susquehanna River Basin. This effort would include a reexamination of the approved operating plans for Cowanesque and Curwensville, as well as an examination of operational changes at other Federal reservoirs. One objective of the investigation would be to determine if additional releases from these reservoirs could be provided to the Conowingo pond during low flow periods. Effects of these additional releases on the Federal reservoirs are unknown at this time.

13. **U.S. Fish and Wildlife Service –** U.S. Fish and Wildlife Service has many interests in management of the Conowingo pond including, but not necessarily limited to:

   a. Relicensing of Conowingo, Muddy Run and Peach Bottom;
   b. General health of living resources in the pond and in Conowingo's tailwaters;
   c. Impacts of Conowingo hydropower generation schedule on downstream resources;
   d. Anadromous fish restoration and safe upstream and downstream passage of fish (especially diadromous species including eels); and
   e. Impact of water development projects on aquatic resources (e.g., egg and larvae impingement at water intakes, streamside development, endangered species issues).

   Description of fish and wildlife resource issues:

   a. Aquatic resource issues of particular concern to the U.S. Fish and Wildlife Service relate what we call our trust resources – interjurisdictional diadromous species, migratory birds, threatened or endangered species, unique habitats (e.g., wetlands), and federal project review, including FERC and NRC licensing, under the Fish and Wildlife Coordination Act.

   b. U.S. Fish and Wildlife Service coordinates the anadromous fish restoration program for the Susquehanna (with the three basin states and the Commission) and specifically expects that any operational changes among pond users (hydro or domestic water supply) will not adversely affect adult shad and herring migrations upstream, or juvenile shad and herring migrations downstream through the pond and Conowingo dam. With relicensing on the horizon for both Conowingo and Holtwood dams (2014), and U.S. Fish and Wildlife Service is currently examining a petition to list the American eel as threatened or endangered under the Endangered Species Act, eel passage issues (both directions) will be important for both projects.

   c. U.S. Fish and Wildlife Service staff leading the effort on anadromous fish restoration in the basin believes that the specific issue of whether or not leakage is included in Conowingo's minimum flow requirement can be accommodated for migratory fish by maintaining current FERC flows for April-June and providing a permanent waiver (e.g., including leakage) for all other months.

14. **York County Planning Commission –** In comprehensively planning for York County's future, the York County Planning Commission must consider all social, economic, historical, and environmental aspects of the Conowingo pond. The Commission is to be commended for being proactive in developing a management plan for this valuable resource.

Obviously, the York County Planning Commission is concerned with the pond being maintained as a viable water supply source for residents and a reliable source of power generation to the PJM Grid of which York County is a part. York Water Company's water supply intake is to be used as an emergency source of water to York Water Company customers in times of drought. This will mean, York Water Company will be withdrawing from the Susquehanna River upstream of the pond at a time when the pond will be under maximum stress. Peach Bottom Atomic Power Station was near to a shutdown in 2002 due to the lowered pond level. Hopefully, the goal of a quicker/easier Conowingo leakage credit will prevent an unstable PJM Power Grid from a Peach Bottom Atomic Power Station shutdown due to a low pond level with York Water Company's new emergency withdrawal on line in the future. Looking into the future with York County's development pressures, it is possible that York Water Company's pond river withdrawal may become a normal source of water supply instead of an emergency supply.

The Conowingo pond provides habitat for threatened and endangered species of flora and fauna that are contained in several natural areas, as mapped in the Natural Areas Inventory component of the County Comprehensive Plan. Protection of these habitats is important. The pond's watershed is vital in the County's Open Space/Greenway's Plan, as well as other regional efforts throughout the state. The recreational opportunities for County stakeholders, as well as the historic, educational, and environmental potential of the pond and its watershed, must be preserved and enhanced (aquatic biota, reestablishment of the shad, petroglyphs, etc.).

Most importantly, the planning efforts of the Commission, Pennsylvania, Maryland, surrounding counties and municipalities, and utilities must be collaborative and coordinated efforts as established by the Conowingo Pond Management Plan.

Susquehanna River Basin Commission
a water management agency serving the Susquehanna River Watershed
SRBC

November 1, 2005

Mr. Don Baldwin
Susquehanna Electric Company
Conowingo Hydro Station
2569 Shures Landing Road
Darlington, MD 21034-1503

Re: Conowingo Pool Management Plan

Dear Mr. Baldwin:

This is being sent to all Conowingo Pool Workgroup members to confirm that at its October 11, 2005, meeting, the Workgroup voted unanimously (with one abstention) to select the "Automatic Q-FERC + 1000" operational alternative for purposes of finalizing a Conowingo Pool Management Plan to recommend to the Susquehanna River Basin Commission (Commission).

The selected alternative calls for automatic initiation of a leakage credit (800 cubic feet per second [cfs]) at Conowingo Dam when flow at the Marietta gage falls below an amount equal to 1,000 cfs greater than the applicable Q-FERC trigger flow level, except during the anadromous fish spawning season (April–June).

Though the meeting on October 11 was very well attended, there were a number of Workgroup members not in attendance. If this includes you, please know that we are very interested in determining your organization's support, objection, or acquiescence to the selected alternative. Please communicate your support or objection to me or Drew Dehoff by November 30, 2005. If we do not hear from you by then, we will assume acquiescence. For your reference, materials distributed at the meeting and not provided in advance are enclosed with this letter.

It was acknowledged at the meeting that many of the Workgroup members, though personally supportive of the selected alternative, were not speaking officially on behalf of their respective organizations and wanted to undertake their internal reviews before a formal recommendation is made by the Workgroup to the Commission. If this includes you, please attempt to complete your organizational review and communicate any support or objection in writing to me or Drew Dehoff by November 30, as I had requested at the meeting. If we do not receive a written response by November 30, we will assume acquiescence.

1721 North Front Street, Harrisburg, PA 17102-2391 • Phone: (717) 238-0423 • Fax: (717) 238-2436
website: http://www.srbc.net e-mail: srbc@srbc.net

Let me also reemphasize the point I made to members in attendance at the October 11 meeting, and inform the members who were not, that Drew and I are prepared to meet with you or other representatives of your respective organizations to present additional information or respond to questions concerning the operational alternatives evaluated by the Workgroup, the selected alternative, or the process moving forward. If you want to meet with us, please be in contact with Drew or me.

In terms of the process moving forward, barring significant objection to the selected alternative, we will prepare a draft Workgroup report, which will include a proposed management plan, to circulate to all Workgroup members for review in advance of our next meeting. The report is intended to inform the Commission of the process undertaken by the Workgroup, and to serve as the transmittal document for the proposed management plan the Workgroup would urge the Commission to adopt.

Based on the response to proposed meeting dates circulated recently, the next meeting of the Workgroup will be held on January 26, 2006. We will provide additional information concerning the meeting schedule, agenda, and location at a later date.

Our goal is to have the Workgroup finalize the report and proposed management plan at the January meeting, or at the latest by mid-February, so that it can be presented to the Commission at its March 15, 2006, meeting in Williamsport, Pennsylvania. We anticipate that the Workgroup would recommend to the Commission that it initiate a public review process prior to taking final action on the proposed management plan. The Commission's next scheduled meeting on June 14, 2005, in New York State (location to be determined) would represent the first opportunity to take such final action.

Both the public review process and the subsequent meeting of the Commission at which final action would be taken afford any of the entities represented by Workgroup members another opportunity to provide the Commission with the official position of your entity about the merits of the plan.

On behalf of Workgroup chairman, Mat Pajerowski, Maryland Department of the Environment, Drew Dehoff and myself, thank you for your participation and contribution to date. We look forward to working with you as we bring this process to what I hope we all believe will be a successful closure.

Sincerely,

Thomas W. Beauduy
Deputy Director

cc: H.A. Ryan, Exelon Generation
J. Rooney, Susquehanna Electric Company

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Robert L. Ehrlich, Jr., *Governor*
Michael S. Steele, *Lt. Governor*
C. Ronald Franks, *Secretary*

November 14, 2005

Thomas W. Beauduy
Deputy Director
Susquehanna River Basin Commission
1721 North Front St.
Harrisburg, PA 17102-2391

Re: Conowingo Pool Management Plan

Dear Mr. Beauduy:

This is in response to your letter of November 1, 2005 requesting our comments on the Conowingo Pool Workgroup selection of the "Automatic Q-FERC + 1000" operational alternative. This alternative calls for automatic initiation of a leakage credit of 800 cfs at Conowingo Dam when the flow at the Marietta gage falls below an amount equal to 1,000 cfs greater than the applicable FERC license minimum flow level, except during the anadromous fish spawning season (April-June). The Maryland Department of Natural Resources (MDNR) has participated in this workgroup for the past several years and has provided the technical expertise of its consultant, Versar, Inc., in evaluating the Water Use Plan model and various alternative operating scenarios for use during low flow periods. MDNR also participates as a member of the Fish Passage Technical Advisory Committee and works on a variety of Susquehanna River power plant issues, so we are very familiar with the various fisheries and power plant issues in and around the lower Susquehanna River.

It is our belief that it is in Maryland's best interest to endorse the operational plan alternative selected by the workgroup. During the course of the last several years, we have evaluated minimum flow and leakage issues at Conowingo, including 4 emergency waivers in that period with which we concurred. This alternative provides for the wisest use of limited water supply under low flow conditions, both for operational needs within Conowingo Pool and for downstream natural resources. The waiver process is also cumbersome and will be unnecessary once the above mentioned operational alternative is implemented. The Maryland Department of Natural Resources supports the selection of this operational alternative. I look forward to continuing to work with the SRBC in finalizing a Conowingo Pool Management Plan.

Sincerely,

Richard L. McLean
Energy Resource Administrator
Power Plant Research Program

Cc: Mat Pajerowski, MDE
Pete Dunbar, PPRP

Tawes State Office Building • 580 Taylor Avenue • Annapolis, Maryland 21401
410.260.8DNR or toll free in Maryland 877.620.8DNR • www.dnr.maryland.gov • TTY users call via Maryland Relay

Pennsylvania Fish & Boat Commission

established 1866

EXECUTIVE DIRECTOR
P.O. BOX 67000
HARRISBURG, PA 17106-7000
717-705-7801 – 717-705-7802 (FAX)
E-MAIL: DAUSTEN@STATE.PA.US

November 23, 2005

Thomas W. Beauduy
Deputy Director
Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, PA 17102-2391

Dear Mr. Beauduy:

Thank you for including the Pennsylvania Fish and Boat Commission in the important tasks of the Conowingo Pool Workgroup.

My staff have provided me with a thorough review of the minimum flow issues at Conowingo Dam within the context of other water uses at critical flow levels and critical times of the year.

The Pennsylvania Fish and Boat Commission supports, in principle, the "Automatic Q-FERC + 1000" alternative for managing the water resources of the Conowingo Pool.

While the Q FERC + 1000 seems the optimum alternative at this juncture, all of the ramifications to the fishery resources are not clear. The Pennsylvania Fish and Boat Commission would appreciate continued participation in this important process and would expect to seek additional considerations for fishery resources, including evaluation of anadromous fish passage efficiency at Conowingo, evaluation of causes of downstream fish kills during the spring, as well as continued West Lift operations and other fishery matters that may emerge.

Sincerely,

Douglas J. Austen, Ph.D.
Executive Director

Our Mission: www.fish.state.pa.us

To provide fishing and boating opportunities through the protection and management of aquatic resources.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Susquehanna River Coordinator
1601 Elmerton Avenue
P. O. Box 67000
Harrisburg, PA 17106-7000

November 21, 2005

RECEIVED
22
SRBC

Tom Beauduy, Deputy Director
Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102-2391

Dear Tom,

This responds to your letter of November 1, 2005 requesting agency concurrence with the preferred operational alternative to be included in the forthcoming Conowingo Pool Management Plan being developed by SRBC. As a member of the Conowingo Pool Workgroup I have reviewed the numerous alternatives and model runs related to discharge options at Conowingo Dam to best meet all water needs in the impoundment. These needs include minimum flow releases from the dam for downstream resource protection, water withdrawals for domestic consumptive use, recharge of Muddy Run Pumped Storage Project, cooling capability at Peach Bottom APS, and maintenance of recreational pond levels.

I am currently the federal fisheries coordinator for the Susquehanna River Anadromous Fish Restoration Cooperative and chair the FERC-created Susquehanna River Technical Committee (SRTC). This latter group is charged with managing all aspects of the shad program at Conowingo Dam including upstream and downstream fish passage, operational adjustments and minimum flows.

I concur with the Workgroup recommendation whereby the Conowingo Hydroelectric Project would be granted automatic leakage credit of approximately 800 cfs whenever natural river flow measured at the Marietta gage falls below an amount equal to 1,000 cfs greater than the applicable Q-FERC trigger flow level, except during the anadromous fish spawning season of April through June, and as needed to augment downstream fish passage in the fall. Automatic leakage credit, if approved by FERC, will avoid the last-minute scrambling for state and federal agency concurrence each time we enter an extreme low flow period while still providing needed protection for all pool water needs.

Sincerely,

Richard St. Pierre
Susquehanna River Coordinator

cc: Jen Kagel
Dave Sutherland

TAKE PRIDE® IN AMERICA

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1715
BALTIMORE, MARYLAND 21203-1715

REPLY TO THE
ATTENTION OF

November 29, 2005

Engineering Division
Civil Works Branch

DEC - 8 2005

Mr. Thomas W. Beauduy
Deputy Director
Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, PA 17102-2391

Dear Mr. Beauduy:

I have received your letter of November 1, 2005 concerning the Conowingo Pool Management Plan. You requested support for a tentatively selected management alternative that will become part of the final plan to be presented to the Susquehanna River Basin Commission.

Members of my Water Control Team, along with other natural resource agencies and utilities, have been participating on the Commission's Conowingo Pool Workgroup since its formation in early 2002. The Workgroup considered the competing uses of the Conowingo Pool, identified alternatives to satisfy these uses, and assessed and evaluated the impacts of the alternatives.

The Workgroup has selected the "Automatic Q-FERC + 1000" alternative for the purpose of finalizing the Conowingo Pool Management Plan. This alternative calls for an automatic implementation of an 800 cfs leakage credit at Conowingo Dam, except during the anadromous fish spawning season (April - June). The automatic leakage credit can be applied whenever river flow at the Marietta gage falls below an amount equal to 1000 cfs greater than the applicable Q-FERC trigger flow level.

Based on the results of the analyses conducted by the Workgroup, I support the inclusion of the "Automatic Q-FERC + 1000" operational alternative in the Conowingo Pool Management Plan. This alternative provides system reliability and flexibility for the electric utilities, without compromising natural resource protection.

Changes to operational policies at the Conowingo Pool do not directly affect Corps of Engineers projects, and I see no significant unresolved issues with respect to our present water control responsibilities. I remain very interested, however, in the long-term management of the Conowingo Pool system along the lower Susquehanna River. This interest stems from proposals by others to increase releases from our upstream federal reservoirs. The purpose would be to offset the adverse effects of rising consumptive uses in the future that occur simultaneously with low stream flows.

Thank you for the opportunity to participate on the Conowingo Pool Workgroup and to comment on the tentatively selected management alternative. I look forward to receipt of the draft Workgroup report and to final Commission action on the Conowingo Pool Management Plan.

Sincerely,

Stanislaw P. Gembicki Jr., P.E.
Chief, Engineering Division

CF: CENAB-PL-P (Mr. Dan Bierly)

Safe Harbor Water Power Corporation

ONE POWERHOUSE ROAD, CONESTOGA, PA 17516 ■ TELEPHONE 717-872-5441 FAX 717-872-0282

DEC - 8 2005

December 2, 2005

Thomas W. Beauduy
Deputy Director
Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, Pennsylvania 17102-2391

Dear Mr. Beauduy:

Safe Harbor Water Power Corporation is very appreciative of the opportunity to be represented on the Susquehanna River Basin Commission's Conowingo Pool Workgroup. The Plan developed by this group does not cause concern with the commercial operation of our facility at this time.

If additional studies or changes to the plan are required in the future we would again be willing to support these activities.

Regards,

Richard A. Johnson
Manager of Engineering

Marshall J. Kaiser
President & CEO

RAJ/MJK/cgc

DAVID R. CRAIG
HARFORD COUNTY EXECUTIVE

LORRAINE COSTELLO
DIRECTOR OF ADMINISTRATION

HARFORD COUNTY GOVERNMENT

November 22, 2005

Mr. Thomas W. Beauduy
Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, PA 17102-2391

Re: Conowingo Pool Management Plan

Dear Mr. Beauduy:

Please accept this letter as written concurrence on Harford County Government's affirmative support of the selected operational alternative referred to as "Automatic Q-FERC + 1000". This is written in response to your November 1, 2005 letter to Ms. Jackie Ludwig, regarding the need for formal response for the vote that stakeholder members cast at the October 11, 2005 Conowingo Pool Workgroup meeting.

I understand that after beginning this workgroup in Spring of 2002 and after extensive work on modeling the River, calibrating the existing demands, estimating the future demands and reviewing many operational strategies for the Pool, the group narrowed down to four operational alternatives. The "Automatic Q FERC + 1000" option provided a better overall quantity of water available for all the needs of the Pool, including fish and wildlife, recreational and power and drinking water demand. This alternative also had better ease of implementation, flexibility and operational reliability and manageability.

The County appreciates you and your staff's work effort in the past and in the future on this very important Plan, and that also of your hired consultant, HydroLogics, and their work on modeling the Susquehanna River. Not only is this model a vital tool now, but will be well into the future.

I look forward to the final plan and the Commission support on the workgroup's recommendations.

Cordially,

David R. Craig,
Harford County Executive

Preserving Harford's Past; Promoting Harford's Future

MY DIRECT PHONE NUMBER IS 410-638-3350
101 SOUTH MAIN STREET, BEL AIR, MARYLAND 21014 FAX: 410-638-1387 • TTY 410-638-3086 • www.harfordcountymd.gov

YORK COUNTY PLANNING COMMISSION

100 WEST MARKET STREET, YORK, PENNSYLVANIA 17401
TELEPHONE: (717) 771-9870 FAX: (717) 771-9511

RECEIVED
NOV 16 2005
SRBC

November 14, 2005

Mr. Thomas W. Beauduy
Deputy Director
Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, PA 17102-2391

Re: Conowingo Pool Management Plan

Dear Mr. Beauduy,

In regard to your letter requesting York County Planning Commission's support for an operational alternative for Conowingo Pool management planning, I am writing to confirm York County Planning Commission staff support for the use of "Automatic Q-FERC + 1000" operational alternative for the purpose of finalizing a Conowingo Pool Management Plan to recommend to the Susquehanna River Basin Commission.

The York County Planning Commission was pleased to be invited to participate on the Conowingo Pool Workgroup, and as you are aware, a dedicated staff member was assigned to participate. I would like to commend the Susquehanna River Basin Commission for proactively planning for the future management of the Conowingo Pool in order to best utilize and preserve this valuable resource.

Staff of the York County Planning Commission is pleased to work cooperatively with the SRBC on this effort and future planning efforts.

Sincerely,

Felicia Dell

Felicia Dell
Director
York County Planning Commission

cc: file

"That good York water"
SINCE 1816

The York Water Company

November 8, 2005

Mr. Drew Dehoff
Susquehanna River Basin Commission
1721 North Front St.
Harrisburg, PA 17102-2391

Dear Mr. Dehoff:

We have reviewed your letter dated November 1, 2005 regarding the proposed Conowingo Pool Management Plan. The York Water Company concurs with the proposal to select the "Automatic Q-FERC + 1000" operational alternative.

If you have any questions, please call.

Sincerely,

Jeffrey R. Hines, P.E.
Vice President - Engineering

THE YORK WATER COMPANY 130 EAST MARKET STREET, P.O. BOX 15089 YORK, PENNSYLVANIA 17405-7089
TEL. (717) 845-3601 FAX (717) 852-0058 www.yorkwater.com email: info@yorkwater.com

APPENDIX 2

Model Development and Verification

Appendix 2

Model Development and Verification

The purpose of this appendix is to provide supplementary information and additional detail on the development of the hydrologic computer model used to evaluate the various alternate operating scenarios and eventually recommend an operating plan. Four aspects of the model development are covered in this appendix: (1) hydrologic record development, which is comprised of several tasks itself; (2) extent of model coverage; (3) incorporation of operational parameters; and (4) model calibration and verification.

Section 1. Hydrologic Record Development

The ultimate objective of this effort was to develop a comprehensive set of hydrologic records by converting gaged flows into inflows at the OASIS nodes. The record was developed from gaging records throughout the Susquehanna basin, and is intended to be representative of flows that can reasonably be expected to occur in the future. There are several distinct activities associated with this effort; they are briefly described below and in more detail in subsequent sections of this appendix.

The availability of gage information and the locational need for flow information in the model do not always coincide. A significant task related to development of the hydrologic record is transferring the non-impaired and extended flow records to the various model nodes and junctions, and computing the inflow, or reach gains, from the intervening drainage area between two or more model nodes.

Development of the hydrologic record is also complicated by apparent discrepancies between records from adjacent gages. It is not uncommon for the sum of two tributary gages to exceed the measured flow at the first gage downstream of their confluence on the following day. Likewise, the situation can arise where the flow at an upstream gage is greater than the flow at another gage immediately downstream on the following day. This discrepancy can be caused by travel times, evaporation, withdrawals and discharges, and losses of flow to streambank infiltration. An additional significant source of discrepancies is the uncertainty inherent in streamflow measurements; the data from USGS gages is, at its best, rated as having an error of 5 to 10 percent less than or greater than the actual flow value.

When discrepancies such as those described above arise, the routine used to generate local inflows might return negative values for the flow contribution from intervening drainage areas between nodes and gages. While perhaps counterintuitive, “negative inflows” act to preserve the integrity of the flow record and should not be seen as inherently erroneous.

A brief description of the major activities in development of the hydrologic record are given below. More detailed information is presented in subsequent sections.

<u>Assembly of Hydrologic Records</u> – The hydrologic record runs from 1930 to 2002. The starting date for the record was chosen in order to include the drought of the 1930s and a

few antecedent years, and because eight gages were started in 1928 and 1929. Prior to 1928, the paucity of available gaging records makes it difficult to develop a representative reconstruction of all of the gages required to produce the hydrologic records for the model. Other records used include rainfall measurements, evaporation measurements, and records of reservoir operations.

Development of Historic Water Use Time Series – It was important for two reasons to develop estimates for consumptive water use in the Susquehanna basin: first, for use in reconstructing the "unimpaired" hydrologic flow record (see below); and second, for use in the model simulations of various operating scenarios. For the first purpose, monthly average consumptive use estimates were developed for various locations in the basin spanning the entire period of record, then distributed to appropriate corresponding gage locations and added to the historic gage records to develop an "unimpaired" hydrologic record. For the second purpose, the time series monthly average consumptive uses developed for the first purpose were used to generate estimates of current consumptive use throughout the basin and, in conjunction with population projections, to generate estimates of consumptive use in the year 2025.

Computation of Unimpaired Gage Flows – The first step in building the record from available gage data was to compute a monthly record of "unimpaired" gage flows. Gages only show the actual flow in the stream; they have no information about what the flow would have been without human intervention. "Impairments" are modifications of the natural flows due to change in reservoir storage (including evaporation and precipitation on the reservoir surface) and consumptive withdrawals of water (municipal, industrial, or agricultural). If water is withdrawn above a gage and returned to the river below the gage, the impairment is the entire withdrawal. Only by first reconstructing the natural flows at gages can the data then be used to accurately generate synthetic flow data between gaging locations or to fill in data gaps in gage records.

Synthesis of Missing Gage Records and Reach Gains – Many of the gages have incomplete records; their operation either began after 1930 or ended prior to September 30, 2002. The second step in the process is to assemble a monthly record of unimpaired gage flows and "gains," the difference in unimpaired flow between a given gage and the gage(s) immediately upstream. These flows and gains were fed into a program named *fillin* (developed by William Alley and Alan Burns of the USGS[1]) to fill in the missing flows and gains for each gage with missing records. The results of the *fillin* program are referred to as "extended" flows and gains.

Computing Inflows at OASIS Nodes – The next step in the process is to compute the OASIS nodal inflows based on the flows and gains computed in step 3. The monthly values are disaggregated into daily values as a part of this step. The output from this step is the set of inflows at all the OASIS nodes for the period of record.

[1] "Mixed-Station Extension of Monthly Streamflow Records," *Journal of Hydraulic Engineering*, ASCE, Vol. 109, No. 10, October 1983

Application of Flow Routing – The transport of flow from one node to the next downstream node is, in most cases, assumed to occur completely within one full timestep of the model (one day). However, there were 15 stream reaches between model nodes where either extensive travel distance or hydrologic complexity led the modeling team to conclude that flow routing was necessary. Flow routing is the application of a formula related to the natural dispersion characteristics of a volume of flowing water; the formula describes the portion of the flow that arrives downstream in the next timestep and the remainder that arrives during the following timestep. The Muskingum routing methodology was used to develop routing coefficients for the formulas.

A. Assembly of Hydrologic Records

The data used to develop the hydrologic record are listed in Table 1.1. All of the files used in developing this record are in the folder *hydrology* located in the OASIS model directory at the Commission office.

Table 1.1. Sources of Data

Type of Data	Source
Streamflows	USGS
Susquehanna Basin Reservoir Historical Stages	SRBC, COE
Rainfall at Reservoirs	SRBC
Evaporation	SRBC
Susquehanna Basin Water Use Demands	SRBC
Baltimore System Inflows and Demands	City of Baltimore

The 61 streamflow gages in the Susquehanna basin that are used in this project are listed in Table 1.2. Additional drainage area data for reservoirs and OASIS model stream nodes are shown in Tables 1.3 and 1.4, respectively.

Table 1.2. List of USGS Stream Gages

Stream	Location		Gage Number	Start Date	End Date	Area Sq. mi.	---- OASIS Reference --- Name	Num.
Susquehanna River	Colliersville	NY	14975	10/1/24	9/30/68	349	Colliersville	1
Susquehanna River	Unadilla	NY	15005	6/8/38	3/31/95	982	Unadilla	2
Unadilla River	Rockdale	NY	15025	11/22/29	3/31/95	520	Rockdale	3
Susquehanna River	Conklin	NY	15030	1/1/13		2,232	Conklin	63
Tioughnioga River	Cortland	NY	15090	5/20/38		292	Cortland	4
Tioughnioga River	Itaska	NY	15115	10/1/29	6/30/67	730	Itaska	5
Chenango River	Chenango Forks	NY	15125	11/11/12		1,483	ChenangoFk	6
Susquehanna River	Vestal	NY	15135	10/1/37	6/30/67	3,941	Vestal	7
Susquehanna River	Waverly	NY	15150	3/1/37	9/30/95	4,773	Waverly	8
Cowanesque River	Lawrenceville	PA	15200	10/1/51		298	Lawrenceville	12
Tioga River	Lindley	NY	15205	1/11/30	3/31/95	771	Lindley	13
Tioga River	Erwins	NY	15265	7/12/18		1,377	Erwins	14
Chemung River	Corning	NY	15299.5	10/1/74		2,005	Corning	64
Chemung River	Chemung	NY	15310	9/7/03		2,506	Chemung	65

Table 1.2. List of USGS Stream Gages (continued)

Stream	Location		Gage Number	Start Date	End Date	Area Sq. mi.	---- OASIS Reference --- Name	Num.
Susquehanna River	Towanda	PA	15315	10/1/13		7,797	Towanda	15
Towanda Creek	Monroeton	PA	15320	2/1/14		215	Monroeton	16
Susquehanna River	Meshoppen	PA	15334	10/1/76		8,720	Meshoppen	17
Tunkhannock Creek	Tunkhannock	PA	15340	2/1/14		383	Tunkhannock	18
Lackawanna River	Old Forge	PA	15360	10/1/38		332	OldForge	19
Susquehanna River	Wilkes Barre	PA	15365	4/1/1899		9,960	Wilkes Barre	20
Susquehanna River	Danville	PA	15405	4/1/05		11,220	Danville	21
WBr Susquehanna River	Bower	PA	15410	10/1/13		315	Bower	22
Clearfield Creek	Dimeling	PA	15415	10/1/13		371	Dimeling	23
WBr Susquehanna River	Karthaus	PA	15425	3/1/40	9/30/95	1,462	Karthaus	24
Driftwood Branch	Sterling Run	PA	15430	10/1/13		272	Sterling Run	25
Sinnemahoning Creek	Sinnemahoning	PA	15435	10/1/38		685	SinnCk	26
First Fork	Stevenson	PA	15440	10/1/53		245	Stevenson	27
Kettle Creek	Cross Fork	PA	15445	10/1/40		136	CrossFk	28
WBr Susquehanna River	Renovo	PA	15455	10/1/07		2,975	Renovo	29
Spring Creek	Axeman	PA	15465	10/1/40		87.2	Axeman	30
Bald Eagle Creek	Milesburg	PA	15472	10/1/55		265	Milesburg	31
Bald Eagle Creek	Blanchard	PA	15475	5/1/54		339	Blanchard	32
Blockhouse Creek	English Center	PA	15495	10/1/40		37.7	EnglishCenter	33
Pine Creek	Waterville	PA	15497	10/1/57		944	Waterville	34
Lycoming Creek	Trout Run	PA	15500	12/1/13		173	TroutRun	35
WBr Susquehanna River	Williamsport	PA	15515	3/1/1895		5,682	Williamsport	36
Chillisquaque Creek	Washingtonville	PA	15537	5/1/79		51.3	ChillisCk	38
Susquehanna River	Sunbury	PA	15540	10/1/37		18,300	Sunbury	39
Penns Creek	Penns Creek	PA	15550	10/1/29		301	PennsCk	40
E Mahantango Creek	Dalmatia	PA	15555	10/1/29		162	EmahanCk	41
Frankstown Branch	Williamsburg	PA	15560	10/1/16		291	Williamsburg	42
Juniata River	Huntingdon	PA	15590	10/1/41		816	Jun_Hunt	43
Raystown Branch	Saxton	PA	15620	10/1/11		756	Saxton	44
Raystown Branch	Huntingdon	PA	15632	10/1/46		960	Ray_Hunt	45
Juniata River	Mapleton Depot	PA	15635	10/1/37		2,030	Mapleton	46
Aughwick Creek	Three Springs	PA	15645	6/1/38		205	3Springs	47
Juniata River	Newport	PA	15670	4/1/1899		3,354	Newport	48
Sherman Creek	Shermans Dale	PA	15680	10/1/29		200	Shermansdale	49
Clarks Creek	Carsonville	PA	15685	10/1/37	12/31/96	22.5	Carsonville	50
Letort Spring Run	Carlisle	PA	15698	6/15/76		21.6	Carlisle	51
Conodoguinet Creek	Hogestown	PA	15700	10/1/11		470	Hogestown	52
Susquehanna River	Harrisburg	PA	15705	10/1/1890		24,100	Harrisburg	53
Yellow Breeches Creek	Camp Hill	PA	15715	1/1/10		216	CampHill	54
Swatara Creek	Harper Tavern	PA	15730	1/1/19		337	HarperTavern	55
W Conewago Creek	Manchester	PA	15740	10/1/28		510	Manchester	56
Codorus Creek	Spring Grove	PA	15745	5/1/29		75.5	SpringGrove	57
Codorus Creek	York	PA	15755	8/1/40	9/30/96	222	York	58
Susquehanna River	Marietta	PA	15760	10/1/31		25,990	Marietta	59
Conestoga River	Lancaster	PA	15765	10/1/28		324	Lancaster	60
Susquehanna River	Conowingo	MD	15783.1	10/1/67		27,100	Conowingo	61
Deer Creek	Rocks	MD	15800	10/1/26		94.4	Rocks	62

A map depicting the location of the stream gages used in the development of the hydrologic record is shown on the following page.

Figure 1.1. Locations of Stream Gages Used in Development of Hydrologic Record

Table 1.3. Drainage Areas of Reservoirs

Dam	Area sq. mi.	Oasis Node	Stream
Otsego	75.3	100	Susq R
East Sidney	103	125	Ouleout Ck
Whitney Point	257	150	Otselic R
Tioga	280	185	Tioga R
Hammond	122	190	Crooked Ck
Cowanesque	298	200	Cowanesque R
Curwensville	365	290	W Br Susq R
Glendale	41.9	292	
Stevenson	243	305	First Fork Sinn
Bush	226	320	Kettle Ck
Sayers	339	345	Bald Eagle Ck
Little Pine Ck	165.4	355	Little Pine Ck
Chillisquaque		375	Chill. Ck
Shawnee	37.5	395	Raystown Br Juniata R
Raystown	959	400	Raystown Br Juniata R
Dehart	21.6	425	Clarks Ck
Letterkenny	33.8	440	Conodoguinet Ck
York Haven	24,973	475	Susq R
Pinchot	17.5	490	Conewago Ck
Marburg	24.3	505	Codorus Ck
Indian Rock	94	520	Codorus Ck
Redman	40	525	E. Br. Codorus Ck
Williams	41.6	530	E. Br. Codorus Ck
Safe Harbor	26,090	555	Susq R
Holtwood	26,786	560	Susq R
Muddy Run	9.2	565	Muddy Run
Conowingo	27,100	570	Susq R
Octoraro	139.6	585	Octoraro Ck

Table 1.4. Drainage Areas of Stream Nodes

Stream Nodes	Area (sq. mi.)	OASIS Node
Susquehanna River @ Colliersville	349	110
Susquehanna River @ Oneonta	679	115
Susquehanna River @ Unadilla	982	130
Unadilla River @ Rockdale	520	135
Susquehanna River @ Bainbridge	1,610	140
Susquehanna River @ Conklin	2,232	145
Susquehanna River @ Binghamton	2,286	165
Otselic River @ mouth	258	150
Tioughnioga River @ Whitney Point	457	155
Chenango River @ Chenango Forks	1,483	160
Susquehanna River @ Vestal	3,941	175
Susquehanna River @ Waverly	4,773	180
Susquehanna River @ Athens	4,933	245
Tioga River @ Tioga	282	185
Crooked Creek @ mouth	132	195
Tioga River @ Lindley	771	205
Tioga River @ Erwins	1,377	210
Cohocton River @ Campbell	470	215
Chemung River @ Corning	2,006	220
Chemung River @ Elmira	2,162	230
Chemung River @ Chemung	2,506	240
Susquehanna River @ Towanda	7,797	250
Susquehanna River @ Meshoppen	8,720	255
Lackawanna River @ Old Forge	332	270
Susquehanna River @ Wilkes Barre	9,960	275
Susquehanna River @ Danville	11,220	280
Clearfield Creek @ Dimeling	371	295
West Branch Susquehanna @ Karthaus	1,462	300
West Branch Susquehanna @ Keating	1,594	315
Sinnemahoning Creek @ Sinnemahoning	685	310
West Branch Susquehanna @ Renovo	2,975	325
West Branch Susquehanna @ Lock Haven	4,120	350
Bald Eagle Creek @ Milesburg	265	340
Pine Creek @ Waterville	944	360
West Branch Susquehanna @ Jersey Shore	5,167	365
West Branch Susquehanna @ Lewisburg	6,847	380
Susquehanna River @ Sunbury	11,298	385
Juniata River @ Huntingdon	960	405
Juniata River @ Mapleton Depot	2,030	410
Juniata River @ Newport	3,354	415
Susquehanna River @ Duncannon	23,131	420
Susquehanna River @ Dauphin	23,489	435
Conodoguinet Creek @ Hogestown	470	445
Susquehanna River @ Harrisburg	24,100	450
Yellow Breeches Creek @ Camp Hill	216	460
Swatara Creek @ Lebanon	337	465
Susquehanna River @ Marietta	25,990	495
Codorus Creek @ Glatfelter Diversion	75.5	510
Codorus Creek @ York	222	535
Conestoga River @ Lancaster	324	545
Deer Creek @ Rocks	94.4	600
Deer Creek @ Darlington	168	610

B. Development of Historic Water Use Time Series

All available records or estimates of consumptive water use for all locations in the basin were compiled for use in generating a time series of monthly average consumptive use on a watershed basis. Available records included the two Pennsylvania State Water Plans from the 1930s and the 1970s, municipal withdrawal records, periodic USGS water use estimates, records of power plant construction and water use, and reports of withdrawal and consumptive use made to the Commission by regulated entities. Use records were compiled by watershed; the 8-digit USGS Hydrologic Unit Code (HUC) regions were used in New York and Maryland, and the State Water Plan sub-watersheds were used in Pennsylvania.

Two aspects of the consumptive use time series were considered: (1) the "background" consumptive use, representing the distributed use by households, agricultural operations, and small commercial and industrial applications; and (2) large point source consumptive uses such as those associated with power plants and municipal diversions. Fairly accurate records for power plant and municipal use are available, but the modeling team needed to rely on available estimates for most domestic, agricultural, commercial, and industrial water demand.

These two components of consumptive water use were treated differently in the generation of the time series. The background use was assumed to change gradually from year to year, in conjunction with changes to populations. Large point sources, however, are recognized as incremental uses that begin on specific dates and increase by discrete blocks rather than gradually over time.

C. Computation of Unimpaired Gage Flows

The consumptive water use at each demand node and the flow equivalent of both the change in reservoir storage (storage at end of current month minus storage at the end of the previous month) and the net evaporation (evaporation minus rainfall) were added to the gage flows. These computations are done with monthly data. It is important to note that an impairment carries all the way downstream. For example, the change in flow due to a change in storage at Cowanesque Lake carries all the way down to the mouth of the Susquehanna. Thus, the quantity of water entering the Conowingo pond is affected by all the demands and reservoirs upstream.

The final output from this activity was a record of unimpaired flows at all the gages that are affected by demands and change in storage. The consumptive water use demand and reservoir nodes for which data are available are listed in Table 1.4. Rather than attribute localized demands to each individual node, the demands were aggregated and applied at a limited number of nodes near the mouths of major watersheds in the basin, at 15 nodes. There are also five nodes representing the demand at individual power plants. The six reservoir nodes where change in storage was computed represent the largest reservoirs in the basin and are all flood control facilities of the U.S. Army Corps of Engineers. Other modeled reservoirs, specifically water supply reservoirs, are smaller than Corps reservoirs and do not exhibit dramatic changes in storage and, thus, do not have significant effects on streamflows over long-term periods.

Table 1.5. Demand and Reservoir Nodes with Data

Demand Nodes				Reservoir Nodes	
Number	Name	Number	Name	Number	Name
170	Binghamton	182	Waverly	175	Whitney Point
225	Corning	235	Chemung	190	Tioga/Hammond
265	Wilkes Barre	285	Berwick PP	200	Cowanesque
316	Keating	366	Jersey Shore	290	Curwensville
382	Montour PP	386	Sunbury	345	Sayers
406	Huntingdon	416	Newport	400	Raystown
421	Duncannon	451	Harrisburg		
476	York Haven Local	480	Three Mile Island PP		
485	Brunner Island PP	496	Marietta Local		
550	Lancaster	575	Peach Bottom PP		

D. Synthesis of Missing Gage Records and Reach Gains

Computations for this section are done after *fillin* has been run to extend the record of flows and gains for gages with missing records. An important part of this process is "scaling." The objective of scaling is to ensure that the sum of filled-in records upstream of a gage with an actual record equals the actual recorded flow. The *fillin* program does not ensure this for two reasons. First, it utilizes only a single correlated record for each value generated, thus ignoring sums, and second, it works with log transforms, and not actual flows.

In order to ensure that the sums equal the actual flows, the individual flows making up the sum are all multiplied by common scaling factor. The value of the factor is set for each period so that the sums match.

Factor = actual flow / sum of *fillin*-generated flows and gains

When each of the generated flows is multiplied by this factor, the sum of the products will be the actual flow. The products are the values that will be used as the final-generated gains or flows.

Here is an example. From April 1995 to present, the Colliersville, Rockdale, and Unadilla gages have no record, so there is no actual gain at either Unadilla or Conklin. The two gage records and two gains were extended using *fillin.* Those extended values then needed to be adjusted so that the sum of the two flows and the two gains matched the recorded flow at Conklin. So, the Conklin actual flow is maintained by scaling with the Rockdale extended flow and the Unadilla and Conklin extended gain. The calculation is:

> Colliersville flow = Conklin actual flow * Colliersville extended flow / (Colliersville extended flow + Unadilla extended gain + Rockdale extended flow + Conklin extended gain)

In this way, it is ensured that the total volume of all the flows and gains upstream from a given gage match the flow at the gage. The formulas for each node are available for review in the project files at the Commission.

E. Computing Inflows at OASIS Nodes

This section describes how the local inflows to the OASIS nodes are computed. These inflows are the water that joins the water from the upstream node as it flows to the node of interest. The inflows are disaggregated into daily flow and gain values from the monthly values. The disaggregation formula is:

daily unknown = monthly unknown * daily known / monthly known

It is important to note that the goal is not to replicate history in disaggregating the monthlies into dailies; rather, it is to build daily flows whose variation is *representative* of history.

The formulas for computing the nodal inflows and disaggregating them from monthly values to daily values are available for review in the project files at the Commission.

F. Application of Flow Routing

The Muskingum routing method relies on two coefficients: K (a measure of travel time through a reach) and X (a measure of channel storage within a reach), to compute the outflow hydrograph (stream flow versus time) from a reach, given an inflow hydrograph. The K and X values lead to the computation of three coefficients (c1, c2, and c3), which are used in the following equation to compute an outflow hydrograph.

$$O_{t+1} = c1*I_{t+1} + c2*I_t + c3*O_t$$

Where, O_{t+1} is today's outflow from the reach, O_t is yesterday's outflow from the reach, and I_t and I_{t+1} are yesterday's and today's inflow into the reach, respectively.

The method used to calculate the coefficients was the optimizer function in Microsoft Excel. Three hydrographs were entered into Excel: the upstream gage values (u/s), the computed gains, and the downstream gage values (d/s). The gains are added to the upstream hydrograph; this is then used with the downstream hydrograph to compute the c values. The objective function is to minimize the sum of the absolute values of the residuals, subject to c1+c2+c3 = 1 and each c is non-negative. A sample computation and the resultant coefficients are shown below. All of the files used in this analysis are available in the project files at the Commission.

Bainbridge to Conklin, node 140 to node 145. U/s hydrograph is Rockdale gage plus Unadilla gage plus Inflow140 plus Inflow145, gage at Conklin is d/s hydrograph.

Results: c1 = 0.108; c2 = 0.838; c3 = 0.054

Section 2. Extent of Model Coverage

Although the focus of the planning study is on the conditions in and below the Conowingo pond, the Workgroup recognized that upstream conditions play a role significant enough to merit their inclusion in the model. Specifically, operations at the Conowingo dam during low flow conditions are driven by conditions at the USGS stream gage located at Marietta, Pennsylvania, and reliable modeling capabilities at that location on the Susquehanna River are, thus, essential to successful analysis. Further, conditions at Marietta are, in turn, driven by hydrologic conditions in the 25,990 square miles of upstream drainage. Those conditions are influenced not only by upstream flow regimes, but also by upstream water demands and the operation of flood control and water supply reservoirs. See Figure 2.1 for a depiction of the extent of basin coverage by the model.

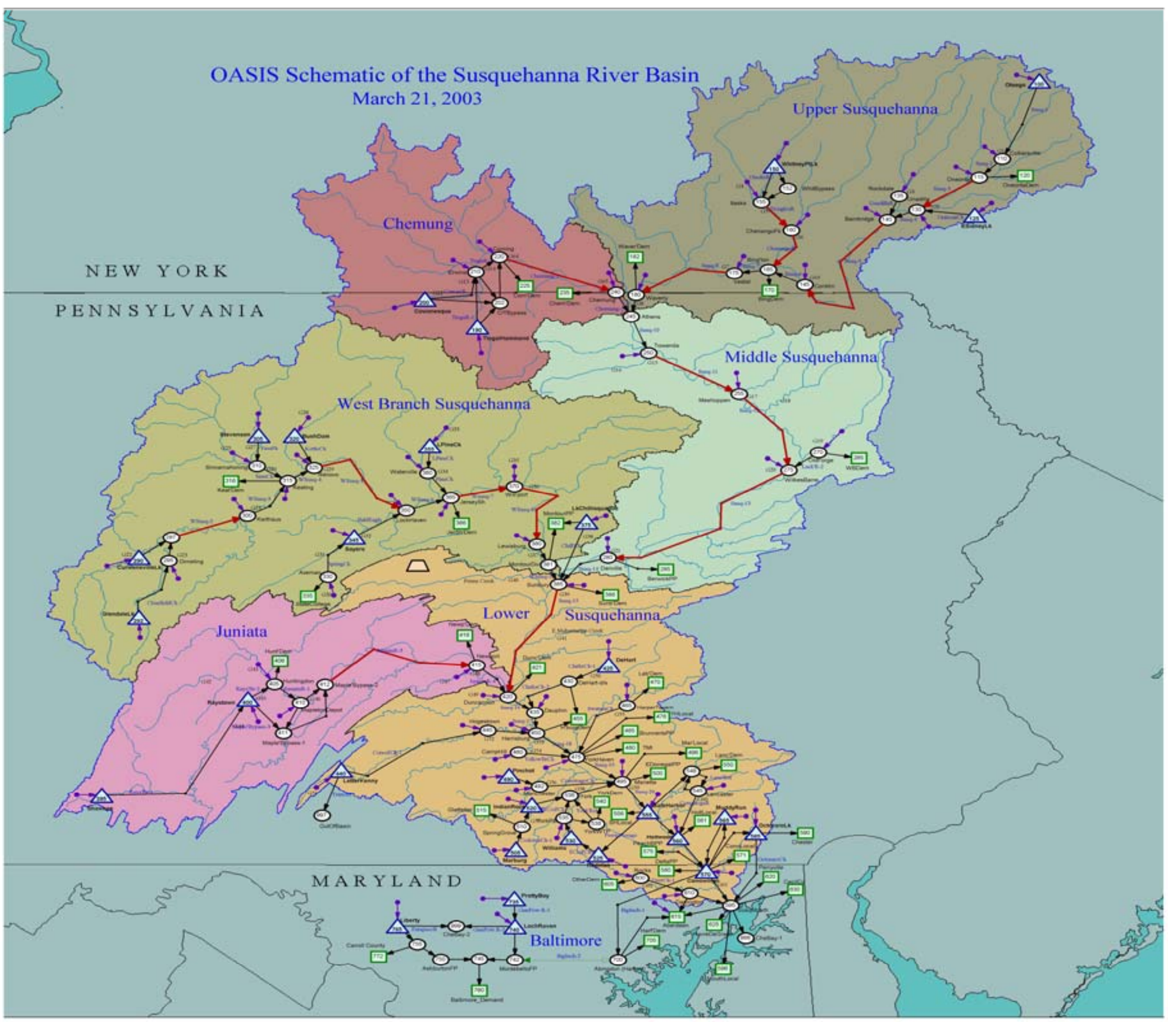


Figure 2.1. Schematic of Hydrologic Model Coverage

Section 3. Incorporation of Operational Parameters

Concerted efforts were made to understand and accurately model the sometimes complex operating rules and management protocols of the large reservoirs and hydroelectric facilities that can affect the Conowingo pond, particularly operations during low flow conditions.

A. Water Supply Reservoirs

Based on information provided by the owners and operators of the water supply reservoirs built into the OASIS model, the appropriate conservation releases (see Table 2.1) and operating rules were incorporated into model logic.

Table 3.1. Water Supply Reservoir Conservation Releases

Reservoir	Owner	Conservation Release, mgd (cfs)
Lake Redman	York Water Company	Not applicable[1]
Lake Williams	York Water Company	7.8 (12)
Octoraro Lake	Chester Water Authority	18 (27.7)
Liberty Reservoir	City of Baltimore	Not applicable[2]
Prettyboy Reservoir	City of Baltimore	7.2 (11)
Loch Raven Reservoir	City of Baltimore	Not applicable[3]

1 – Lake Redman feeds directly into Lake Williams without any intervening stream.
2 – Liberty Reservoir discharges significant quantities of water, well above a conservation release, on a continual basis to supply the Ashburtion filtration plant, the western zone of the City of Baltimore's service area, and needs in Carroll County.
3 – Loch Raven Reservoir discharges significant quantities of water, well above a conservation release, on a continual basis to supply the Montebello treatment plant, the eastern zone of the City of Baltimore's service area, and needs in Harford County.

Operating Rules: General rules for major water supply reservoirs are described below. Detailed rule documentation is available in the project file at the Commission.

Chester Water Authority: The rules supplied by Chester Water Authority for pumping from the Susquehanna River and Octoraro Reservoir are based on levels in the Octoraro Reservoir and the seasonal and annual balance between pumping sources.

City of Baltimore: Operating rules for the City's reservoirs are based on seasonal levels at the Prettyboy and Loch Raven reservoirs. Those levels also determine the extent of pumping from the Susquehanna River.

York Water Company: The timing and duration of pumping from the Susquehanna River are determined by the level of storage in Lake Redman.

B. Flood Control Reservoirs

USACE reservoirs are subject to many complex rules, particularly during flood events. The most important rules for this modeling effort are those that pertain to low flow events, specifically with respect to conservation releases. See Table 3.2. It is not uncommon for published operating rules to provide for conservation releases that exceed the amount of flow that would be present in the reach under unregulated conditions. For that reason, the conservation releases from USACE reservoirs have the potential to affect water availability in the Conowingo pond.

Table 3.2. USACE Reservoir Conservation Releases

Reservoir	Conservation Release, mgd (cfs)
Cowanesque	9.7 (15)
Tioga/Hammond	22.6 (35)
Whitney Point	6.5 (10)
East Sidney	6.5 (10)
Curwensville	32.3 (50)
Stevenson	23.3 (36)[1]
Bush	6.5 (10)
Sayers	80.8 (125)
Raystown	129 (200) mid-May through mid-November; 310 (480) remainder of year
York Indian Rock	Not applicable[2]

1 – Operations are managed by USACE, but the dam is actually owned by PADEP.
2 – York Indian Rock is a dry reservoir, except during heavy rains.

Operations of Commission Storage at Cowanesque and Curwensville: The baseline version of the model operates under the release protocols as defined in the agreement between USACE and the Commission, but alternate model runs were available for simulation, in which the criteria for timing and quantity of low flow releases were altered. Because it cannot be assumed that operating protocols will change, only the existing contracted operations were used in the final set of alternatives. The contract entails the release of Commission storage when the flow at the Wilkes Barre or Harrisburg gage drops below the Q7-10 value. Q-FERC levels at Marietta occur much more frequently than Q7-10 does, so it is possible that critical low flow problems are occurring in the Conowingo pond without any releases being made from Commission storage.

C. Hydroelectric Facilities

Operations at the major hydroelectric facilities on the lower Susquehanna River were modeled in accordance with the requirements contained in the separate FERC operating licenses, specifically with respect to meeting minimum release requirements and pond elevation requirements. See Table 3.3.

Table 3.3. FERC Operating Requirements

Facility	Owner	Pond Elevation Limits (NGVD)	Minimum Release, mgd (cfs)
Safe Harbor	PPL, BGE	224.2 – 227.2	Not applicable[2]
Holtwood	PPL	163.5 – 171; minimum of 167.5 for recreation	Not applicable[2]
Muddy Run	Exelon	480-520	Not applicable[2]
Conowingo	Exelon	101.5 – 108.5[(1)]; minimum of 106.5 for recreation	Minimum of flow at Marietta gage or seasonal thresholds (see Section III.B. of the main report)

1 – Elevations are in reference to the Conowingo datum.
2 – These facilities do not have minimum release requirements in their FERC licenses, and at times will release no water to downstream reaches.

Operating Capacities and Protocols:

Safe Harbor and Holtwood: These facilities were modeled as run-of-river operations, although they are subject to peaking operations, particularly during low flows. However, the quantity of inflow to the facilities is generally the same quantity of water discharged over a 24-hour period, so the peaking cycle occurs within the timestep of the daily model. These two dams are, therefore, modeled to remain at full pond levels and, thus, discharge only the excess inflow water after evaporation and demand needs are satisfied.

Muddy Run: When sufficient water is available in Conowingo pond, Muddy Run Pumped Storage Facility is operated in accordance with the schedule shown in Table 3.4. When lesser quantities of water are available in Conowingo pond for pumping up to Muddy Run, the operations require that all available water be pumped. All water is also discharged in accordance with the schedule, even if circumstances are such that insufficient water is likely to be available for refilling Muddy Run on subsequent days.

Conowingo: Top priority at Conowingo is given to satisfying withdrawals for public water supply and power plant cooling needs, followed by meeting minimum release requirements. Maintenance of recreation levels and making water available for Muddy Run operations are given lesser priority, in that order.

Table 3.4. Muddy Run Pumped Storage Facility Operating Schedule

Day of Week	Pumping Rate and Duration	Discharge Rate and Duration
Sunday	24,800 cfs for 8.33 hours overnight	No discharge
Monday	24,800 cfs for 10.2 hours overnight	32,000 cfs for 9 hours during the day
Tuesday	24,800 cfs for 10.2 hours overnight	32,000 cfs for 9 hours during the day
Wednesday	24,800 cfs for 10.2 hours overnight	32,000 cfs for 9 hours during the day
Thursday	24,800 cfs for 10.2 hours overnight	32,000 cfs for 9 hours during the day
Friday	No pumping	32,000 cfs for 9 hours during the day
Saturday	24,800 cfs for 9 hours overnight	No discharge

Section 4. Model Calibration and Verification

It was not the intent of the programmers to develop a hydrologic record that matches the published record precisely on a daily basis. By virtue of the methodology used to develop the hydrologic time-series, the generated record and the published record will match each other on a monthly-average basis, within a few percent. The resulting hydrologic time-series, while not exactly reproducing the measured data, give a very reasonable representation of a range of flow conditions that could be expected to occur in the Susquehanna River Basin.

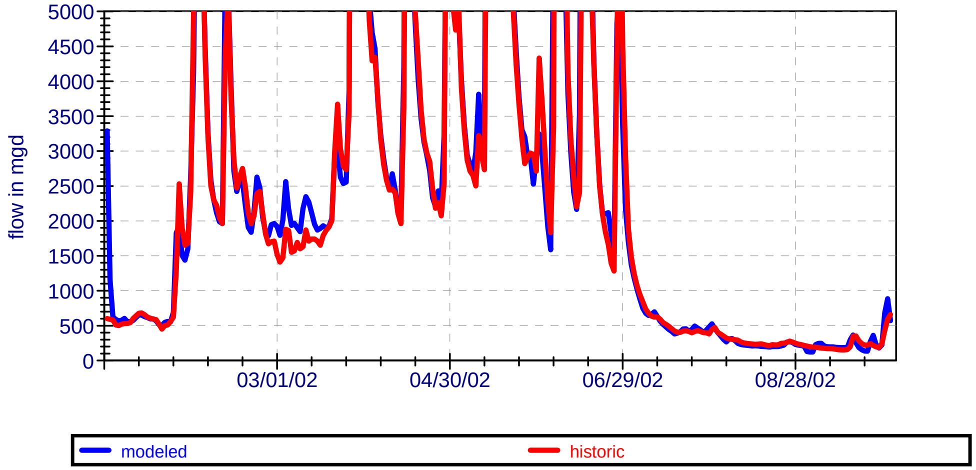
Because the timing of the model development coincided with the drought of 2002, hydrologic conditions during the drought were used to verify that the model was producing reasonable results. Operational rules and parameters in place during the summer of 2002 were simulated in the model and run with the hydrology generated for the year. Model results were compared to observed conditions in various areas of interest, grouped into the categories Hydrology and Operations. The comparative plots used for the verification by the Workgroup are displayed below.

A. Hydrology

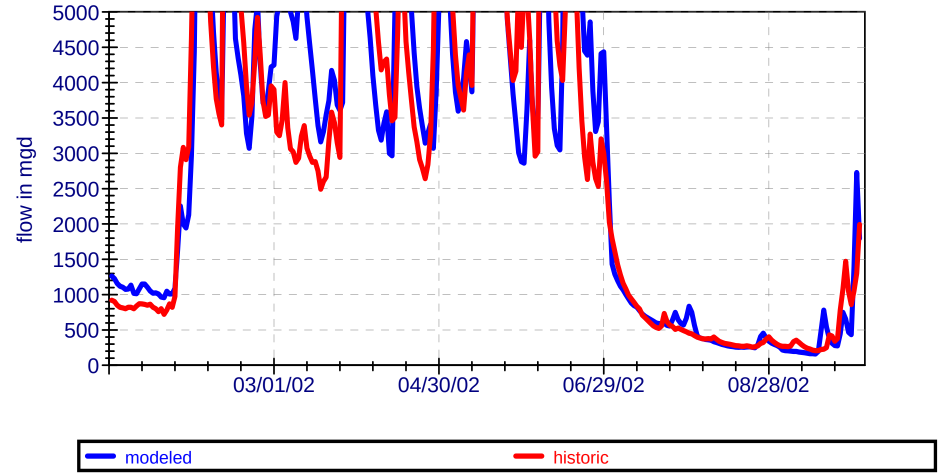
Plots of historic and modeled river flow were prepared for 10 locations throughout the basin and are presented below. Each of the six major subbasins was represented by at least one location: Chemung River at Chemung, Susquehanna River at Conklin, Susquehanna River at Wilkes Barre, Susquehanna River at Danville, West Branch Susquehanna River at Williamsport, Susquehanna River at Sunbury, Juniata River at Newport, Susquehanna River at Harrisburg, Susquehanna River at Marietta, and Susquehanna River below Conowingo Dam (representing releases from the dam).

Plots of time series of flow at the 10 locations are shown below. Because the 2002 drought had recently occurred and was familiar to Workgroup members, it was used to display the comparison between historic and modeled flows. At each of the 10 locations, the modeled flows matched the historic flows very well. An analysis of flow replication over the period of record in the model showed that the flow at every model node matched records within a few percentage points on a monthly average basis, well within the accuracy of the streamflow gage measurements.

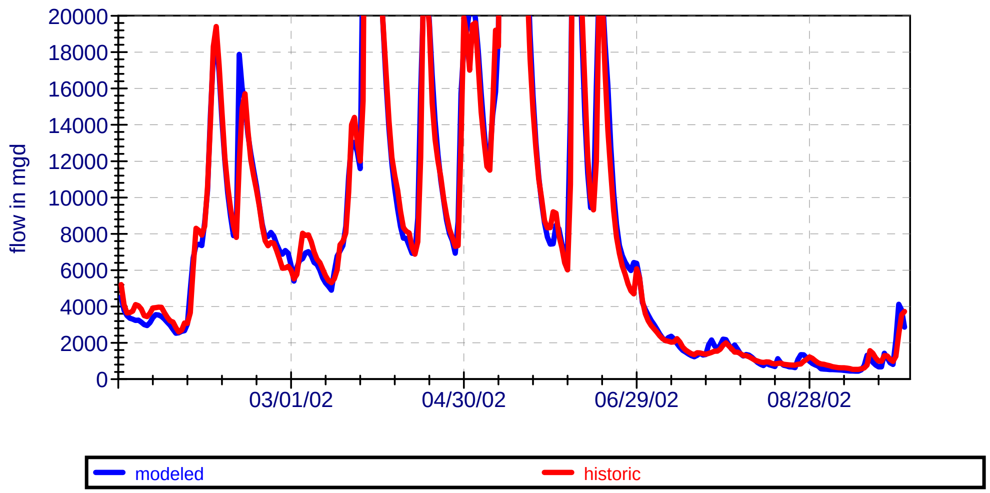
Chemung Flow



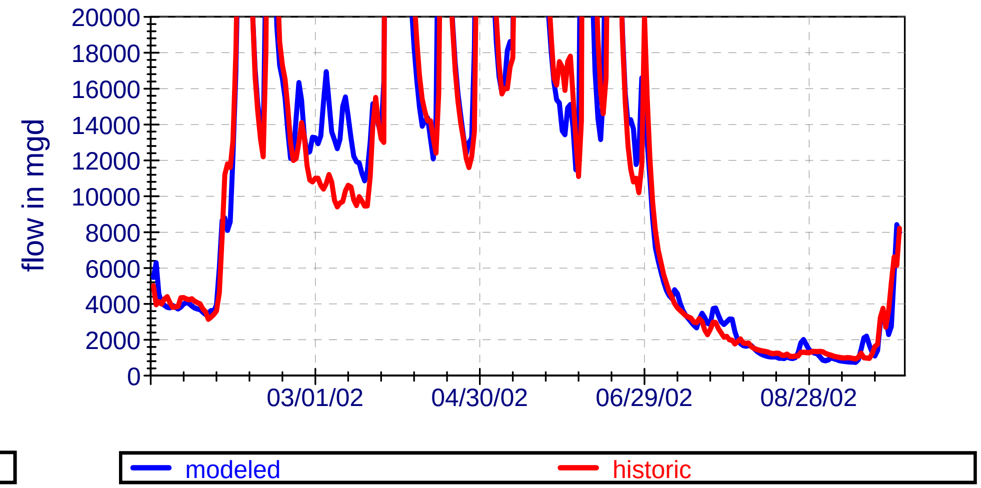
Conklin Flow

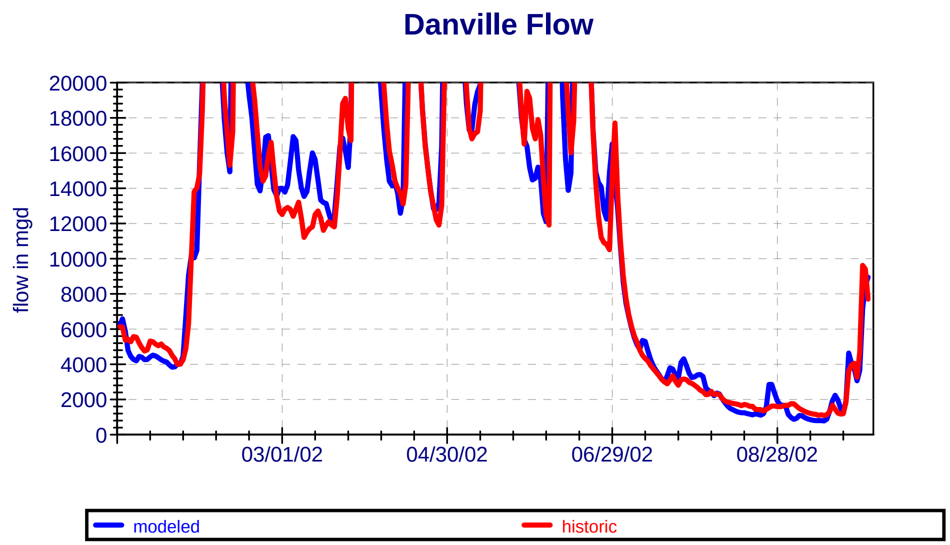


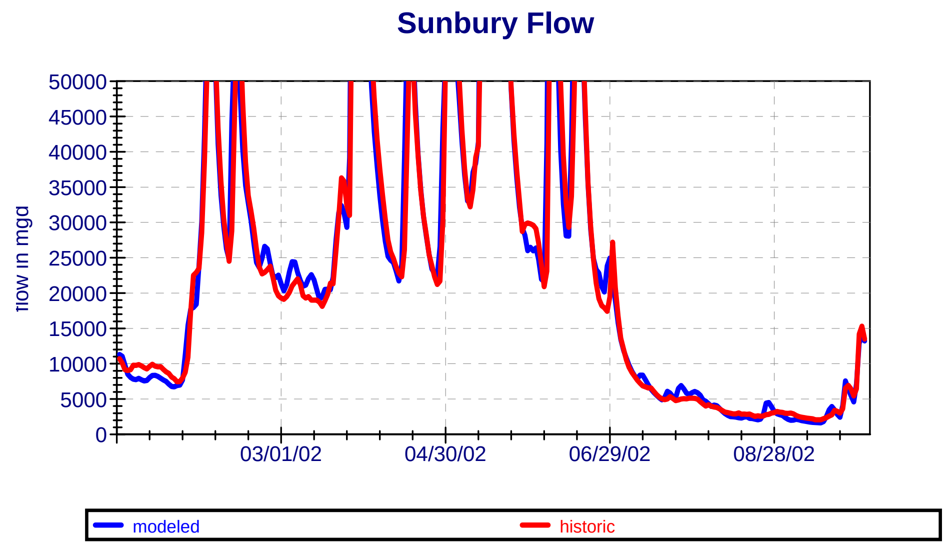
Williamsport Flow

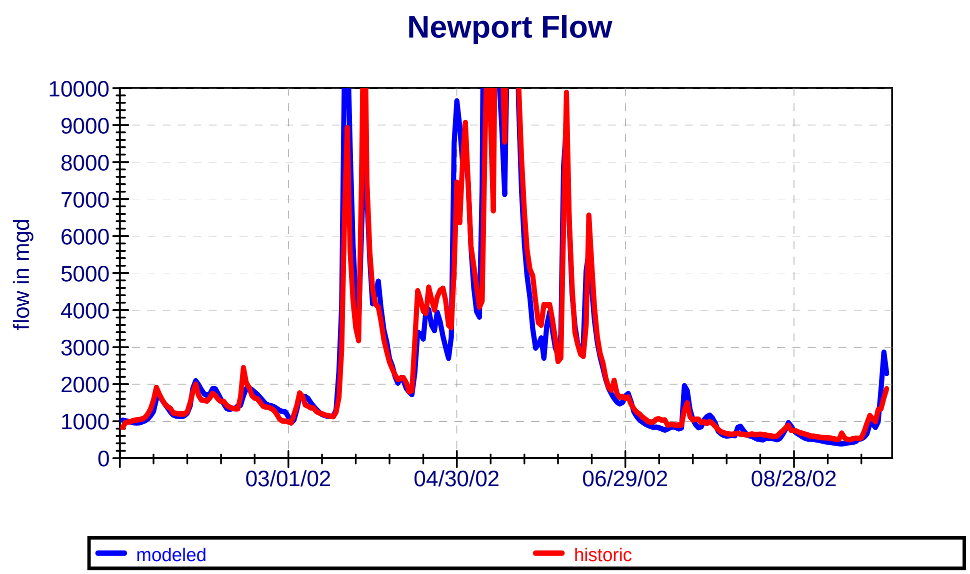


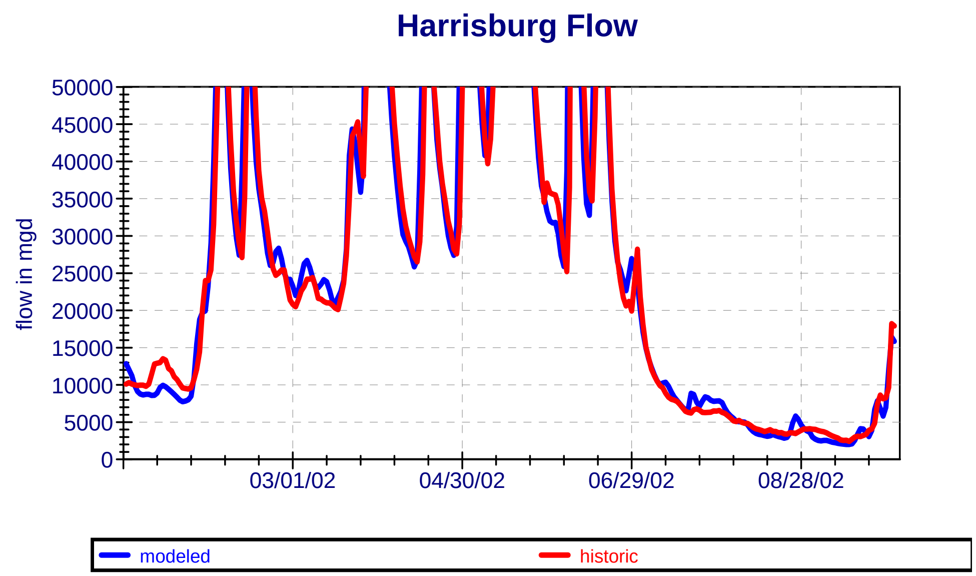
Wilkes Barre Flow

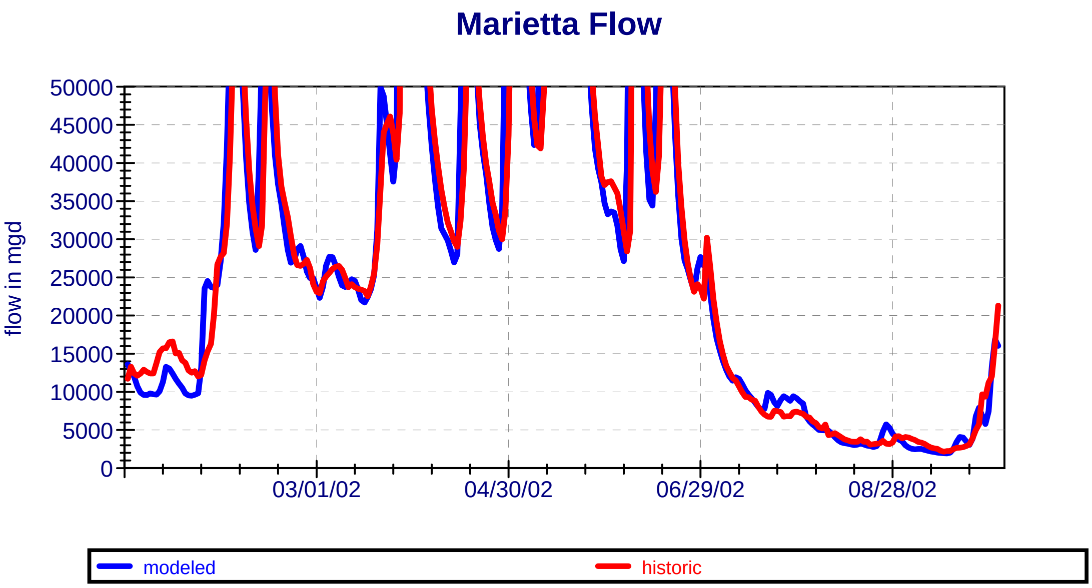


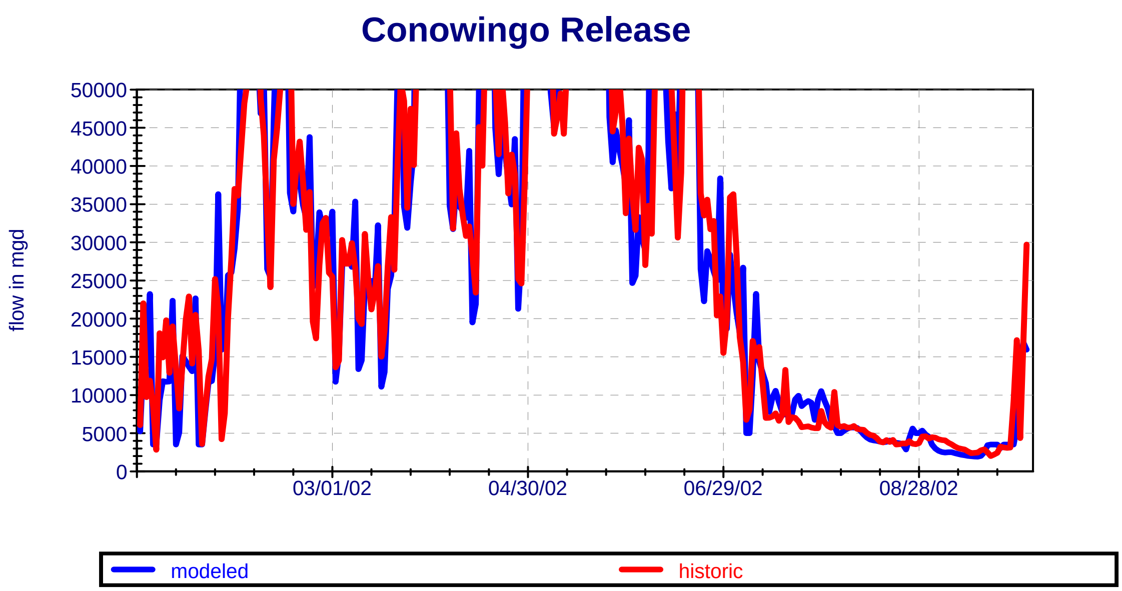

Danville Flow
flow in mgd
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historic


Sunbury Flow
flow in mgd
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historic


Newport Flow
flow in mgd
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historic

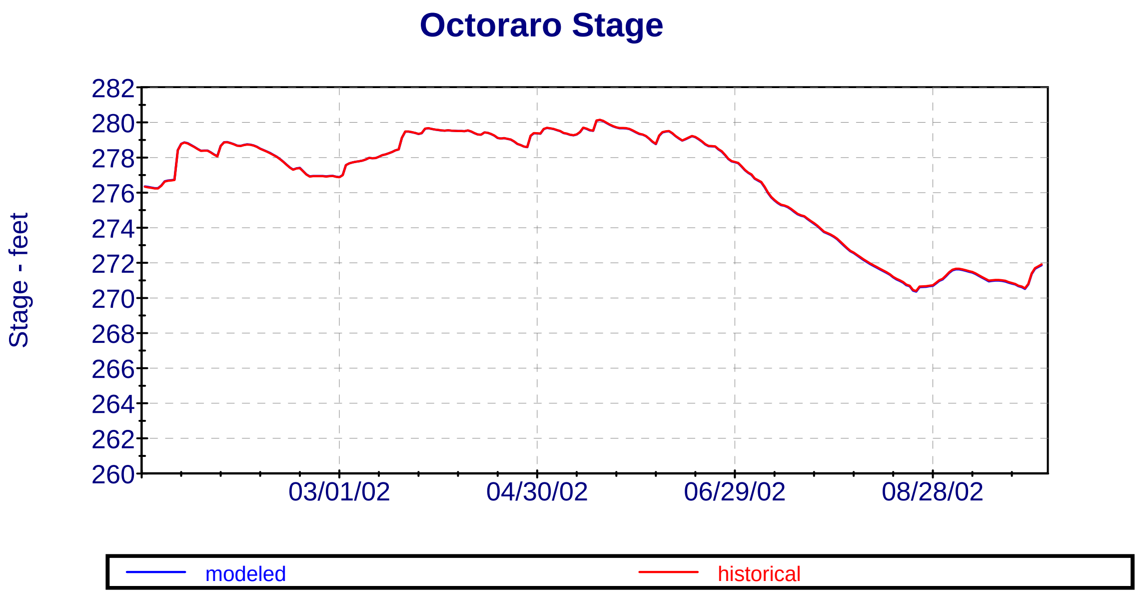

Harrisburg Flow
flow in mgd
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historic

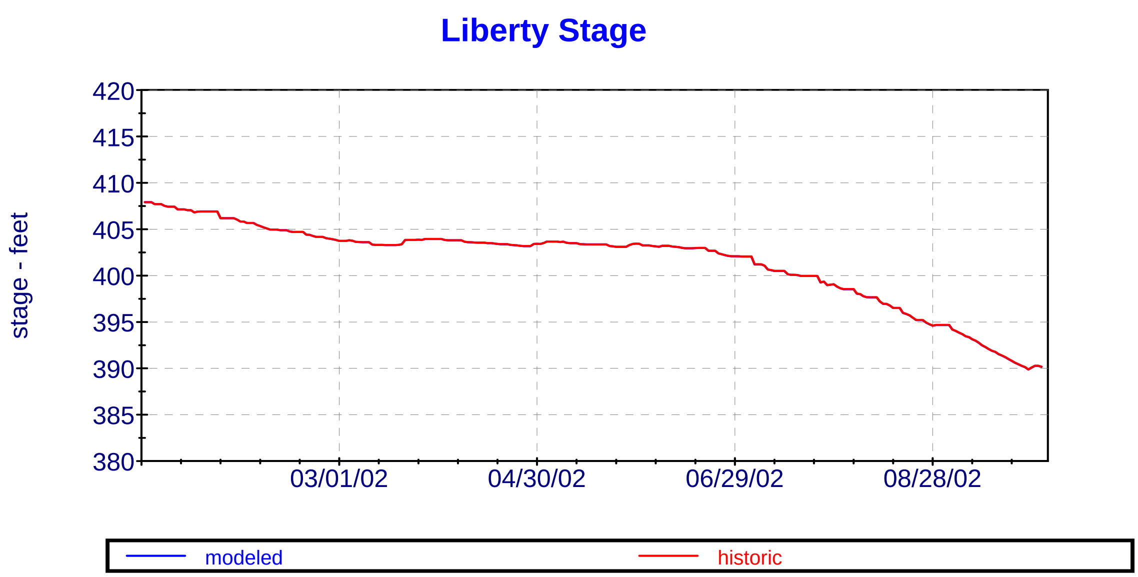


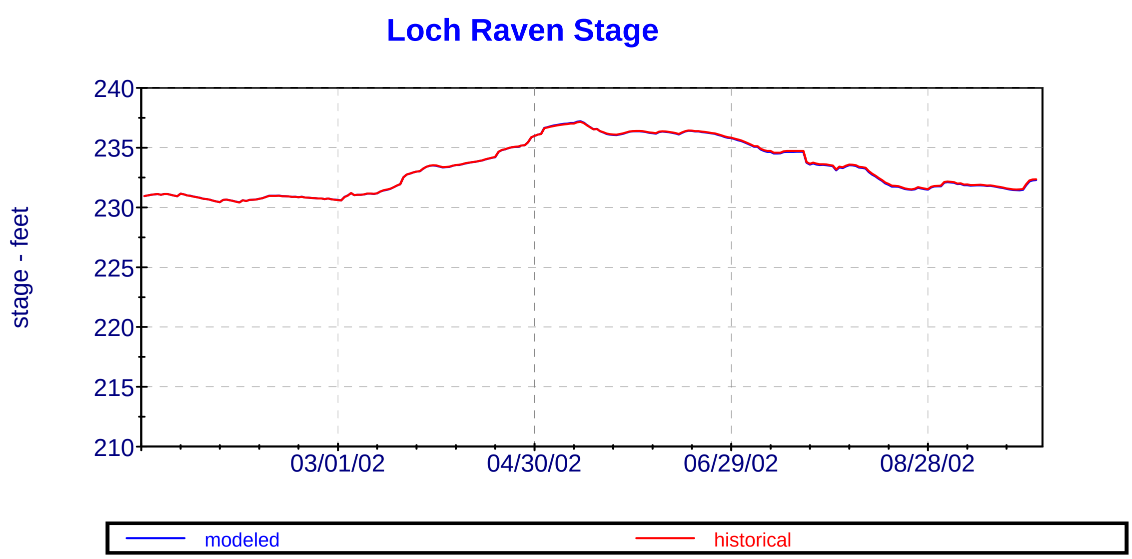


B. Reservoir Operations

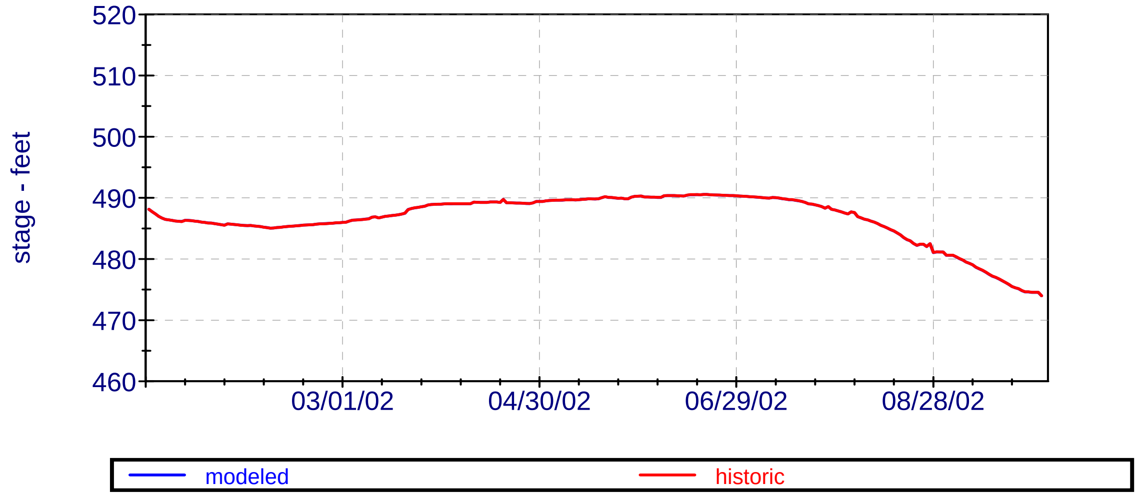
Plots of modeled and observed stages at water supply reservoirs (Chester Water Authority's Octoraro Reservoir and City of Baltimore's Liberty, Loch Raven and Prettyboy Reservoirs) and the Conowingo pond were prepared and are shown below. The results are similar enough that the trace of the modeled results cannot be seen underneath the observed historical results. The similarity between the modeled stages and the observed stages served to confirm that the physical and operational parameters of the reservoirs were modeled accurately, including flow characteristics such as inflow and releases, as well as the relation between volume and elevation.


Octoraro Stage
Stage - feet
282
280
278
276
274
272
270
268
266
264
262
260
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historical

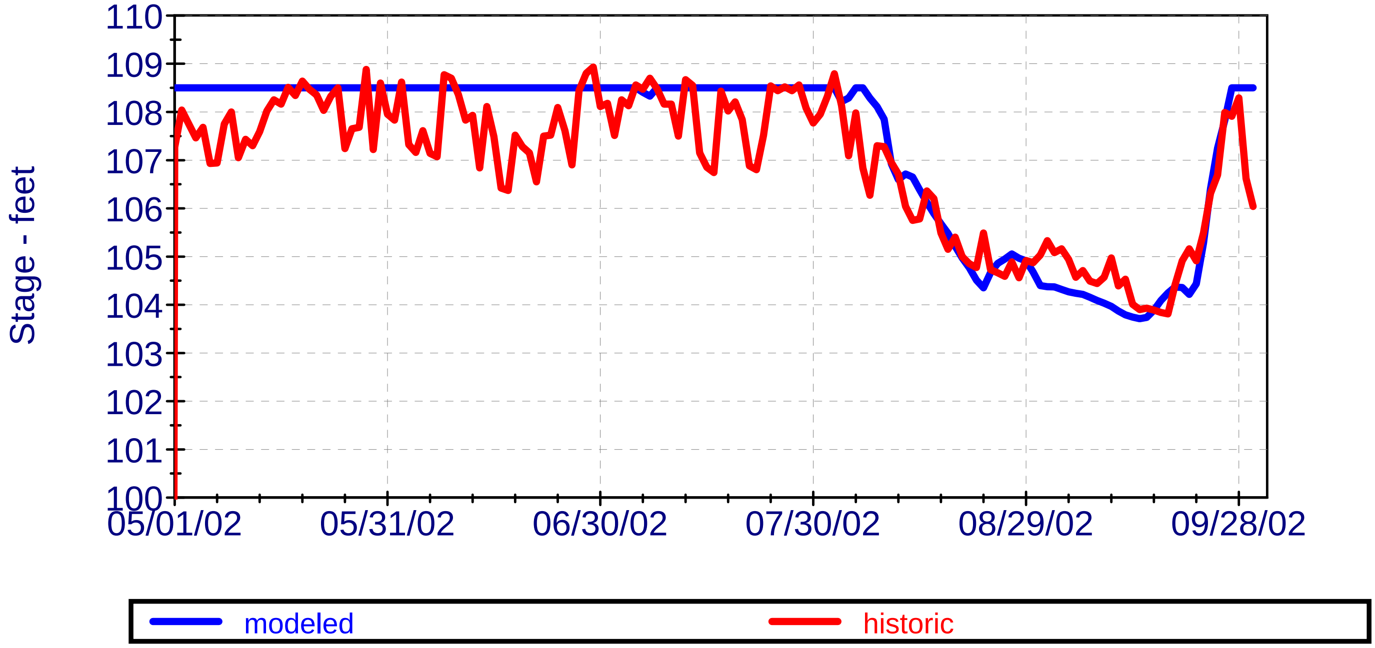

Liberty Stage
stage - feet
420
415
410
405
400
395
390
385
380
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historic


Loch Raven Stage
stage - feet
240
235
230
225
220
215
210
03/01/02
04/30/02
06/29/02
08/28/02
modeled
historical

Prettyboy Stage



Conowingo Stage



APPENDIX 3

Model Results and Evaluation of Alternatives

Appendix 3

Model Results and Evaluation of Alternatives

There were several activities comprising the detailed review of model runs and results, and the eventual selection of preferred and final alternatives. This appendix describes the process and displays sample output and results, but does not include an exhaustive summary of all model runs and detailed results that were viewed by the Workgroup. The full inventory of output is available in the data files of the Commission.

The process for evaluating alternatives that was undertaken by the Workgroup consisted of several steps:

- <u>Development of Performance Measures</u> – The selection of output parameters used to evaluate the success or failure of a particular alternative.
- <u>Identification of Preliminary Operational Alternatives</u> – The compilation by the Workgroup of the initial set of alternatives to be evaluated.
- <u>Computer-Aided Negotiations (CAN)</u> – Interactive Workgroup sessions involving the critique of operational alternatives.
- <u>Evaluation of Results</u> – The review of results for selected operational alternatives, displayed in the form of performance measures.
- <u>Selection of Preferred Operational Alternatives</u> – The selection of a smaller set of promising alternatives for closer analysis.
- <u>Refinement of Alternatives and Final Evaluation</u> – The fine-tuning of alternatives based on review of preliminary results.
- <u>Selection of Recommended Alternative</u> – The final selection of the preferred alternative and the use of position analysis.

These steps are described in further detail in the remainder of this appendix.

A. Development of Performance Measures

Performance measures are simply displays based on the results of an evaluation of an alternative. Each performance measure shows how well the alternative does with regard to one or more management objectives, such as maintaining minimum pond releases or providing adequate cooling water. Each performance measure is designed to allow one or more stakeholder to determine whether one alternative is better than another with respect to the objective that is important to them. There are numerous objectives for management of the Conowingo pond, so many performance measures were developed.

Initially, 26 performance measures were proposed by Workgroup members for consideration. They are listed below.

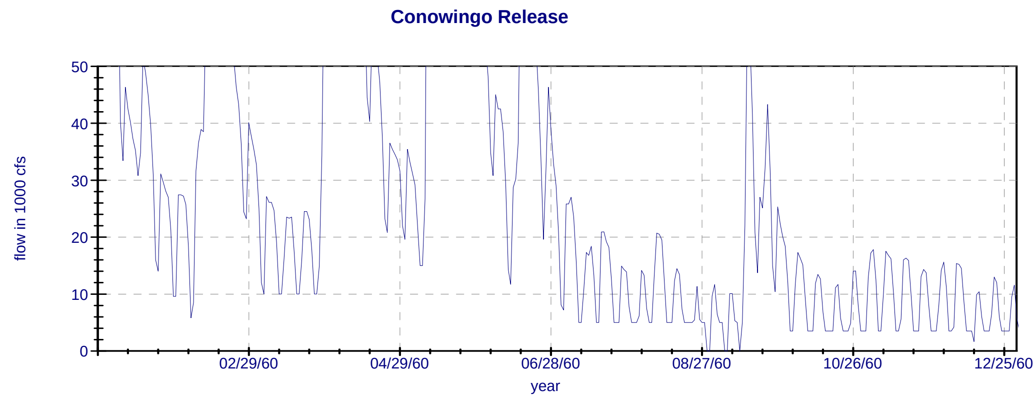
- Days of reduced withdrawals – based on rules.
- Years of inadequate fish flows.
- Days of potential turbidity problems.

- Sodium levels at intakes downstream of dam.
- Occurrence of discharge restrictions from dam (because Marietta flow <Q-FERC).
- Total flow from the dam (including leakage).
- Days total flow from dam is less than seasonal criteria.
- Minimum Baltimore system storage.
- Average turbidity at Deer Creek pumping station (City of Baltimore intake).
- Daily Baltimore pumpage.
- Minimum York Water Co. system storage.
- Minimum Octoraro Reservoir storage.
- Nutrient levels at Chester Water Authority intake/reservoir.
- Minimum Lancaster supply.
- Days Baltimore pumpage <250 mgd.
- Days Commission releases from upstream storage.
- Difference between Commission releases and Q-FERC restrictions.
- Energy – days under 5,000 cfs at Conowingo.
- Energy – pumped storage water available per week.
- Days pool level below 104.5 feet at Conowingo.
- Days of reduced pumped storage operations.
- Recreation pool requirement violations (especially on weekends).
- Fish spawning.
- Upstream lake levels (not Raystown – perhaps in lakes with Commission storage).
- Days of upstream restrictions.
- Number of trigger flow days over period of record.

All performance measures fall into one of the following five categories. To illustrate the potential use of the performance measures, mock displays are presented for each category.

1. **Basic Time Series Output Measures –** Basic time series outputs for flows, water deliveries, and reservoir levels were made available in the form of both plots and tables. Displays showed these time series individually or side-by-side for comparison of values from a single model run or across runs for different alternatives.

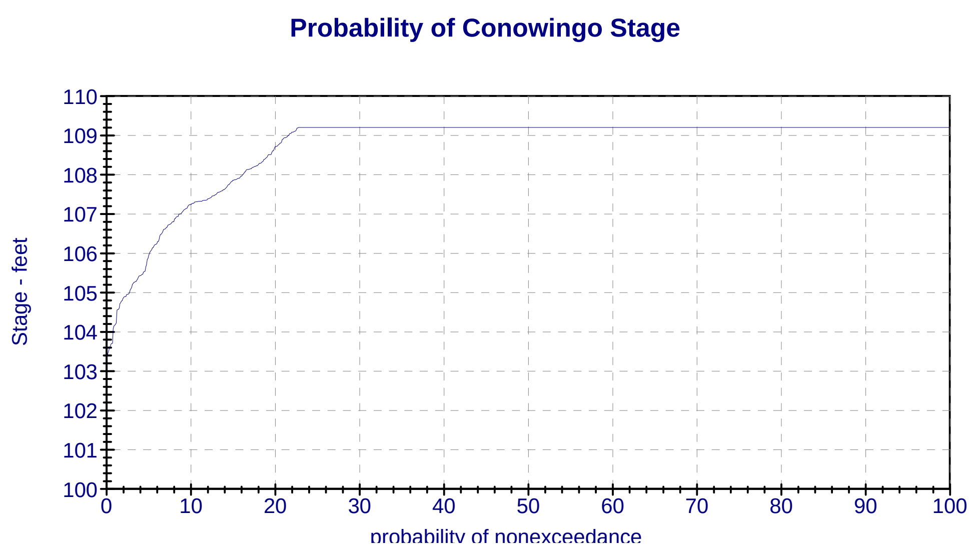
   The mock-up example below shows a time series trace of the flow released from the Conowingo dam. The plot is useful because it demonstrates the range of releases that might be expected over the course of a year and, in particular, shows the potential for extreme conditions during the drier summer months.



2. **Conowingo Pond Level-Based Performance Measures**

a. Probability of Pond Level: Plotting the probability that the pond falls below a given level allowed stakeholders to ascertain rapidly how often various facilities could be impacted by low pond levels.

In the mock-up below, stakeholders can determine that the pond level is at a level below the maximum approximately 23 percent of the time. Further, if the level 106 is critical, stakeholders can learn that the pond falls below that level about 5 percent of the time.



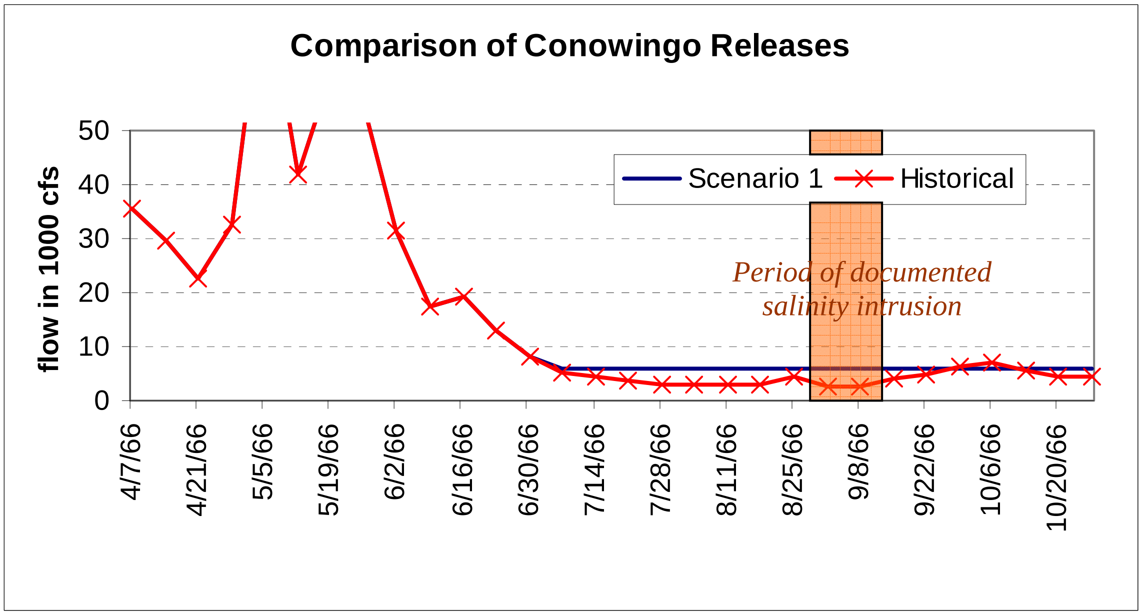
b. Number of Days and Events Below Threshold Levels and Number of Years with Events: This was a tabular output for comparing alternatives. There was one row per alternative and several groups of three columns (days, events, and years with events) for each threshold of interest. Displayed below is a mock-up sample set of output data for the number of days when water demand falls below a given threshold. For example, the table shows that scenario No. 2 results in 45 days below the threshold of 12 mgd, while there are 50 days below with scenario No. 1. However, when the threshold is increased to 15 mgd, both scenarios result in the same number of days below (80 days).

Scenario	Demand Threshold (mgd)	Days Below Threshold	Demand Threshold (mgd)	Days Below Threshold	Demand Threshold (mgd)	Days Below Threshold
1	10	40	12	50	15	80
2	10	30	12	45	15	80

3. **Displays Related to Conditions Below Conowingo Pond** – In addition to time traces of releases from Conowingo pond, there was interest in salinity intrusion in the reach below the dam. There is also substantial interest in maintaining adequate flow for fish habitat and to support fish migration.

   Flows During Periods of High Salinity in the Upper Chesapeake Bay: It was outside the scope of this study to develop flow/salinity relationships for this reach of the river. As a surrogate, modeled flows for historical periods of high salinity were graphed alongside historical flows for the same period. The graphs were annotated with available information as to historical salinity in the reach if such information was available.

   In the sample display below, a historical flow trace during a period of documented salinity intrusion is plotted alongside the results from a model scenario (scenario No. 1). Although the display gives no specific information about salinity levels, the selected scenario results in flows sustained at a higher level than those documented during the period of salinity intrusion. Consequently, stakeholders may deduce that salinity conditions may be more favorable under scenario No. 1 than under historic conditions.



4. **Water Supply Related Performance Measures** – In the lower Susquehanna basin, water use restrictions are based on two flow indices: the Q7-10 and the FERC minimum flow at Marietta. The frequency of these flows may be influenced by releases from upstream reservoirs and/or the growth of water demands upstream. In addition, stakeholders may need to impose water use restrictions based on levels in local storage reservoirs.

   Number of Days Under Water Use Restrictions, Number of Water Use Restriction Events, Number of Years with Water Use Restrictions, and Total Water Not Delivered: Displays of this type were tabular outputs for comparing alternatives. There was one row per alternative and several groups of three columns (days, events, and years with events). Examples of parameters displayed include Conowingo releases below the FERC seasonal values, and water withdrawal restrictions for the City of Baltimore.

   The table below demonstrates a general sample of the type of display for this category.

Scenario	Number of Days in Water Restriction	Number of Years with Water Restrictions	Volume of Water Not Delivered (million gallons)
1	10	1	25
2	16	3	30
3	5	5	5
4	25	3	140
5	30	6	130
6	18	2	65

5. **Hydropower Related Performance Measures** – Hydropower generation on the lower Susquehanna River is a peaking operation, and water can be held in both the Conowingo and Muddy Run ponds overnight and over weekends. Low flow requirements can force releases from Conowingo dam which do not optimize power generation because less water is available for power generation at Muddy Run.

   Reduction of Water Available for Pumping to Muddy Run: This was a tabular output for comparing alternatives. It consisted of one row for each scenario, and two columns – one identifying the scenario and the other displaying the volume of water unavailable for hydropower generation at Muddy Run.

Scenario	Reduction in Water Available for Pumping to Muddy Run Pond (acre-feet)
1	1,000
2	1,240
3	320
4	320
5	800
6	900

   In a year with ample flow, operators would have enough water in Conowingo pond to start each generation cycle with a full pond at Muddy Run. However, in years with low flow conditions, some cycles will begin with less storage available. The accumulated storage deficit over the year or period of record is an indication of how well a scenario performs with respect to optimizing hydro generation. In the sample table above, the conditions of scenario Nos. 3 and 4 provide the most water for generation at Muddy Run, with a reduction of only 320 acre-feet over the period, while the conditions of scenario No. 2 result in the most amount of water reduction, 1,240 acre-feet.

   After further consideration, the Workgroup identified a smaller set of performance measures to be used for evaluation of alternatives. These measurements are listed below.

   - Conowingo releases less than FERC seasonal flows.
   - Conowingo stages lower than recreation levels.
   - Conowingo releases less than surrogate flows for salinity intrusion.
   - Probability of Conowingo stage levels.
   - Time series of Conowingo stage.
   - Time series of Conowingo release.
   - Average and minimum Conowingo releases during drought periods.
   - Water available for pumped storage power generation.

B. Identification of Preliminary Operational Alternatives

The Workgroup initially identified 32 alternative operational plans for consideration at the Conowingo pond. Initially, all alternatives were given equal consideration. Key variable parameters were established to distinguish differences in the alternatives. The parameters used and alternative plans are discussed below. A summary table displaying the 32 alternatives and parameters follows the discussion.

1. **Parameters Used**:

   a. Q-FERC Requirements Met: Does the alternative meet (Yes) or not meet (No) the minimum downstream flow releases required by the 1988 settlement agreement (see Section IV-B)?

   b. Credit for Leakage Allowed: Is a credit for gate leakage at Conowingo dam allowed toward meeting the minimum flow requirements notwithstanding the prohibition against this in the settlement agreement?

   c. Baltimore Withdrawal, Maximum/Low Flow: Defines the maximum water supply withdrawal allowed under normal and low flows into the Conowingo pond, respectively. Currently, Baltimore has an approved maximum withdrawal of 250 mgd, a maximum output of 137 mgd, and a reduced 30-day withdrawal rate of 64 mgd during low flow periods.

   d. Chester Water Authority Withdrawal: Defines the maximum water supply withdrawal allowed from the Conowingo pond by Chester Water Authority. Currently, Chester Water Authority has an approved maximum withdrawal of 30 mgd.

   e. Consumptive Use in the Basin: The amount of consumptive water use in the Susquehanna River Basin, upstream of the Conowingo pond, based on estimates of daily averages for peak monthly use in 2000 and a similar projection for 2025, and an assumed increase of 30 percent in the 2025 daily averages as an estimate for the maximum peak daily use. These consumptive uses are 456, 640, and 830 mgd, respectively.

   f. Commission Reservoir Storage Trigger: The Commission-owned water supply storage at Cowanesque and Curwensville Lakes in the upper basin is used to augment low flows when trigger levels are reached at one of several key stream gages. Under current rules, the trigger level is Q7-10, which is defined as the consecutive 7-day low flow values having a frequency of occurrence of 10 percent in a given year (commonly referred to as once in 10 years). An alternative trigger value considered for the purpose of this analysis is Q-FERC. This is defined as the comparable flow at key upstream gages that correspond to the minimum flow release requirements at the Conowingo pond as established in the 1988 settlement agreement (see Section IV-B).

2. **Alternative Operational Plans**:

   a. **"_SimBase" Options** (five options): Represents baseline conditions with existing operations in place and four other modified baseline options as defined by varying parameters for leakage credit, Baltimore's maximum water withdrawal, and consumptive water use in the basin. If a credit for leakage was included, its implementation was triggered on the condition of the pond declining below the critical elevation of 104.5 feet, at which continued operation of Muddy Run is threatened. At that time, a credit of 800 cfs for gate leakage was allowed.

   b. **"AutoWaiver" Options** (seven options): Includes an automatic credit allowance for gate leakage toward the required minimum flow releases. The time period for the credit is either year-round, from July–March or June 16–March 31. Other parameters are changed for several alternatives, including Baltimore's and Chester's maximum water withdrawals, consumptive water use in the basin, and the low flow trigger for releasing water from Commission-owned storage in two upstream federal reservoirs.

   c. **"Stepped_Waiver" Options** (two options): Includes an automatic flow credit for gate leakage, but the credit is allowed in increments of 250, 500, and 750 cfs, as needed, to maintain a stable Conowingo pond level. A second option increases Baltimore's maximum water withdrawal.

   d. **"Level_Storage" Options** (five options): This set of alternatives includes a minimum operability level in the pond of 104.5 feet to maintain both Muddy Run storage transfers into/from the Conowingo pond and reliable Peach Bottom operations. Minimum flow releases from Conowingo dam, Baltimore's maximum water withdrawal, and consumptive water use in the basin were varied to distinguish options.

   e. **Other Alternatives**: Thirteen other initial alternatives were considered by varying the parameters in different combinations.

Conowingo Pond Management Plan
Alternative Operational Plans Considered

Plan Number	Alternative Plan	Q-FERC Requirements Met	Credit for Leakage Allowed	Baltimore Withdrawal Max/Low Flow (mgd)	Chester Withdrawal (mgd)	Consumptive Use in Basin			Commission Reservoir Storage Trigger	
						2000	2025	Max. Peak	Q7-10	Q-FERC
	A. "_SimBase" Options									
1.	A1. **_SimBase** = baseline conditions	Yes	No[1] (unless waived)	137/64	30	X			X	
2.	A2. **_SimBase** with no emergency waiver for leakage credit	Yes	No	137/64	30	X			X	
3.	A3. **Future_Baseline** = **_SimBase** with 2025 CU levels	Yes	No[1] (unless waived)	137/64	30		X		X	
4.	A4. **_SimBase_Plus** = Auto **Waiver** plus Baltimore low flow withdrawal to 100 mgd	Yes	Yes	137/100	30	X			X	
5.	A5. **Future_Plus** = **_SimBase_Plus** with 2025 CU	Yes	Yes	137/100	30		X		X	
	B. "AutoWaiver" Options									
6.	B1. **AutoWaiver** = year-round leakage credit	Yes	Yes	137/64	30	X			X	

Plan Number	Alternative Plan	Q-FERC Requirements Met	Credit for Leakage Allowed	Baltimore Withdrawal Max/Low Flow (mgd)	Chester Withdrawal (mgd)	Consumptive Use in Basin			Commission Reservoir Storage Trigger	
						2000	2025	Max. Peak	Q7-10	Q-FERC
7.	B2. **Future_Max** = **AutoWaiver** plus Baltimore and Chester max withdrawals of 250 and 40 mgd	Yes	Yes	250/100	40		X		X	
8.	B3. **AutoWaiver** with Commission reservoir storage trigger of Q-FERC	Yes	Yes	137/64	30	X				X
	B4. **AutoWaiver** with no leakage credit from April 1 to June 30:									
9.	a. With Commission reservoir storage trigger at Q7-10	Yes	Yes (July-March)	137/64	30	X			X	
10.	b. With Commission reservoir storage trigger at Q-FERC	Yes	Yes (July-March)	137/64	30	X				X
	B5. **AutoWaiver** with no leakage credit from April 1 to June 15:									
11.	a. With Commission reservoir storage trigger of Q7-10	Yes	Yes (June 16 to-March)	137/64	30	X			X	
12.	b. With Commission reservoir storage trigger of Q-FERC	Yes	Yes (June 16 to-March)	137/64	30	X				X

Plan Number	Alternative Plan	Q-FERC Requirements Met	Credit for Leakage Allowed	Baltimore Withdrawal Max/Low Flow (mgd)	Chester Withdrawal (mgd)	Consumptive Use in Basin			Commission Reservoir Storage Trigger	
						2000	2025	Max. Peak	Q7-10	Q-FERC
	C. “Stepped_Waiver” Options									
13.	C1. **Stepped_Waiver** = leakage a credit in steps of 250,500 and 750 cfs	Yes	Yes	137/64	30	X			X	
14.	C2. **Stepped_Waiver** plus Baltimore withdrawal of 100 mgd	Yes	Yes	137/100	30	X			X	
	D. “Level_Storage” Options									
15.	D1. **Level_Storage** = maintain storage so Muddy Run is full and Conowingo pond is at least 104.5 elev. Provide minimum release of 3,250 cfs.	No	Yes	137/64	30	X			X	
16.	D2. **Level_ Storage** with 2025 CU levels	No	Yes	137/64	30		X		X	
17.	D3. **Level Storage** plus Baltimore withdrawal of 100 mgd	No	No	137/100	30	X			X	
18.	D4. **Level_ Storage** with Q-FERC requirements and with leakage credit	Yes	Yes	137/64	30	X			X	
19.	D5. **Level_ Storage** with Q-FERC requirements and without leakage credit	Yes	No[1] (unless waived)	137/64	30	X			X	

Plan Number	Alternative Plan	Q-FERC Requirements Met	Credit for Leakage Allowed	Baltimore Withdrawal Max/Low Flow (mgd)	Chester Withdrawal (mgd)	Consumptive Use in Basin			Commission Reservoir Storage Trigger	
						2000	2025	Max. Peak	Q7-10	Q-FERC
	E. Other Options									
20.	E1. Max current withdrawals plus max CU	Yes	No[1] (unless waived)	250/64	30			X	X	
21.	E2. **E1** with Chester at 40 mgd and year 2000 CU	Yes	No[1] (unless waived)	250/64	40	X			X	
22.	E3. **E2** with max CU	Yes	No[1] (unless waived)	250/64	40			X	X	
23.	E4. **Balt-84** = **_SimBase** with 84 mgd lowflow withdrawal	Yes	No[1] (unless waived)	137/84	30	X			X	
24.	E5.**SRBC_FERC_Trig**	Yes	No[1] (unless waived)	137/64	30	X				X
25.	E6. Upstream reservoir storage offset CU below Marietta	Yes	No[1] (unless waived)	137/64	30	X				X
26.	E7. **E9** with Chester at 40 mgd	Yes	No[1] (unless waived)	137/64	40	X			X	
27.	E8. **Fictional_Lake** = use new reservoir for low flow augmentation	Yes	No[1] (unless waived)	137/64	30	X			X	
28.	E9. **FERC_Passthru**	Yes[2]	No[1] (unless waived)	137/64	30	X			X	

Plan Number	Alternative Plan	Q-FERC Requirements Met	Credit for Leakage Allowed	Baltimore Withdrawal Max/Low Flow (mgd)	Chester Withdrawal (mgd)	Consumptive Use in Basin			Commission Reservoir Storage Trigger	
						2000	2025	Max. Peak	Q7-10	Q-FERC
29.	E10. **Storage_Waiver** = leakage credit when Conowingo pond and Muddy Run storage is 10,000 ac-ft or more below normal	Yes	Yes	137/64	30	X			X	
30.	E11. **Salinity4500** = minimum release flows only when 30-day avg. release decreases to 4,500 cfs or less	No	Yes	137/64	30	X			X	
31.	E12. Compare release flow to downstream dissolved oxygen	Yes	No[1] (unless waived)	137/64	30	X			X	
32.	E13. Compare release flows to downstream temperature	Yes	No[1] (unless waived)	137/64	30	X			X	

[1] Temporary emergency waivers to allow leakage credit have been approved by FERC in 1995, 1999, 2001, and 2002 when the Conowingo pond was at, or near, elevation 104.5 feet. Alternatives were modeled assuming a waiver was in place for pond elevations of 104.5 feet or less.

[2] Minimum release from Conowingo is Q-FERC less the difference between inflow downstream of Marietta and leakage estimate when inflow is less than leakage.

3. **Results of Analysis of Alternatives –** These initial 32 alternatives were the starting point for evaluation of management options at the Conowingo pond. The Workgroup analyzed the alternatives by reviewing the key performance measures identified earlier to determine which options warranted further consideration. After careful consideration of the alternatives, it was determined that 14 of them had sufficient merit to be carried forward for further analysis. Conversely, 18 alternatives failed to produce positive results and were dropped from further consideration.

   The 14 remaining alternatives are shown in the table below, with details on the parameters defining each alternative included.

Alternative Operational Plans Evaluated During Computer-Aided Negotiations

Plan No.	Alternative Plan	Threshold for Leakage Credit	Upstream Consumptive Use Level	Commission Reservoir Storage Release Trigger	Baltimore Maximum Withdrawal	Chester Maximum Withdrawal	Other Pond Consumptive Use
1	**_SimBase**	Pond < 104.5'	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
3	**Future_Baseline**	Pond < 104.5'	Year 2025	Q7-10	137/64 mgd	30 mgd	Year 2025
4	**SimBase_Plus**	Always	Year 2000	Q7-10	137/100 mgd	30 mgd	Year 2000
5	**Future_Plus**	Always	Year 2025	Q7-10	137/100 mgd	30 mgd	Year 2025
6	**AutoWaiver**	Always	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
7	**FutureMax_AW**	Always	Year 2025	Q7-10	250/100 mgd	40 mgd	Year 2025
13	**Stepped_Waiver**	**(1)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
15	**Level_Storage**	Always **(2)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
23	**Balt-84mgd**	Pond < 104.5'	Year 2000	Q7-10	137/84 mgd	30 mgd	Year 2000
24	**SRBC_FERC_trig**	Pond < 104.5'	Year 2000	Q-FERC	137/64 mgd	30 mgd	Year 2000
27	**Fictional_Lake**	Pond < 104.5'	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
28	**FERC_Passthru**	Local inflow **(3)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
29	**Storage_Waiver**	**(4)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000
30	**Salinity4500**	Always **(5)**	Year 2000	Q7-10	137/64 mgd	30 mgd	Year 2000

(1) The credit for leakage increases from 250 cfs to 500 cfs to 750 cfs as conditions worsen in the pond.
(2) Total release must exceed 3,000 cfs.
(3) Conowingo dam must pass the lesser of the leakage estimate (800 cfs) or the incremental inflow between the Marietta gage and the Conowingo pond (estimated by drainage area relationships).
(4) The credit for leakage is dependent on storage deficit in Muddy Run and the Conowingo pond.
(5) Leakage is credited at all times, unless the 30-day average outflow decreases to 4,500 cfs or below.

C. Computer-Aided Negotiations

After the full set of possible operational alternatives was initially evaluated, the next step involved the use of computer-aided negotiations (CAN) on the remaining alternatives. Computer modeled results of operations and facility scenarios were prepared in advance and distributed at the beginning of the meetings. Stakeholders reviewed results of the alternatives and critiqued both the positive aspects and the problems presented by the alternatives. The Workgroup then identified alternatives to be dropped from consideration, modifications to alternatives, and new alternatives to mitigate any problems identified from the results.

Sample results of the evaluation of alternatives during the CAN sessions are shown in the following tables and plots.

Display of Conowingo Dam Releases Less Than FERC Seasonal Flows: A very important result of any credit to Conowingo for leakage is that the resulting total flows out of the dam have the potential to be lower than the flows established by FERC in the 1988 settlement agreement. While not necessarily an adverse result, it is nevertheless an important piece of information. The table below displays the frequency ("number of events") and duration (in terms of days) of releases less than the FERC values for the remaining 14 alternatives. It also shows the occurrence of such releases during the critical spawning season of April, May and June. The various alternatives did not show a great deal more events than the existing conditions ("Simbase"), but the results did demonstrate that it might be necessary to impose restrictions on the leakage credit during the spawning period.

	Conowingo Flows Less than FERC Flows, June - Nov.						April & May Events*	April - June Events*
	Years (out of 73) with Number of Days Specified					Max Number of Days		
	0 Days	1-15 Days	16-30 Days	31-60 Days	Over 60 Days			
_SimBase	36	17	5	10	5	104	0	0
Future_Baseline	34	13	10	11	5	111	0	0
SimBase_Plus	24	18	13	12	6	128	0	3
Future_Plus	21	21	11	14	6	132	0	3
AutoWaiver	24	19	12	13	5	123	0	3
FutureMax_AW	21	21	11	13	7	132	0	3
Stepped_Waiver	33	16	10	11	3	113	0	0
Level_Storage	24	18	11	13	7	129	0	3
Balt-84	36	17	5	10	5	104	0	0
SRBC_FERC_trig	37	16	7	10	3	104	0	0
Fictional_Lake	36	17	7	10	3	102	0	0
FERC_Passthru	32	15	10	11	5	108	0	1
Storage_Waiver	24	19	12	13	5	124	0	3
Salinity4500	0	11	19	39	4	89	17	39

* Number of years with one or more occurrence.

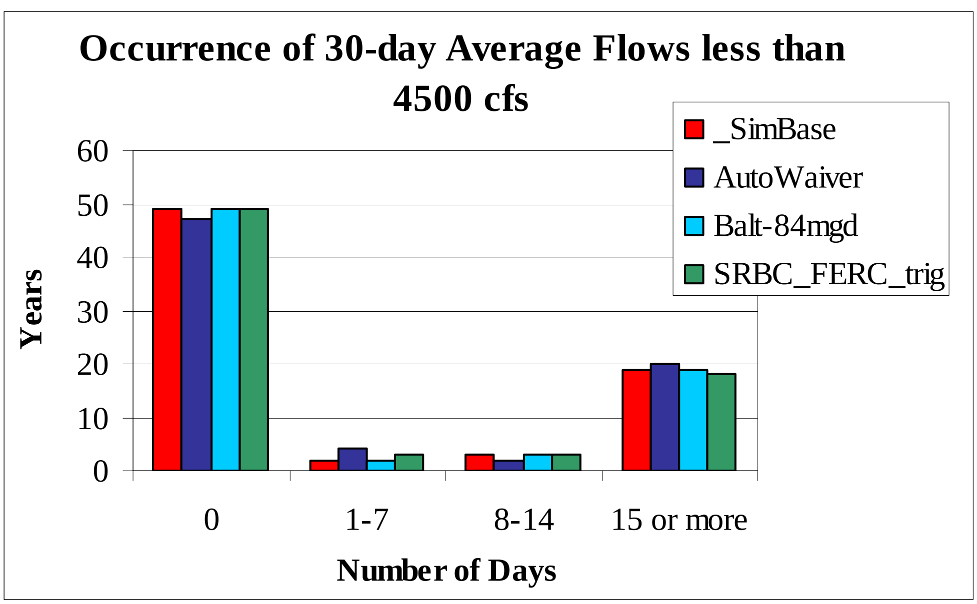
Display of Conowingo Pond Stages Lower Than Seasonal Recreation Levels: During extreme low flow conditions, various competing requirements for water may render Conowingo unable to maintain seasonal recreation levels. It may be that varied operating requirements or upstream conditions can alleviate the adverse impacts of low flows on recreation. The table below offers a comparison for the remaining 14 alternatives by displaying the frequency and duration of pond elevations below the seasonal recreation level. As might be expected, options that liberally apply a leakage credit to help conserve storage, such as "AutoWaiver," and options that add water to the system, such as "Fictional_lake," show a reduction in the frequency and duration of pond levels below recreation thresholds.

	Unmet Recreation Levels, May - September						
	Years (out of 73) with Number of Days Specified					Max Number of Days	Total No. of Days
	0 Days	1-7 Days	8-15 Days	16-30 Days	Over 30 Days		
_SimBase	24	26	12	10	1	37	439
Future_Baseline	22	25	13	12	1	38	526
SimBase_Plus	27	40	4	2	0	21	202
Future_Plus	23	40	4	6	0	28	296
AutoWaiver	40	29	4	0	0	10	120
FutureMax_AW	22	41	4	6	0	30	312
Stepped_Waiver	25	31	10	6	1	34	366
Level_Storage	3	29	29	12	0	23	667
Balt-84	24	26	12	10	1	37	439
SRBC_FERC_trig	32	25	9	7	0	25	292
Fictional_Lake	24	28	13	7	1	35	410
FERC_Passthru	24	35	7	6	1	33	333
Storage_Waiver	38	31	4	0	0	10	123
Salinity4500	61	3	5	4	0	22	126

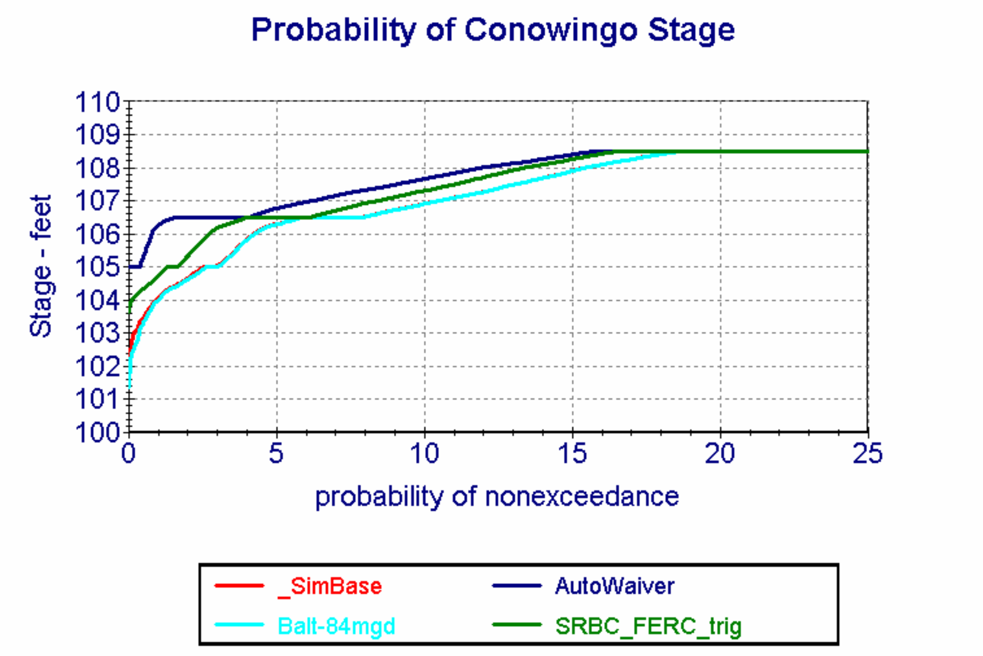
Display of Conowingo Dam Releases Less Than Surrogate Flows for Salinity Intrusion: While it was beyond the scope of this study to model salinity levels downstream of the Conowingo dam, the Workgroup did establish that a 30-day average flow rate from Conowingo of 4,500 cfs or less correlated well with the historic occurrences of salinity problems at the water intake at Havre de Grace. It was, therefore, useful to display the frequency and duration of events in which Conowingo releases meet that threshold, as shown in the table below. Although there is some variation in the occurrence of the salinity threshold among the different alternatives, the results suggest that natural conditions are more important than operating protocols in driving salinity presence. If the favorable combination of the tidal cycle, wind direction and strength, and flows out of Deer Creek all converge, salinity intrusion poses a threat regardless of slight fluctuations of releases from Conowingo dam.

	Salinity Indicator (30-day average flow < 4,500 cfs)		
	Number of Occurences (years)	Maximum Consecutive Days	Average Duration (days)
_SimBase	23	134	40
Future_Baseline	26	136	41
SimBase_Plus	26	134	36
Future_Plus	26	138	43
AutoWaiver	26	124	36
FutureMax_AW	26	138	43
Stepped_Waiver	23	131	40
Level_Storage	26	134	39
Balt-84	23	134	40
SRBC_FERC_trig	24	128	38
Fictional_Lake	22	132	39
FERC_Passthru	24	136	39
Storage_Waiver	26	124	36
Salinity4500	27	107	36

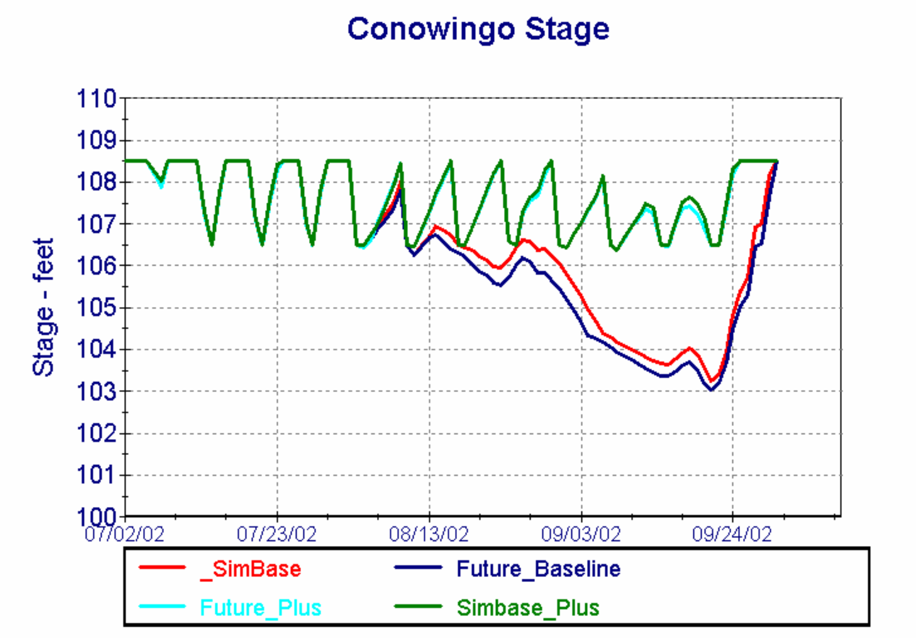
The bar chart below shows the same information in a different format, with more details about the duration of occurrences. As in the table above, there are not significant differences between the alternatives shown with regard to occurrence of the surrogate flows for salinity intrusion. The relatively infrequent occurrence of the surrogate for a period of 1 to 2 weeks, and the more frequent occurrence of duration over 15 days, also serves to demonstrate that the occurrence of salinity intrusion is the result of severe low flow conditions when several factors combine favorably. The phenomenon is not readily influenced by the day-to-day operations of the Conowingo facility.



Probability of Conowingo Stage Level: Because there are important considerations associated with various levels of the Conowingo pond (such as the recreation level of 106.5 feet and the concern for Peach Bottom's cooling intake below elevation 104.5 feet), it was useful to display the likelihood of Conowingo pond at various elevations. The probability plot shown below allowed the Workgroup to compare the frequency of occurrence of pond levels for the remaining scenarios. The most difference was realized at the extreme infrequent occurrences, where the credit provided by the AutoWaiver option allowed the pond to remain above recreation levels more often than the other alternatives, and also preserved the pond at a higher minimum level than the other scenarios (105.0 feet).



Time Series of Conowingo Stage: In addition to the probability of certain stages at Conowingo being observed over the period of record, it was useful to display daily results during known drought years to observe the pond behavior on a real-time basis. The plot below demonstrates that the two alternatives with an automatic waiver ("Future_Plus" and "Simbase_Plus") perform more favorably with regard to maintaining stage in the pond during the drought of 2002.



D. Evaluation of Results

The results of the CAN sessions served to demonstrate positive and negative aspects of the various scenarios, and allowed the Workgroup to eliminate operating parameters that do not offer desirable outcomes. Evaluation of results also allowed the Workgroup to focus on operating parameters that meet the objectives of the planning effort. Because many of the alternatives involved variations in other aspects of the system, such as water demands or storage releases, examination of the results provided a sensitivity analysis for the system; the Workgroup was, thus, able to discern those parameters that deserved the most scrutiny during selection of the final alternative.

1. **Water Demand** – The Workgroup felt it was important to evaluate the impact of water withdrawals and upstream consumptive water uses on the ability of the Conowingo pond to remain viable during droughts. In addition to running the scenarios with estimates of current water demands in the Susquehanna River Basin, scenarios were run using demands increased to 2025 levels, and 2025 demands with a peaking factor to estimate maximum short-term water use. Various levels of water use were also investigated for specific water users such as Chester Water Authority and the City of Baltimore. Also, new anticipated water uses were incorporated into the total demands. The results showed that, although water demand from the pond and the upstream basin was projected to increase by as much as 59 percent, the impact of varying water demands on the resource (pond stage and minimum dam releases) was not significant. Dam releases were generally not affected and pond stages were diminished by less than one foot. Although still deemed important to incorporate accurate estimates of future water demand, it was not anticipated to have

significant impacts on the pond resource and, thus, the Workgroup's efforts were focused more on other aspects of planning.

The Workgroup also considered the role water conservation might play in mitigating low flow conditions on the Conowingo pond. Estimates were made about potential reductions obtainable through conservation. Even using optimistic reductions of 10 to 20 percent basinwide, maximum water savings are relatively small compared to river flows, and would offer limited drought relief. Therefore, while conservation measures are to be encouraged and are a vital component of sound drought management, they do not offer the mitigation needed to sustain the Conowingo pond.

2. **Water Releases to Augment Low Flows –** The water storage owned by the Commission at two federal reservoirs in the upper basin is currently dedicated to offsetting specific consumptive uses during droughts in the vicinity of Wilkes Barre and Harrisburg, Pennsylvania. Certainly, it can be argued that any water released will eventually supplement flows into the Conowingo pond. However, that storage has not been a factor in pond management during recent droughts because none of the storage was used to offset the identified consumptive uses during that time. Under the contractual agreement between the Commission and the USACE, release of the storage is predicated on flow conditions of Q7-10 at either the Harrisburg or Wilkes Barre stream gages. That condition was not met in recent low flow years.

   To gain an understanding of the potential for large storage projects to mitigate drought conditions at the Conowingo pond, different operating conditions were investigated. For example, because much of the operations at Conowingo dam are dictated by flow conditions at the Marietta gage relative to the Q-FERC values, model runs were performed using Q-FERC values as the criterion for the release of augmenting flow from Commission-owned storage. Results showed that excess inflow can be demonstrated at the pond, but the benefit is not significant, particularly when compared to the leakage flow of 800 cfs from Conowingo dam. The ability of the storage to improve conditions at the pond is limited due to the relative size of the storage with respect to the daily fluctuations typically observed in the pond. The Commission owns 30,000 acre-feet of storage collectively at the two projects, which is equivalent to roughly 4 feet of water in the pond.

   Releasing a quantity of storage that is of significant use to the pond would deplete the Commission's storage in a matter of days; conversely, releasing the storage at a rate sustainable over a summer-long drought (75 – 125 cfs) would contribute minimal extra inflow to the pond on a daily basis. While further study may demonstrate unrealized potential for drought mitigation from Commission storage, the Workgroup decided it is beyond the scope of this effort, and it was not pursued as a management objective.

3. **Implementation of Leakage Credit –** The single variable that most directly and measurably impacted the pond is the credit for including leakage in meeting minimum flows. The quantity of credit and the timing of its use proved to be very

influential in the ability of the pond to remain viable for multipurpose use during low flows. As such, much of the Workgroup's subsequent effort was focused on evaluating implementation strategies for the credit, discussing the need for restrictions on use of the credit, and assessing the potential for the credit to offer benefits and impart adverse impacts to the pond and the river downstream of the dam.

Following completion of the CAN sessions and evaluation of the model results as described above, the Workgroup selected a set of preferred operation alternatives for closer analysis and final evaluation.

E. Selection of Preferred Operational Alternatives

The final set of preferred operating alternatives differ mainly in operating rules for release requirements from Conowingo dam during times of low flow. Parameters such as demand for water supply and water withdrawal operations were kept consistent in the scenarios to best allow for direct comparison between them. Consumptive use in the Susquehanna basin and withdrawal demands from the Conowingo pond were set at projected levels for 2025, as agreed upon by the Workgroup.

1. Description of Preferred Alternatives

a. Baseline: The model was configured to represent as closely as possible the existing operations in the Conowingo pond, using the previous "SimBase" model as a basis. In contrast to the "SimBase" alternatives, in which the credit for leakage was conditioned solely on the pond level declining below 104.5 feet, Exelon personnel assisted Commission staff in crafting a rule for implementation of ad hoc leakage credits that served as a reasonable approximation of the historic occurrences of such a waiver by FERC. The rule based the implementation of a credit for leakage on the storage in the pond and the time of year. Otherwise, the release requirements contained in the FERC license, which do not include a consideration for leakage estimates, were followed. For example, if the matching release is 4,000 cfs, the volume of the pond was reduced by 4,000 cfs plus an additional 800 cfs that is estimated to be leaking through the gates.

   Similarly, all other operations (e.g., control of Commission-owned storage in upstream reservoirs and operation of other water supply reservoirs and flood control dams) were modeled to reflect, as closely as possible, currently existing rules or requirements. Results of this scenario represented the "baseline" for comparison and served to demonstrate to the Workgroup the long-term conditions that can be expected in the pond if no action is taken to modify existing protocols.

b. Automatic Credit: Under this scenario, the full 800 cfs leakage was recognized and credited towards satisfying minimum dam releases at all times, regardless of flow conditions at Marietta. Although minimum flow releases made from Conowingo dam were still dependent on flow conditions at the Marietta gage, as required by the existing FERC settlement agreement, their magnitude was automatically reduced by 800 cfs to account for leakage. This outcome was true whether the flow at Marietta was greater or less than the FERC-identified flow (i.e., Q-FERC) for a particular day.

For example, during June, the dam is required under the settlement agreement to release 5,000 cfs if Marietta flow is at least that much. Including the 800 cfs leakage, a total of 5,800 cfs actually passes downstream. Under the Automatic Credit scenario, 800 cfs for leakage is discounted from the required release of 5,000 cfs, leaving a release of 4,200 cfs. That release, combined with the 800 cfs leakage, totals a quantity passing the dam of 5,000 cfs.

On the other hand, if the flow at Marietta is below the threshold of 5,000 cfs in June, the settlement agreement stipulates that the dam match the Marietta flow. Under the settlement agreement, if 4,000 cfs is measured at Marietta, the dam must release 4,000 cfs in addition to the 800 cfs that leaks through, for a total of 4,800 cfs passing the dam. Under the Automatic Credit scenario, 800 cfs is credited toward the required matching release (4,000 cfs in this example), and only 3,200 cfs is released from the dam. Combined with the 800 cfs leakage, a total of 4,000 cfs passes the dam.

The only exception to the full-time inclusion of the leakage credit in meeting release requirements arose out of concern for passage of spawning anadromous species; the credit for leakage was never available in April, May, or June.

c. Critical Level: The full credit of 800 cfs for uncontrolled leakage was allowed under this scenario, but only when the elevation of the Conowingo pond dropped below a pre-defined critical stage (104.5 feet, Conowingo datum) due to extreme low flow conditions. That stage was selected because it is a reasonable indication of conditions at which continued operations at Peach Bottom and Muddy Run lose sustainability. Above that stage, no consideration was given for estimated leakage. Below that stage, the dam could count all 800 cfs of estimated leakage toward meeting the FERC-required minimum release. As in scenario No. 2, the credit for leakage was never available in April, May, or June, regardless of the pond elevation, out of concern for fish migration.

d. System Deficit: Rather than linking a credit for leakage to the flow past Marietta as in scenario No. 2, or to a critical stage of the Conowingo pond as in scenario No. 3, the rules of this alternative defined a minimum operability level for the combined pond and Muddy Run system, and allowed a leakage credit (up to 800 cfs, as needed) to maintain that minimum operability level. In other words, the scenario was structured such that enough water would always be held in the combined ponds of the Conowingo pond and the Muddy Run facility, such that when Muddy Run is full, the Conowingo pond would not be below an identified threshold. After some deliberation, the Workgroup established a threshold of 106.5 feet (Conowingo datum) for the pond.

Under typical operating conditions, there is sufficient water so that both Muddy Run and the pond can be held full; however, during low flow conditions, the total combined storage between the two can begin to trend downward when the operators act according to license requirements. The threshold of 106.5 feet was chosen because it represents a condition in which some of the operational capacity of Muddy Run has been lost, but operations at Peach Bottom are still fully sustainable.

An example of the application of the System Deficit alternative follows: if flows into the pond are sufficiently low so that the designated amount of storage can be maintained only through the allowance of a credit for 300 cfs of the leakage, then a credit of 300 cfs is allowed. Unlike scenario Nos. 2 and 3, the operators are prohibited from taking a credit for the remaining 500 cfs in leakage for the purpose of maintaining pond level above 106.5 feet. Only when river flows naturally provide sufficient water can the pond level be restored to 108.5 feet. As in the above scenarios, the credit for leakage was never available in April, May, or June, regardless of the situation in the pond.

e. Stepped Waiver: The introduction of a leakage credit was applied incrementally in this alternative, based on conditions in and around the Conowingo pond. There were two basic criteria: (1) the flow at Marietta dropping below the specified threshold levels (5,000 or 3,500 cfs, seasonally); and (2) the estimated local inflow (downstream of Marietta) into the pond being less than the estimated 2025 combined public water supply (for Baltimore and Chester withdrawals) and thermal power generation consumptive water use (for Peach Bottom and new Conectiv project) from the pond. If either of the two basic criteria was met, a credit for up to 250 cfs of the estimated leakage was granted. Intermediately, if both criteria were met, the credit was additive and granted up to 500 cfs. If the pond continued to trend downward in spite of the credit for leakage and reached a pre-defined critical stage (104.5 feet, Conowingo datum), the maximum credit of the full 800 cfs was allowed. As in the above scenarios, the credit for leakage was never available in April, May, or June, regardless of conditions in and around the pond.

f. Minimum Flow: Under this scenario, the flow thresholds established by Conowingo's FERC license (5,000 and 3,500 cfs, seasonally) were adopted as absolute minimum release criteria, even during times when Marietta flows were below these thresholds. In consideration of the dam striving to meet those minimum releases at all times, the estimated leakage of 800 cfs was always fully counted toward that goal. From the perspective of having the credit available under any conditions, this scenario resembles No. 2, Automatic Waiver. However, the mandated minimum release of 3,500 or 5,000 cfs was unique to this alternative. The only circumstance under which no credit for leakage was given was during the months of April, May, and June, as in the above scenarios.

2. **Evaluation of Preferred Alternatives –** Based on an evaluation of results for the six preferred alternatives, the Workgroup was able to identify positive and negative aspects of each option. The Workgroup was able to eliminate certain options from consideration because they were unable to meet various objectives for the plan, the most important being sustained viability of the Conowingo pond.

    a. Baseline: The Baseline alternative was developed only with the intent to serve as being representative of existing conditions for comparison purposes, and not as a proposal for recommended operations. Instead, the goal of the Workgroup was to modify existing conditions, as warranted, for improved management of the pond.

    b. Automatic Credit: The Automatic Credit option was very successful at protecting the level of the pond during droughts, and was deemed worthy of further evaluation. However, the Workgroup was concerned about allowing the variance for leakage even during times when the dam can be operated at full capacity without the credit. The intent behind formalizing the credit for leakage was to ensure reliability of the pond during droughts, and not to enhance operations of the hydroelectric facility. The results of the Automatic Credit option indicated that there are times during moderately low flows where usage of a leakage credit could noticeably alter the dam's outflow as a result of intra-day peaking. Implementing a permanent, full-time credit for leakage runs counter to the settlement agreement negotiated in 1988 to protect downstream habitat, and affords more flexibility to the dam at the expense of downstream flows than is warranted. Nevertheless, the Automatic Credit option consistently provided reliability to the storage in the Conowingo pond, and the Workgroup recognized the potential benefits.

    c. Critical Level: The Critical Level option quickly proved to be inadequate in ensuring sustainability of the pond. By restricting the leakage credit until the pond was at a level of 104.5 feet, the opportunity to maintain flexibility necessary to withstand droughts was generally lost. In other words, the variance simply came too late. Further, by tying the variance to the pond level, which is a parameter entirely within the control of the dam operators, the Workgroup expressed concern that the public would perceive the potential for a conflict of interest.

    d. System Deficit: Although the results for the System Deficit option were very favorable in terms of timing of the variance and success in sustaining pond operations, concern was expressed that the implementation of the variance was overly complicated and potentially restrictive of operational flexibility at the dam. It is not the intent of the plan to dictate operations to Exelon. Also, the variance relied on conditions in the pond that are not always readily available to the public, or even to members of the Workgroup, and might under certain circumstances be considered proprietary and confidential by Exelon. Nevertheless, the alternative was viewed favorably overall, as it was successful at providing the credit for leakage when it was truly needed, and allowed the pond to remain viable. At the same time, the conditions required for the credit ensured that the waiver does not benefit hydroelectric operations at the expense of downstream habitat. As such, the System Deficit alternative was recommended for further consideration and possible selection as the final recommended alternative.

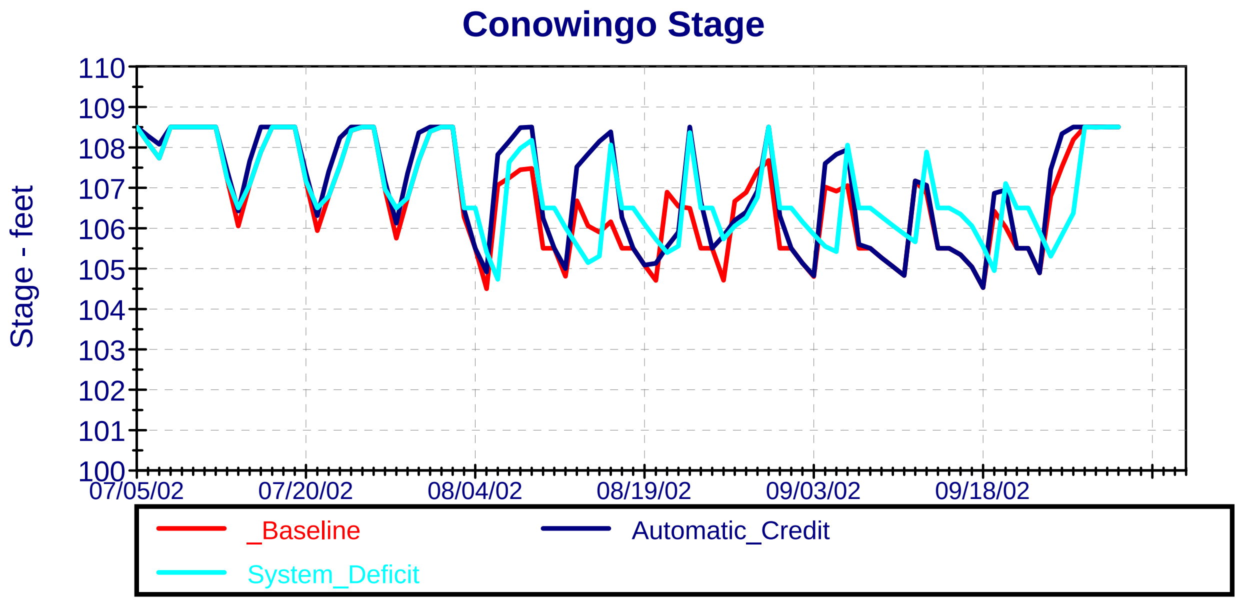
e. Stepped Waiver: In contrast to the criteria associated with System Deficit, the criteria under the Stepped Waiver option are readily available to the public and members of the Workgroup. However, daily assessment of withdrawals, pond level, and inflow estimates was deemed overly complicated and in opposition to the goal of a more direct and straightforward protocol for implementing the leakage credit. Further, despite several overlapping criteria for the variance, the option was not able to, in all cases, ensure pond viability during drought conditions.

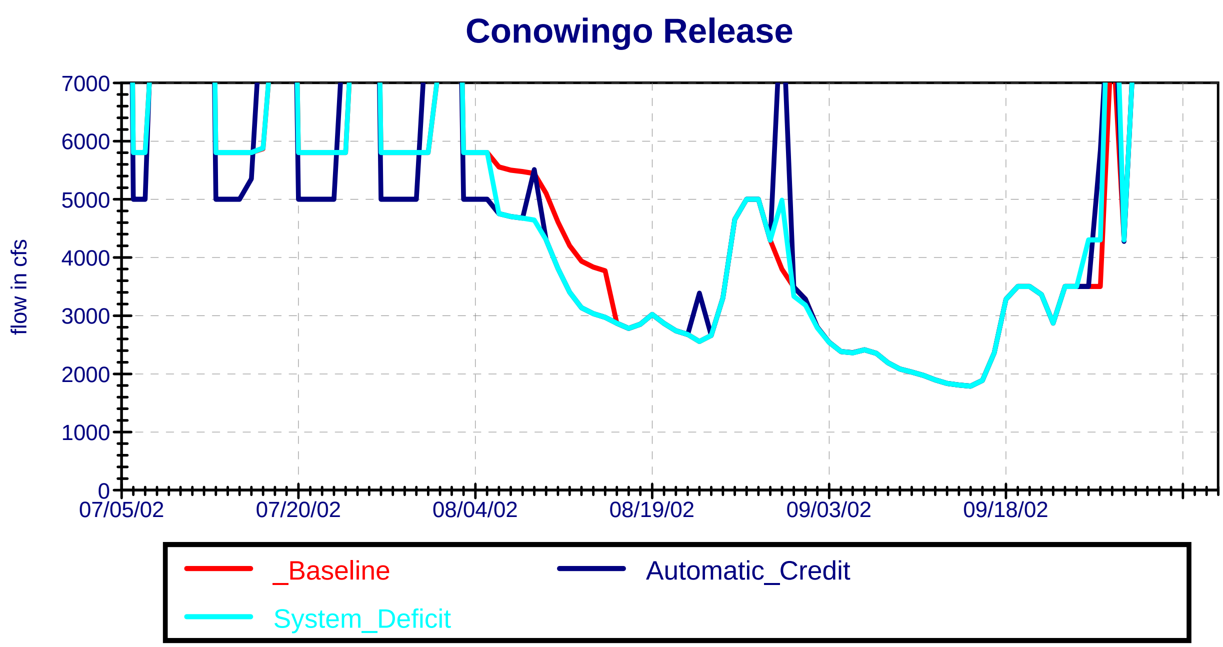
f. Minimum Flow: Finally, the Minimum Flow alternative demonstrated that the pond is simply unable to meet sustained releases of 5,000 and 3,500 cfs under drought conditions, even with the advantage of a full-time credit for leakage. The results reinforced the rationale implicit in the 1988 settlement agreement, tying required releases to the conditions at the Marietta stream gage. Adoption of the Minimum Flow alternative would have run contrary to that negotiated agreement, and would not have met the goals of the Conowingo Pond Management Plan.

The table and samples of the plots used to evaluate the six preferred alternatives are shown below.

Alternative Plan	1. Baseline	2. Automatic Credit	3. Critical Level	4. System Deficit	5. Stepped Waiver	6. Minimum Flow
Conowingo Releases						
Probability less than Q-FERC	6.1%	15%	5.3%	6.4%	4.8%	
Maximum days below Q-FERC	132	132	120	131	124	
Max consecutive days less than Q-FERC	65	65	62	51	65	
Events with flows < Q-FERC :						
For 1-7 days	6	13	6	13	8	*This alternative*
8-15 days	5	9	5	9	11	*was eliminated*
16-30 days	11	11	12	10	8	
31-60 days	12	15	10	15	11	
Over 60 days	6	6	6	7	6	
Events below salinity threshold	27	27	27	28	27	
Max days below salinity threshold	131	131	136	136	136	
Conowingo Stage						
Probability stage < 108.5 ft	18.9%	16.8%	19.3%	19.3%	19.2%	*This alternative*
Probability stage < 106.5 ft	4.2%	2.0%	6.4%	4.6%	5.8%	*was eliminated*
Probability stage <104.5 ft	0.6%	0%	2.2%	0.1%	1.9%	
Probability stage <103 ft	0.04%	0%	0.2%	0%	0.1%	
Minimum Stage (ft)	102.6	104.8	101.9	103.4	102.1	
Drought Comparisons						
Average release during August 1964	4061 cfs	4164	4262	4157	4290	
Minimum release during August 1964	2588	2588	2588	2588	2588	
Average release during September 1964	2195	2195	2195	2195	2195	
Minimum release during September 1964	1806	1806	1806	1806	1807	
Average stage during summer 1964	107.1 ft	107.1	105.1	106.6	105.6	*This alternative*
Minimum stage during summer 1964	106.2	106.3	102.7	104.8	103.0	*was eliminated*
Average release during August 2002	4553	4604	4985	4405	4687	
Minimum release during August 2002	2555	2659	3355	2495	3040	
Average release during September 2002	3502	3502	2924	3630	3303	
Minimum release during September 2002	1786	1786	1786	1786	1786	
Average stage during summer 2002	107.5	107.7	106.3	107.4	107.0	
Minimum stage during summer 2002	106.3	106.4	103.2	104.9	104.1	

Alternative Plan	1. Baseline	2. Automatic Credit	3. Critical Level	4. System Deficit	5. Stepped Waiver	6. Minimum Flow
Conowingo Recreation Violations						
0-7 days	33	36	25	26	29	
8-15 days	14	3	14	17	11	*This alternative*
16-30 days	4	1	11	25	9	*was eliminated*
Over 30 days	0	0	1	3	2	
Max days	29	17	36	34	37	
Average days	4.5	2.3	7.0	12.9	6.2	
Muddy Run Generation						
Avg. storage (1,000 ac-ft) available, Jul-Sep	1529	1658	1449	1625	1474	*This alternative*
Average storage NOT available, Jul-Sep	644	515	724	548	699	*was eliminated*
Minimum storage available, Jul-Sep	330	488	42	297	11	
Percent generation capacity lost, Jul-Sep	29.6%	23.7%	33.3%	25.2%	32.2%	


Conowingo Stage
Stage - feet
110
109
108
107
106
105
104
103
102
101
100
07/05/02
07/20/02
08/04/02
08/19/02
09/03/02
09/18/02
_Baseline
Automatic_Credit
System_Deficit


Conowingo Release
flow in cfs
7000
6000
5000
4000
3000
2000
1000
0
07/05/02
07/20/02
08/04/02
08/19/02
09/03/02
09/18/02
_Baseline
Automatic_Credit
System_Deficit

F. Refinement of Alternatives and Final Evaluation

Having evaluated the six preferred alternatives, the Workgroup was able to drop two from consideration, carry one forward for the final evaluation, and suggest modifications to an alternative, leaving four final alternatives for final evaluation. The four final alternatives were No Action, Baseline, Automatic Q-FERC + 1,000, and System Deficit. A full description of the alternatives, including the development of the Automatic Q-FERC + 1,000 alternative, is included in the main body of the report, as is a discussion of the results (see Section V-C).

As with previous evaluations, the Workgroup considered parameters such as minimum pond elevation, average flows from the dam, frequency of the pond being unable to meet required recreation levels, and impact to hydroelectric generating capacity. A detailed discussion of how the four alternatives performed with respect to these parameters is presented below. Following that, the tables and sample plots of results used in the final evaluation are also shown.

<u>Minimum Pond Elevation</u>: The table shows the minimum daily pond elevation reached in the Conowingo pond for each alternative through the entire 73-year period of record. The timely usage of leakage credit under the Automatic Q-FERC + 1,000 scenario allowed the pond the most reliability in terms of maintaining adequate levels. The results clearly show that the Automatic Q-FERC + 1,000 alternative provides the most reliability; two of the other three options declined below 102 feet, and the third remaining alternative allowed the pond to decline to the minimum allowable level specified in the FERC license, several feet below optimum minimum conditions.

During the drought of 2002, each of the options – Baseline, Automatic Q-FERC + 1,000, and System Deficit – maintained a minimum pond level of 104.5 feet by implementing a credit for leakage in different ways. The No Action option, however, not only was unable to maintain 104.5 feet in the pond, but also demonstrated that the pond level would have declined to the extreme minimum of 100.5 feet without the benefit of a credit for leakage. That result serves to reinforce the importance of the credit in keeping the Conowingo pond at reliable levels during droughts.

When looking at the level of the Conowingo pond over the entire 73-year record, a period of 26,663 days, on only 53 days (0.2 percent) did the pond level decline below 104.5 feet under the selected alternative. The No Action, Baseline, and System Deficit alternatives demonstrated pond levels below 104.5 on 1,200 days (4.5 percent), 267 days (1 percent), and 106 days (0.4 percent), respectively.

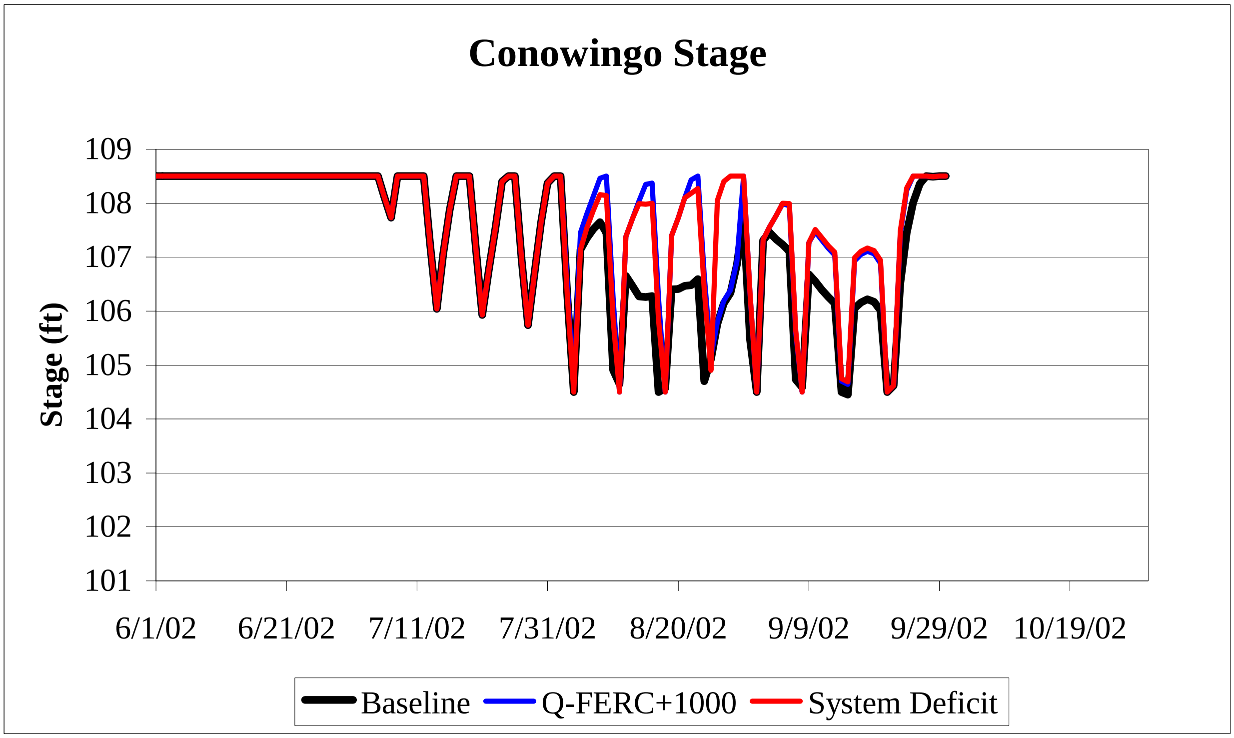
<u>Average Release</u>: The Workgroup looked at simulated releases from Conowingo during several droughts, including 2002. The differences in results of the four alternatives are attributable to the implementation (both timing and quantity) of the leakage credit. Any credit taken will reduce by that same quantity the water that is released downstream. On average during September 2002, the dam released about 3,630 cfs under the Automatic Q-FERC + 1,000 and System Deficit scenarios, while releasing 3,516 cfs under the Baseline scenario and 3,359 cfs under the No Action alternative. It seems counterintuitive that higher releases are shown by the alternatives that apply the leakage credit more liberally, but their ability to do so is

ensured by the higher stages of the pond. When the drought conditions eased in mid-September 2002, the dam was able to return to normal conditions more quickly under those alternatives, while it needed to retain more flow for refilling under No Action and Baseline conditions.

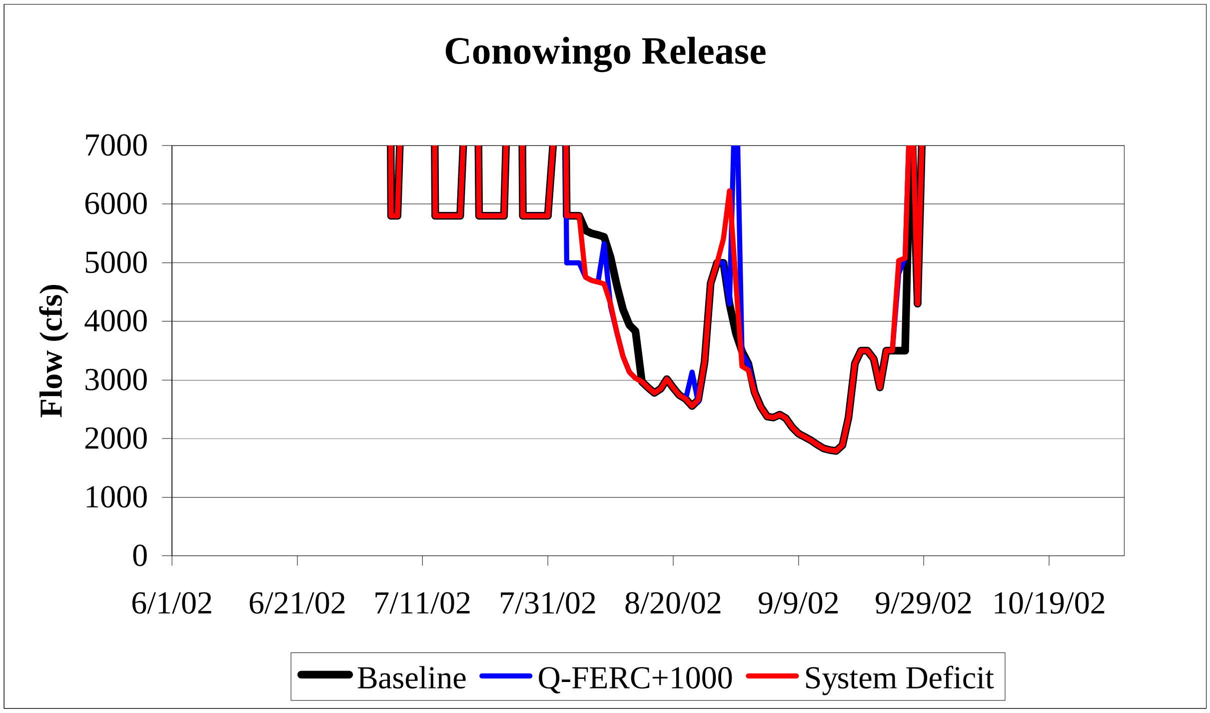
For comparison purposes, it is useful to also consider average releases during August 2002, before flows increased above drought conditions. During that month, the dam released the least water (4,479 cfs) under the System Deficit scenario, followed closely by 4,495 cfs under the Automatic Q-FERC + 1,000 scenario. The Baseline and No Action alternatives allowed releases of 4,616 cfs and 5,055 cfs, respectively. While there is significant difference in those results, the higher releases under the No Action scenario came at the expense of lower pond levels, as described above. Although providing less flow downstream during the month of August 2002, the Workgroup is satisfied that, based on available information, the releases under the Automatic Q-FERC + 1,000 and System Deficit alternatives are no more harmful to aquatic habitat than the releases under the No Action and Baseline scenarios.

Unmet Recreation Days: It is expected that allowing a credit for leakage will increase the reliability of the Conowingo pond to provide adequate levels for recreation. Because the FERC license stipulates maintenance of a recreational pond level of 106.5 feet only on weekends between Memorial Day weekend and the end of September, recreation usage is concentrated during that time, which is roughly 55 to 60 days spread over 18 to 20 weekends. Results show that, over the 73-year record, there are fewer days of unmet recreation levels (on an average annual basis) under the Automatic Q-FERC + 1,000 and System Deficit scenarios, at 12.2 and 12.7 days, respectively. Conversely, an average of 13.5 days (Baseline) and 15 days (No Action) fail to meet recreation needs under the other alternatives. In terms of the total days available for recreation (up to 60), the range of unmet days ranges from about 20 to 25 percent. The results, therefore, show that Automatic Q-FERC + 1,000 and System Deficit operations provided the equivalent of one additional weekend of optimum recreational opportunities (pond level at 106.5 feet) in an average summer. The results also suggest that when impacts do occur to recreation, they are less severe and of shorter duration under the chosen alternative.

Generating Capacity: Although the purpose of establishing management objectives for the Conowingo pond is not to provide the means for sustained or increased hydroelectric generation, reliable power generation is nevertheless a vital multipurpose use of the Conowingo pond. Thus, the generating capacity retained through drought periods is a useful indicator of whether or not the alternatives have provided more sustainable and reliable operations. Results show that the water available for generation at Muddy Run during the July through September timeframe can support about 92 percent of capacity under the Baseline, Automatic Q-FERC + 1,000, and System Deficit alternatives. However, the No Action option can sustain only about 81.5 percent of capacity. The period July through September is particularly useful for evaluation because it is the juxtaposition of the time that low flows are most likely to occur and the typical occurrence of peaks in power demand.



Conowingo Stage
Stage (ft)
109
108
107
106
105
104
103
102
101
6/1/02
6/21/02
7/11/02
7/31/02
8/20/02
9/9/02
9/29/02
10/19/02
Baseline
Q-FERC+1000
System Deficit



Conowingo Release
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
6/1/02
6/21/02
7/11/02
7/31/02
8/20/02
9/9/02
9/29/02
10/19/02
Baseline
Q-FERC+1000
System Deficit

Alternative Plan	1. No Waiver	2. Baseline	3. Q-FERC + 1000	4. System Deficit
Conowingo Releases				
Probability less than Q-FERC	4.2%	6.7%	10.1%	7.6%
Maximum days below Q-FERC	117	132	132	133
Max consecutive days less than Q-FERC	45	65	65	65
Events with flows < Q-FERC :				
For 1-7 days	9	6	16	14
8-15 days	6	5	6	7
16-30 days	11	11	11	11
31-60 days	9	12	14	15
Over 60 days	4	6	7	7
Events below salinity threshold	26	27	28	27
Average days below salinity threshold	44	46	44	46
Max days below salinity threshold	134	134	134	135
Conowingo Stage				
Probability stage < 108.5 ft	20.6%	20.0%	19.1%	19.6%
Probability stage < 106.5 ft	10.0%	7.7%	6.2%	6.8%
Probability stage <104.5 ft	4.5%	1.0%	0.2%	0.4%
Probability stage <103 ft	3.2%	0.1%	0%	0.05%
Minimum Stage (ft)	100.5	101.8	103.1	101.8
Drought Comparisons				
Average release during August 1964	4546 cfs	3968 cfs	4071 cfs	4050 cfs
Minimum release during August 1964	3388	2588	2588	2588
Average release during September 1964	2052	2195	2195	2195
Minimum release during September 1964	1561	1806	1806	1806
Average stage during summer 1964	103.7 ft	106.5 ft	106.6 ft	106.4 ft
Minimum stage during summer 1964	100.5	104.4	104.4	104.4
Average release during August 2002	5055 cfs	4616 cfs	4495 cfs	4479 cfs
Minimum release during August 2002	3355	2555	2620	2555
Average release during September 2002	3359	3516	3633	3636
Minimum release during September 2002	1350	1786	1786	1786
Average stage during summer 2002	105.3 ft	106.9 ft	107.3 ft	107.4 ft
Minimum stage during summer 2002	100.5	104.5	104.5	104.5

Alternative Plan	1. No Waiver	2. Baseline	3. Q-FERC + 1000	4. System Deficit
Conowingo Recreation Violations				
1-7 days	26	26	26	26
8-15 days	15	16	21	18
16-30 days	19	25	21	24
Over 30 days	11	4	3	3
Max days	42	36	33	36
Average days	15.0	13.5	12.2	12.7
Muddy Run Generation	***(max of 1564 thousand acre-feet are available July – September)***			
Avg. storage (1000 acft) available, Jul-Sep	1274	1432	1448	1439
Average storage NOT available, Jul-Sep	290	133	116	125
Minimum storage available, Jul-Sep	171	1173	1172	1172
Percent generation capacity lost, Jul-Sep	18.5%	8.5%	7.4%	8.0%

G. Selection of Recommended Alternative

The evaluation of preferred alternatives showed that Automatic Q-FERC + 1,000 provided the best overall results for key parameters, including minimum pond elevation, minimum and average flows from the dam, frequency of the pond being unable to meet required recreation levels, and impact to hydroelectric generating capacity. Thus, Automatic Q-FERC + 1,000 was carried forward as the best alternative, and was evaluated with respect to the important issues defined by the Workgroup at the outset of the study. A discussion of that evaluation is available in the full body of the main report (see Section VI).

Finally, a position analysis of the alternative was performed for the purpose of predicting the consequences of the application of the recommended operations, in comparison to existing conditions.

Position Analysis for Occurrences of Q-FERC + 1,000 at Marietta

The entire available period of record (October 1, 1931 through September 30, 2005) at the Marietta, Pennsylvania, gage was analyzed to assess the frequency of flows equivalent to Q-FERC + 1,000 cfs and the likelihood that Q-FERC conditions will then follow later that year. Results are shown in the table below.

The second column in the table below shows the number of years in which the gage at Marietta recorded flows less than Q-FERC + 1,000 cfs. Q-FERC is 5,000 cfs from June 1 through September 14, and 3,500 cfs from September 15 through November 30; no instances of flows less than Q-FERC + 1,000 cfs occurred before June 1 or after November 30. The data are separated into 2-week periods, denoting the FIRST occurrence of flows less than Q-FERC + 1,000 cfs in a particular year.

The table's third column shows the number of the years in which the flow at Marietta eventually dropped below Q-FERC. The data show that early occurrences of flows less than Q-FERC + 1,000 are very reliable indicators of eventual flows less than Q-FERC. The later in the year the first occurrence of Q-FERC + 1,000, the less likely the river at Marietta is to eventually decrease below Q-FERC.

Close evaluation of the position analysis yields the following conclusions:

1. Q-FERC + 1,000 events beginning in July or August are highly indicative of subsequent Q-FERC flows.

    a. Forty-two of the 56 Q-FERC + 1,000 events, or 75 percent, began in July and August and 36 of these events, or 86 percent, were followed by Q-FERC flows.

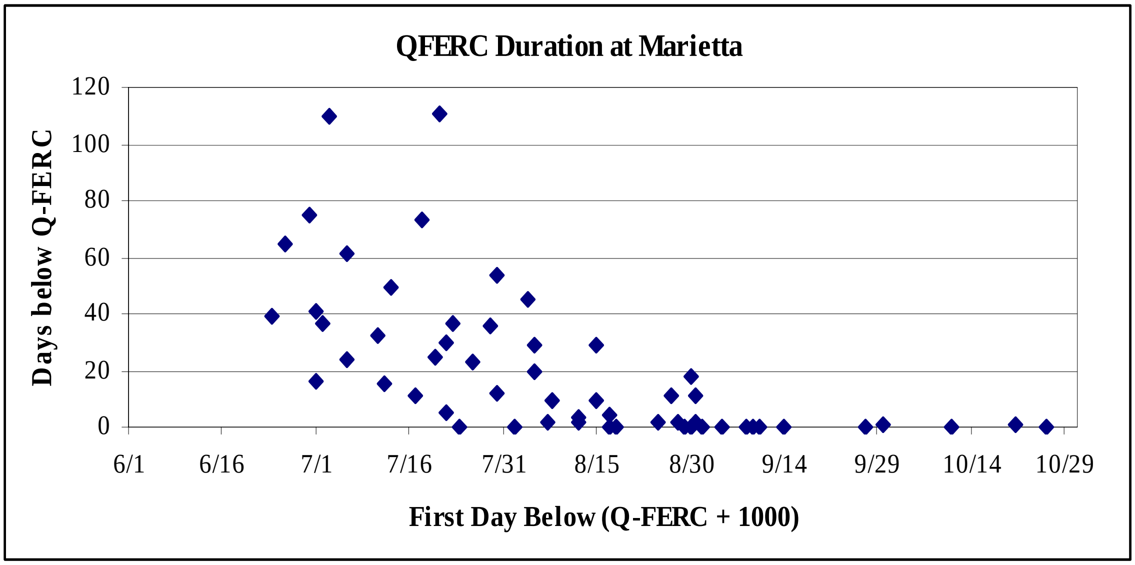
2. Q-FERC + 1,000 events beginning in September and October are not as indicative of the infrequent Q-FERC flows that have occurred in this time period.

a. Eleven of the 56 Q-FERC + 1,000 events, or 20 percent, occurred in September and October, but only 2 of these events, or 18 percent, were followed by Q-FERC flows.

Time Period of First Q-FERC + 1,000 Occurrence	Number of Years Measuring Q-FERC + 1,000	Number of those Years Measuring Q-FERC	Reliability (percent)
June 1 – June 14	0	0	--
June 15 – June 30	3	3	100
July 1 – July 15	9	9	100
July 16 – July 31	12	11	92
August 1 – August 15	10	9	90
August 16 – August 31	11	7	64
September 1 – September 14	6	0	0
September 15 – September 30	2	1	50
October 1 – October 15	1	0	0
October 16 – October 31	2	1	50

3. Q-FERC + 1,000 events beginning in July and August indicate potentially significant durations of subsequent flow periods below Q-FERC.

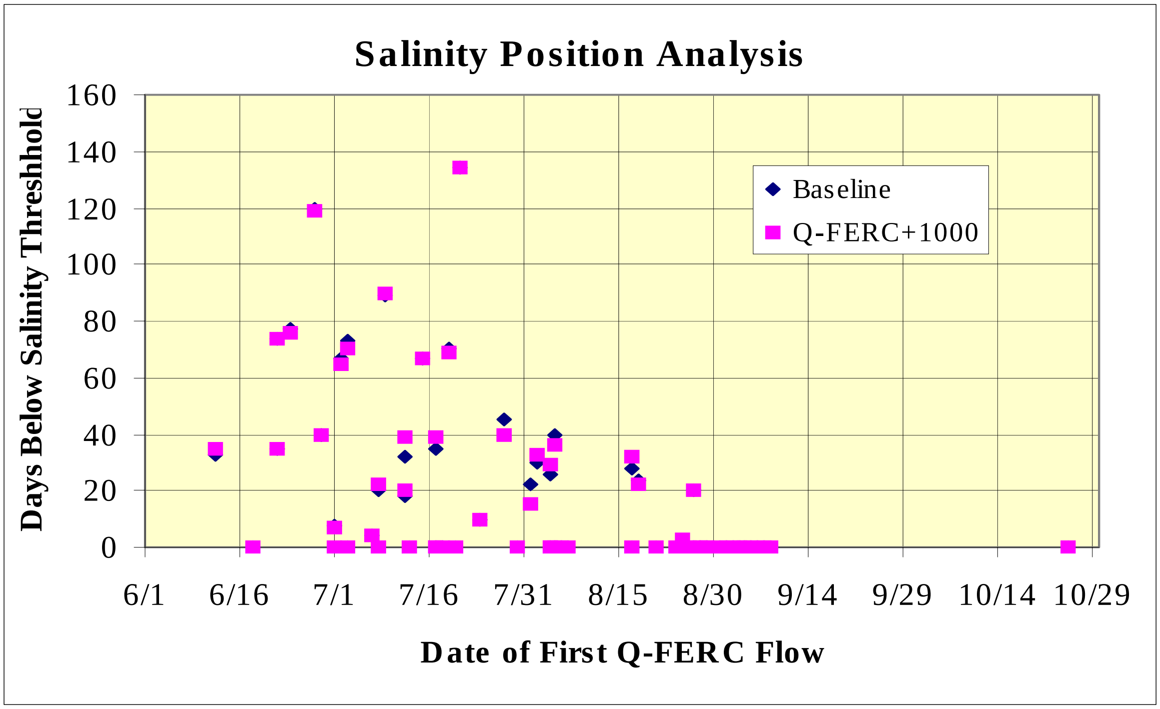
   a. Twenty of the 42 Q-FERC + 1,000 events beginning in July and August, or 48 percent, were followed by Q-FERC durations of 20 days or longer.
   b. Eleven of the 42 Q-FERC + 1,000 events beginning in July and August, or 26 percent, were followed by Q-FERC durations of a few days up to 20 days.
   c. The plot below shows that years with the most days measured below Q-FERC tend to first experience flows lower than Q-FERC + 1,000 prior to the end of August.



Position Analysis for Occurrences of Salinity Threshold Downstream of Conowingo

The Workgroup concluded during the CAN sessions that the various operating alternatives did not have significant impacts on the occurrence of the surrogate salinity threshold downstream of the Conowingo dam. Nevertheless, once an alternative is selected for recommendation to the Commission, it is useful to perform a position analysis to verify that the implementation of the alternative does not cause significantly more frequent occurrences of the salinity threshold.

The plot below shows, for existing conditions (Baseline) and the proposed operations, the number of days below the salinity threshold that can be expected to occur based on the date of the first flow that is below Q-FERC at the Marietta gage.



First, the plot clearly shows that, regardless of operations, years with extended number of days below the salinity threshold (greater than 60 days), are all indicated by an initial occurrence of Q-FERC prior to August 1. Likewise, for both operating modes, the salinity threshold does not occur at all if the first instance of Q-FERC happens after the end of August.

Finally, the position analysis results show that there is not expected to be a significant increase in the number of days below the salinity threshold as a result of implementation of the Q-FERC + 1,000 operations. In fact, it appears that some low flow events actually suffer fewer days below the salinity threshold under the proposed operations. The reason is likely because the proposed operations, by virtue of the credit for leakage, allows the conservation of storage early in a drought, which in turn allows for potentially higher releases towards the drought's end. Higher releases could provide a countermeasure to increased salinity levels downstream of the dam.