DELAWARE RIVER BASIN COMMISSION

Annual Report 1992

Front Cover: An 1821 painting of Philadelphia's Fairmount Water Works, heralded in the mid-19th Century as one of the most efficient and successful municipal water supply systems in the United States and abroad. *The Fairmount Water Works, by Thomas Birch (1779-1851), oil on canvas, courtesy of the Pennsylvania Academy of the Fine Arts, Philadelphia. Bequest of Charles Graff.*

Material for this report was generated by the staff of the Delaware River Basin Commission. The report was compiled and edited by Christopher M. Roberts, the Commission's public information officer.

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Contents

Hello

The Commission has installed a new automated telephone system in its offices in West Trenton, N.J.

The Norstar network incorporates a software package called Star Talk which enables callers to reach members of the staff directly by using a touchtone dial pad to punch in three-digit extension numbers. If the extension is not known, the caller may punch in the last name of the person being called. (A connection normally is made after the first three letters of the name are registered.)

The caller also has the option of reaching the Commission's receptionist who can then direct the call to the appropriate party. This likewise applies to callers using rotary phones which can't interact with the automated network.

In addition, the new system allows callers to deposit messages in individual staff "mailboxes" which then display their own message announcing that a call has been received. These mailboxes can be accessed both internally and externally, meaning a staff person who is away from the office can check his or her messages by following special dialing instructions.

Although it is not necessary to know the extension number of the person being called, it's quite helpful in that it makes for a speedy connection. If you call the Commission frequently it's a good idea to make sure you jot down the applicable extension numbers and keep them in a handy place. You will find the numbers next to the names of the Commission staff listed on the next page.

The Commission • 1992


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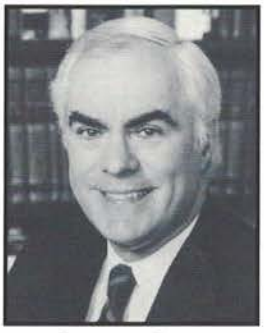
Irene B. Brooks
Alternate

Lt. Col. Kenneth H. Clow
Advisor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Staff

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Susan M. Weisman (203)
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Christopher M. Roberts (205)
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Richard C. Gore (201)
Chief Administrative Officer

Engineering Division

David B. Everett (202)
Chief Engineer

Jeffrey P. Featherstone (208)
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Branch Heads

David P. Pollison (255)
Planning

George C. Elias (221)
Project Review

Richard C. Tortoriello (229)
Operations

Planning:

Richard C. Albert (256)
Pauline A. Ditmars (257)
Thomas J. Fikslin (253)*
Warren R. Huff (237)
Robert C. Kausch (252)
Todd W. Kratzer (261)
Ronald B. Rulon (269)
Paul J. Scally (251)
Paul J. Webber (236)

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Ms. Fox

New Jersey

Governor Jim Florio
Member

Jeanne M. Fox
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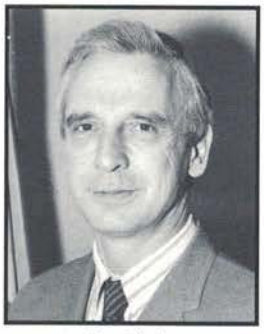
Governor Castle



Dr. Clark

Delaware

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Carol Adamovic (216)
Thomas L. Brand (217)
David C. Brown (270)
H. Page Fielding (225)
Karl S. Heinicke (271)

Operations:
Richard K. Fromuth (232)
Timothy R. Lazaro (274)
Robert L. Limbeck (230)
Judy G. Scouten (228)

Administrative:
Gregg Dusecina (245)
Dorothy L. Golinski (242)
Carolyn M. Hartman (249)
Judith L. Strong (263)
Joseph Sosi (211)

Directorate/Engineering:

Catherine F. Dougherty (222)
Carolyn B. Everett (204)
Susan C. Owens (213)
Odette P. Taft (241)
Anne M. Zamonski (222)

*On loan from EPA to conduct a Delaware Estuary toxics study

Appointments/Retirements

New York Commissioner Named
Harold G. Budka, chief of the New York State Department of Environmental Conservation's Water Quantity Section in the Bureau of Water Resources, Division of Water, was appointed by Governor Mario M. Cuomo to serve as second alternate on the Commission.

Mr. Budka

Mr. Budka holds a bachelor of science degree in civil engineering from the University of Illinois.

Prior to working for the Department of Environmental Conservation, he was employed by the U.S. Bureau of Reclamation in several western states. He moved to Jamestown, N.Y. in 1966 where he was in charge of the bureau's local office which provided staff for the preparation of the Allegheny River Basin Water Resources Planning and Development Program.

Mr. Budka is a licensed professional engineer in the states of New York and Washington.

New Federal Advisor
Lt. Col. Richard F. Sliwoski, who in 1992 became the 49th Commander and District Engineer of the Army Corps of Engineers' Philadelphia District, is the new federal advisor to the DRBC. He succeeds Lt. Col. Kenneth H. Clow.

Col. Sliwoski served since July of 1988 as deputy district engineer for military construction at the Norfolk (Va.) District. He began his Army career in 1973.

He is a graduate of Worcester Polytechnic Institute, holding bachelor and master of science degrees in civil engineering. He also has a masters degree in business administration from Xavier University of Ohio and is a graduate of the Army Command and General Staff College and the Navy Command and Staff College.

Col. Sliwoski

A Valuable Loss
Seven Commission employees with 172 years of combined service retired in 1992, exchanging fond memories for the wisdom and dedication they took with them.

Farewell to Anna Mae Auch (central records clerk), Frances Cook, (head, fiscal section), Bob Everest (regional planner), John Rattie (assistant water resources engineer), Sy Gross (supervising engineer), Mary Zaroff (secretary to the chief engineer) and B. Ahnde Lin (librarian).

Ms. Auch

Ms. Zaroff

And to Anne Van Aken, the Commission's receptionist, who retired a year earlier with a decade of service. She left us not only fond memories but a recording of her cheerful voice which is being used to greet callers accessing the Commission's new automated telephone system.

Ms. Van Aken

Five of the employees who left in 1992 participated in the New Jersey Early Retirement Incentive Program under which three other veteran Commission staffers will be eligible to retire in the spring of 1993.

In addition to staff, the Commission lost two other veterans who played key roles in managing the water resources of the basin.

John Rattie, Bob Everset and Sy Gross celebrate their 25th DRBC Anniversaries

Farewell to John E. McSparran and Joseph Conway.

Mr. McSparran was alternate DRBC commissioner from Pennsylvania from 1987 to 1992 when he left the Pennsylvania Department of Environmental Resources to become chief engineer of the Susquehanna River Basin Commission.

Prior to the new assignment, he served for nine years as chairman of the DRBC's Flow Management Technical Advisory Committee (FMTAC) helping to shape and implement drought management and other water policies in the Delaware Basin.

Mr. Conway, a deputy commissioner with New York City's Department of Environmental Protection, served as advisor to the DRBC's New York State commissioner for more than a decade. As a member of the FMTAC, he worked closely with Mr. McSparran and representatives from the other basin states on water management issues, displaying a refreshing willingness for reasonable compromise.

Mr. Conway retired from the city in 1992 after more than 38 years of service.

Welcome Aboard

There were some additions in 1992.

Mr. Sosi

Joseph Sosi, a certified public accountant, was hired as the Commission's new fiscal section head. He holds a bachelor of science degree in accounting from Glassboro State College.

Prior to joining the Commission, Mr. Sosi was accounting manager for Rimmeir Concepts Inc., a real estate company.

Paul J. Webber, who worked for the Commission from 1967 to 1983, has returned as supervising engineer.

Mr. Webber

He is a graduate of Syracuse University with a bachelor's degree in civil engineering and a masters in sanitary engineering.

A professional engineer registered in three states (Pennsylvania, New Jersey and New York), Mr. Webber is a member of the American Society of Civil Engineers.

He previously was project manager for Applied Wastewater Technology, Inc. of Belle Mead, N.J.

Judith L. Strong is the Commission's new librarian.

She holds a masters degree in library science from San Jose State University, a masters in education from California Polytechnic State University, and a bachelor of arts degree from Grinnell College.

Water Quality:

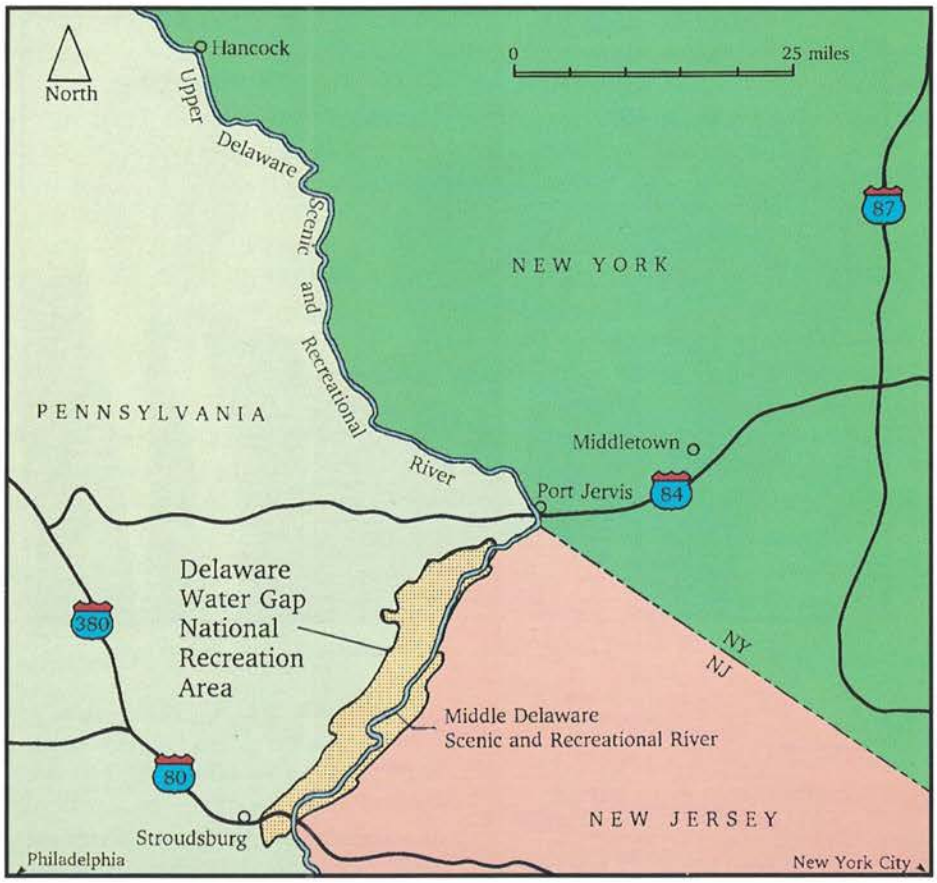
Scenic Rivers Receive Special Protection

The Delaware River Basin Commission adopted regulations in December of 1992 designed to protect existing high water quality in certain designated waterways in the basin.

The regulations were applied immediately to a 125-mile stretch of the Delaware River from Hancock, N.Y. downstream to the Delaware Water Gap, including both the Upper and Middle Delaware Scenic and Recreational Rivers and an eight-mile reach between Millrift and Milford, Pa. Portions of tributaries located within the boundaries of the Delaware Water Gap National Recreation Area and the Upper Delaware Scenic River corridor also were included.

The two Scenic River reaches were added to the National Wild and Scenic Rivers System by Congress in 1978. Unlike most Scenic Rivers, they are located near heavily populated areas, being within several hours' drive of about 20 percent of the U.S. population.

In 1987, the Commission and the National Park Service began working on a water resources management plan to protect the high water quality within the Delaware Water Gap National Recreation Area. The study was triggered by increasing land development, especially in the Poconos, and an attendant increase in the number of wastewater treatment plants and a projected increase in non-point source pollutants, found in runoff that washes into streams and rivers, especially after heavy rains.



Two years later, the Watershed Association of the Delaware River petitioned the Commission, requesting that it designate the entire stretch of the river from Hancock to the Delaware Water Gap as Outstanding National Resource Waters, a term embodied in the U.S. Environmental Protection Agency's (EPA) non-degradation regulations. The Commission subsequently expanded its planning effort to include the Upper Delaware, but opted not to adopt the Outstanding National Resource Waters classification because it banned all new wastewater discharges and thus could have a negative impact on local growth and development.

The new regulations discourage, but do not ban, direct discharges of wastewater to the designated waterways, stipulating that "no new or expanded wastewater discharges or expansions of existing discharges shall be permitted in waters classified as Special Protection Waters until all non-discharge/load reduction alternatives have been fully evaluated and rejected because of technical and /or financial infeasibility."

Non-discharge alternatives include natural systems like spray irrigation where treated wastewater is applied to the ground, floating aquatic plant systems, and filtering wetland systems. They are considered viable wastewater treatment options by such organizations as the Water Environment Federation and the EPA.

The new regulations also require that:
- The minimum level of wastewater treatment for all new and expanding wastewater treatment projects discharging to Special Protection Waters, including projects approved by the Commission after September 1988, will be "Best Demonstrable Technology," including ultraviolet light disinfection or an equivalent disinfection process that results in no harm to aquatic life, does not produce toxic chemical residuals, and results in effective bacterial and viral destruction. "Best Demonstrable Technology" as defined by the regulations represents a tertiary level of treatment including reduction in nutrients and high biochemical oxygen demand (BOD) removals.

- All wastewater treatment facilities discharging to Special Protection Waters shall have available standby power facilities and facilities not staffed 24 hours every day shall have a remote alarm to continuously monitor plant operations whenever the plant is not staffed and alert a person in authority if there is a malfunction.

The regulations also tighten the review threshold for new industrial and municipal wastewater treatment plants discharging to Special Protection Waters, requiring plants designed to discharge a daily average rate of 10,000 gallons a day or more be subject to Commission review. In the rest of the basin, the review threshold remains at 50,000 gallons a day or more.

The Commission's Water Quality Advisory Committee plays a key role in developing policy for many of the Commission's programs aimed at protecting the waters of the basin. At left, Albert Bromberg of the New York Department of Environmental Conservation makes a point during a discussion of the Commission's "Special Protection Waters" regulations which are being applied to a 125-mile reach of the Delaware River. Seated beside him is Douglas Clark of the New Jersey Department of Environmental Protection and Energy. (Leigh Photographic Group)

The new regulations are unique in that they numerically define "existing water quality" and establish riverine boundary control points to detect any "measurable change" in that quality.

Commission staff, working with other agencies, statistically analyzed thousands of water quality data to derive criteria for more than a dozen parameters in developing the definition for existing water quality. Included were biological indices for water quality as represented by bottom-dwelling organisms known as macroinvertebrates, usually aquatic insects which are sensitive indicators of environmental stress. "Measurable change" is defined in the new regulations as an actual or estimated change in a mean (annual or seasonal) instream pollutant concentration that is outside the range of the two-tailed upper and lower 95 percent confidence limits that define existing water quality.

The new regulations were developed with scientific and policy input from the Commission's Water Quality Advisory Committee, which includes representatives from the four basin states, the federal government, and the Commission. The public also played a key role in shaping the changes.

During the planning process, Commission staff spoke at numerous conferences and meetings to ensure that the public was informed as the

John Hutzky, superintendent of the National Park Service's Upper Delaware Scenic and Recreational River, leads a discussion about the new "Special Protection" regulations. Seated clockwise are Warren Huff, Commission staff; Beth Johnson, National Park Service; Mr. Hutzky, Dave Pollison, Commission staff; Committee Chairman Chuck Sapp, U.S. Environmental Protection Agency; and Richard Albert, Commission staff. (Leigh Photographic Group)

process of regulatory change evolved. Various reports presenting alternative approaches were released and made the subject of public discussion and comment.

Briefings were held in November and December of 1990 and April of 1992 and public hearings on the proposed amendments were held in May of 1992 in Matamoras, Pa., Narrowsburg, N.Y. and Wilmington, Del. Testimony was received from 85 persons, raising 133 issues which were addressed in a response document prepared by Commission staff.

Still being addressed at year's end were methods to identify and control sources of non-point pollutants. Regulations being worked on will be expanded to address concerns raised by the public. Additional hearings will be held, probably in 1993, before any new regulations are adopted.

Although the regulations approved on December 9, 1992 affected only the Middle and Upper Delaware, they, along with the pending non-point source regulations, could be applied to other basin waterways considered to have "exceptionally high scenic, recreational, ecological or water supply values..."

The Commission will consider nomination petitions from local, state and federal agencies and the public calling for the designation of Special Protection Waters in other parts of the watershed. Any proposal would involve further studies and public hearings on a case-by-case basis before Commission action could be taken.

A Report Card

In compliance with the federal Clean Water Act, the Commission conducts biennial assessments of the water quality of the Delaware River and Bay and publishes the results in a document called a 305(b) Report. States and other commissions also assess water quality in their respective jurisdictions, publishing their own 305(b) reports.

The U.S. Environmental Protection Agency then uses the collective data to prepare a national water quality assessment report which it presents to the U.S. Congress. The report, designed to pinpoint the type and extent of remaining pollution problems, helps lawmakers determine how the Clean Water Act is working, whether new legislation is called for and where additional resources may be needed.

In the Commission's latest report, issued in March of 1992, water quality was assessed for 1990 and 1991.

The Delaware was divided into three regions: free-flowing, tidal river, and bay. Of the 206 miles of the free-flowing river (from Hancock, N.Y. to Trenton, N.J.) 5.6 miles were judged as "not supporting" certain goals of the Clean Water Act because of a fish consumption advisory issued for the reach between Yardley, Pa. and the head of tide at Trenton.

Twenty-five square miles of the 84 square miles assessed in the river's tidal portion (from Trenton to the bay) also were judged as "not supporting," again because of fish consumption advisories covering the reach from Trenton to the Delaware/Pennsylvania boundary.

The advisories for both regions of the river warn of levels of chlordane and PCBs in the fish tissue of American eel, channel catfish and white perch.

Only 132 square miles of the bay's 782 square miles were assessed. Forty-two square miles were judged as "not supporting" because of seasonal or year-round closures of shellfishing beds.

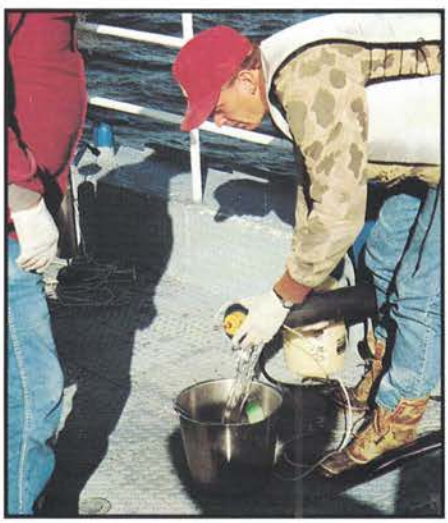
While the report focuses on problem identification, large areas of the river and bay support a majority of the water uses defined in the federal legislation.

The 1992 report includes data collected as part of the Commission's Estuary Toxics Management Study which confirmed, in part, the necessity for the fish consumption advisories.

Also included were data published in *A Summary of Data on Tissue Contamination from the First Three Years (1986-1988) of the Mussel Watch Project* by the National Oceanic and Atmospheric Administration.

Sampling sites in the Delaware Bay were ranked with sites in other bays in the United States for selected trace metals and organic chemicals found in mollusks.

In terms of overall ranking of highest concentrations of these metals and chemicals, one Delaware Bay site ranked 17 out of 177 sites sampled for Total DDT and Dieldrin; and one site ranked 19 for Lindane. In terms of ranking for trace metals, the Delaware Bay sites ranked 1, 3, 8 and 18 for cadmium out of 177 sites; 2, 4, 6 and 13 for copper; 7, 10, 12 and 13 for nickel; and 1, 3, 4, and 5 for concentrations of zinc.



Tom Penuel, a field crew member for the Delaware Department of Natural Resources and Environmental Control, empties a water sample collected as part of the Estuary Toxics Management Program. The surgical gloves are worn to prevent contamination of the sample. (Thomas Fikslin)

The 1992 report also contains a listing of spills of oil and other harmful substances that occurred in the river and bay during 1990 and 1991. Such spills pose a continued threat to the basin's biological community.

The Commission's 305(b) reports are available free of charge to the public.

Managing Toxic Pollutants

Briefings were conducted in the spring of 1992 to solicit comment and input from the public and the regulated community on proposed water quality criteria for toxic pollutants in the Delaware Estuary.

The briefings were held as part of the Estuary Toxics Management Program, a four-year effort by the Commission aimed at controlling the discharge of toxic pollutants from industrial and municipal wastewater treatment plants. The program is being carried out in cooperation with the states of Delaware, New Jersey and Pennsylvania and the U.S. Environmental Protection Agency.

Significant effort was focused during the year on the development of policies and procedures to establish wasteload allocations and effluent limitations for the discharge permits for these plants. The policies and procedures are designed to address the acute and chronic toxicity to aquatic life in the estuary, and the potential impact on humans through ingestion of water, fish and shellfish.

Many of the procedures rely on mathematical models of the estuary to predict the instream concentration of a toxic pollutant under various

hydrological conditions (such as river flow and tidal stage) and loadings in wastewater sources.

The program currently is considering the use of the Cornell Mixing Zone (CORMIX) models to evaluate and size the area where wastewater effluent initially mixes with the river. These areas will be minimized to assure the protection of critical aquatic habitat, prevent lethal conditions near the discharges, and allow for a zone of passage for free swimming and drifting aquatic organisms.

A far-field, one-dimensional model of the estuary from Trenton, N.J. to Artificial Island (just downstream of the Chesapeake and Delaware Canal) also has been developed to control chronic toxicity and to predict the transport and fate of two groups of pollutants which have the greatest potential to impact aquatic life and human health. Several metals and volatile organic compounds have been targeted for further evaluation and the development of wasteload allocations using the model.

A major field study conducted during 1992 was designed to provide data on metals and volatile organic compounds to calibrate and validate the predictions of the far-field model. Two independent surveys were conducted in September and October during low river inflow and at different stages of the lunar cycle. Ambient water samples were collected at 12 sites in the estuary and at five major industrial/municipal facilities during each phase. Data from the first survey will be used to calibrate the predictions of the far-field model. The results of the second phase will be compared to the predictions of the model to verify the model's ability to project the instream concentrations of toxic pollutants.

The Commission plans to hold public hearings in 1993 on the proposed policies and procedures for both the proposed water quality criteria and implementation strategy.

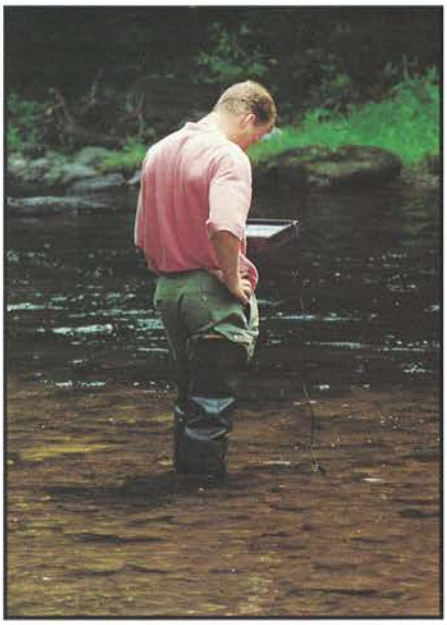
CSO Study

Data collection by DRBC staff was nearing completion at year's end in a program to study and develop control strategies for combined sewer overflows (CSOs) in the Delaware Estuary.

The data, including the location of CSO drainage areas, overflow points and land use characteristics, were provided by the Philadelphia Water Department, Gloucester City, Camden, the Camden County Municipal Utilities Authority (CCMUA), Wilmington, Chester, and the Delaware County Regional Authority.

Combined sewer overflows are common in many large cities in the United States. The sewer system which collects sanitary sewage and industrial wastewater for delivery to wastewater treatment plants is combined with the sewer system which collects stormwater runoff. When it rains, the volume of combined sanitary sewage, industrial wastewater, and stormwater runoff often is too great for the treatment plant to handle, resulting in raw sewage being discharged directly into a waterway.

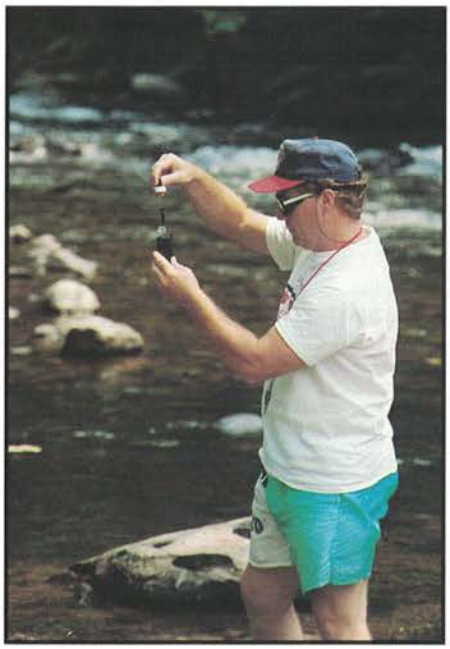
There are nearly 300 locations where combined sewers discharge to the Delaware Estuary during heavy rains. Some discharges also occur during dry weather because gates which divert the waste to the river during storm events can get stuck open.



Each summer the Commission and the National Park Service conduct a summer water quality monitoring program in the middle and upper Delaware River. Jason Smith, a Park Service volunteer, takes a conductivity reading on Flat Brook Creek, a Delaware tributary. At right, Robert Smith tests for pH levels on the same waterway. (Warren Huff)

The next phase of the study will involve water quality monitoring work, to be performed by the Delaware Department of Natural Resources and Environmental Control, the CCMUA, the Philadelphia Water Department and the City of Wilmington.

The New Jersey Department of Environmental Protection and Energy, under contract to the Commission, will use water quality simulation models to evaluate CSO pollution impacts on Delaware Estuary water



quality and will utilize the U.S. Environmental Protection Agency's storm water management model to evaluate and develop various control strategies.

The program is being funded by a $525,000 grant from the EPA.

Scenic Rivers Monitoring Program

Commission and National Park Service personnel sampled over 87 sites in the upper and middle Delaware River and its tributaries during the summer of 1992 as part of their ongoing water quality monitoring program which began in 1984.

Program personnel made approximately 700 station-visits to the sites located on the 125-mile reach of the river between Hancock, N.Y. and the Delaware Water Gap.

Fecal bacteria, dissolved oxygen, water temperature, pH, conductivity and benthic (river bed) organisms were routinely monitored. In addition, biochemical oxygen demand (BOD), Escherichia coli, nitrogen and phosphorus analyses were done for selected locations and flow measurements were made for tributaries which had not previously been gaged.

The BOD, nitrogen, phosphorus and flow data will be used in the development of a water quality model for the Special Protection Waters Program, adopted by the Commission in December of 1992. (See pg. 6 for details).

Most of the samples were analyzed at the Park Service's laboratory in the historic Pierce House near Milford, Pa. Nitrogen, phosphorus, BOD and Escherichia coli analyses were performed by a private laboratory.

A report on the 1992 findings will be released in 1993 and will be available to the public at no charge. Reports from previous years also are available.

The DRBC/NPS water quality program in the scenic rivers region augments various sampling programs conducted by state and local agencies.

Time of Travel Study

A draft report was completed during 1992 containing results of a study that used harmless dye clouds to simulate the movement of potential waterborne pollutants under varying streamflow conditions in the Delaware River.

The field work was conducted during the summer of 1991, generating data which are being used to develop computer water quality and toxic spill models for the 125-mile reach of the river from its headwaters downstream to the Delaware Water Gap. The toxic spill model will be used by emergency response agencies to predict the downstream travel time and concentrations of a hazardous spill.

The draft report, by the U.S. Geological Survey (U.S.G.S.) and the Commission, is titled "Solute Traveltime in the Delaware River, Hancock, New York, to the Delaware Water Gap Using a Conservative Dye Tracer."

The report details the travel time of the dye clouds under varying streamflows as well as the effect of reservoir releases on pollution transport. A separate report on the dispersion characteristics of the dye clouds was in the works at year's end.

During the field work, the harmless dye, Rhodamine WT, was poured into the river during parts of May and August of 1991 and samples were collected downstream. On-site fluorometers were then used to measure dye concentrations at various sampling sites, providing preliminary data on the dye's travel time and dispersion patterns.

The study was a joint effort of the Commission, the National Park Service, the U.S.G.S., the Upper Delaware Council and numerous other organizations which volunteered staff and equipment. In all, more than 120 people spent 14 days collecting and analyzing some 5,000 river samples.

Spring Rains Signal End To Drought Warning

Sixty-eight Billion Gallons of Water Saved

A drought warning which had been in effect in the Delaware River Basin for nine months was lifted June 17, 1992 as storage in major water supply reservoirs climbed to near normal levels.

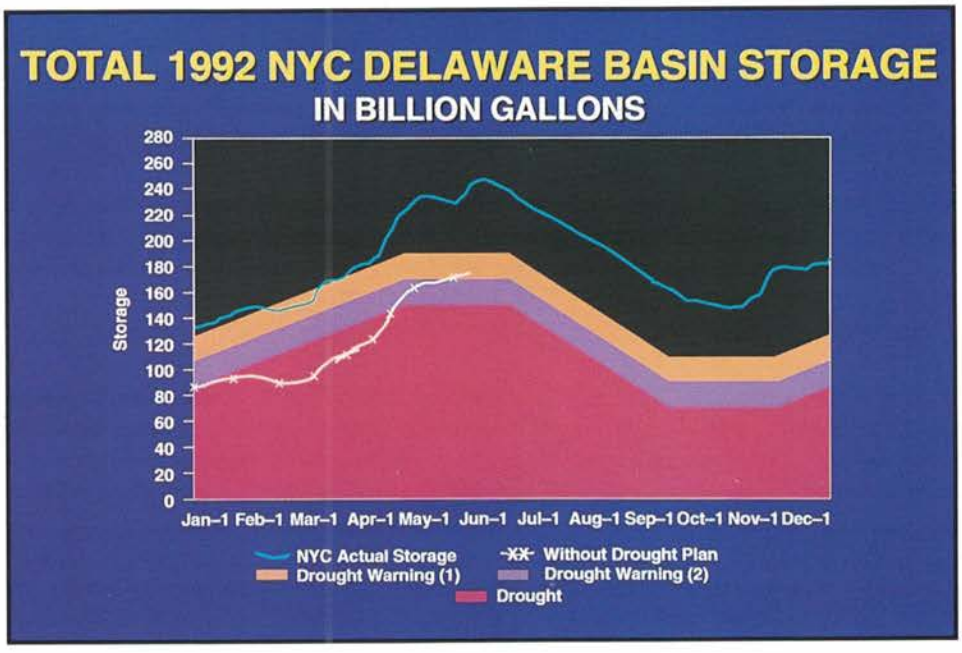
Storms during the first week of June dumped up to four inches of rain in parts of the upper basin, which was soaked days earlier by late May showers.

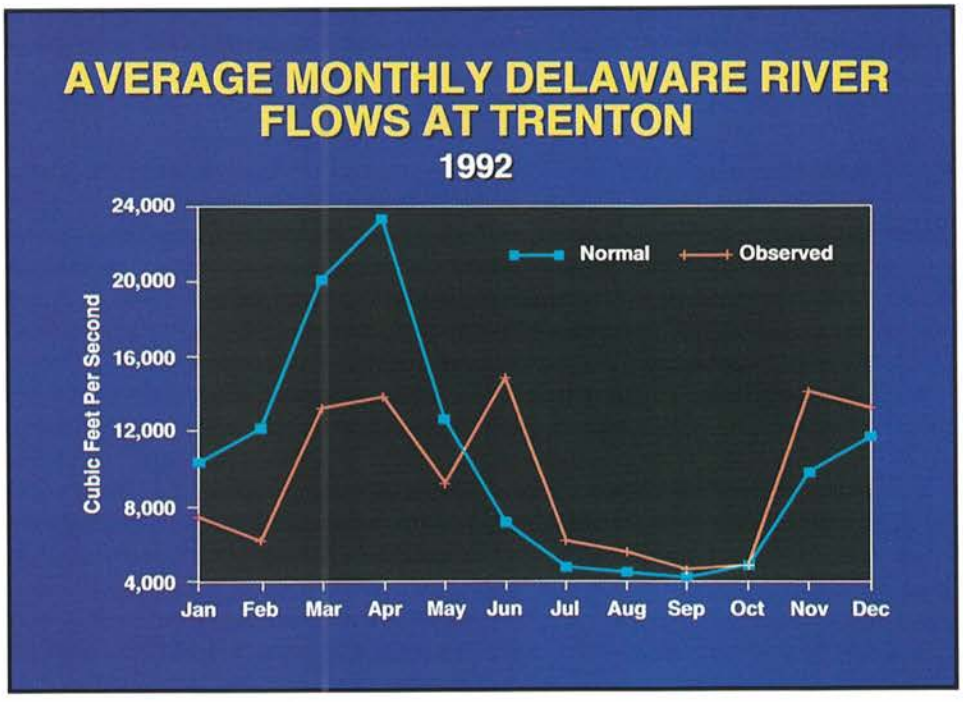
The warning, declared September 13, 1991, was the sixth in the basin in the past eleven years. Two times, in 1981 and 1985, conditions worsened and mandatory water-use restrictions were imposed under drought emergency declarations.

Had conservation steps not been taken during the latest water shortage, another emergency would have kicked in by mid-November of 1991. In all, 68 billion gallons of water were saved in reservoir storage as the result of drought management actions aimed at stretching existing supplies.

When the basin entered drought warning on September 13, the maximum withdrawal limits on out-of-basin diversions to New York City and to central and northern New Jersey were cut back by 15 percent. Streamflow objectives, which during dry times are met by releasing water from reservoirs, also were reduced.

New York City, which lies outside the Delaware Basin, draws roughly half its drinking water from the Neversink, Pepacton and Cannonsville reservoirs, located at the Delaware River's headwaters in the Catskill Mountains. New Jersey





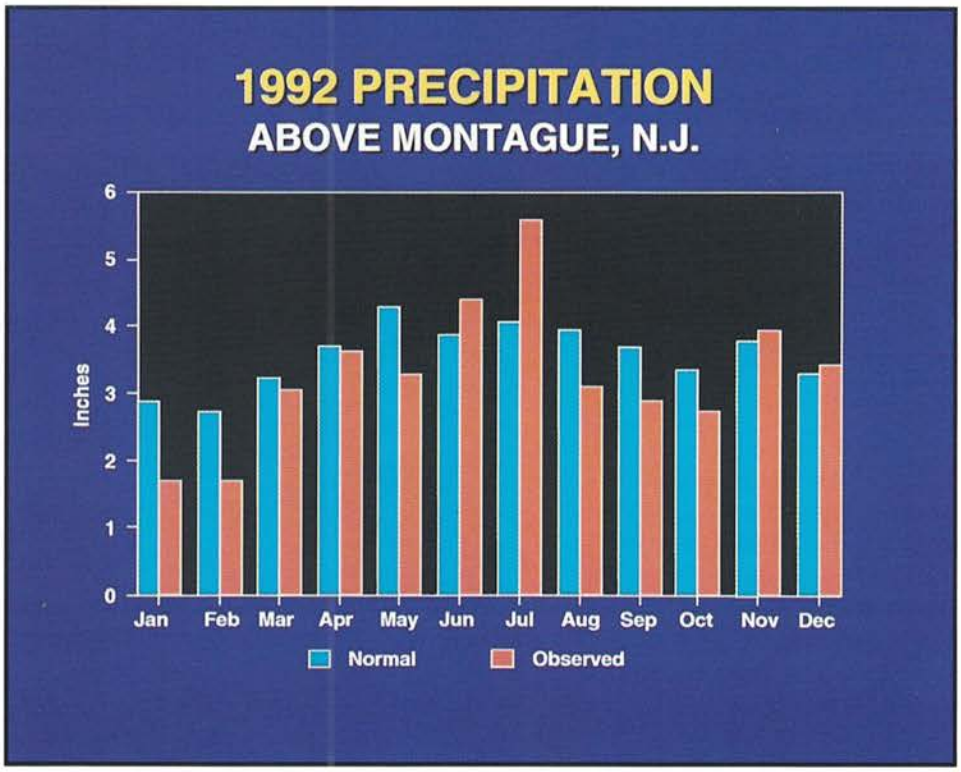
diverts water out of basin through the Delaware and Raritan Canal, which links the Delaware River north of Trenton and the Raritan River in New Brunswick.

New York's allowable withdrawal from the three reservoirs was cut on September 13 from a normal 800 million gallons a day (mgd) to 680 mgd; New Jersey from 100 mgd to 85 mgd. The minimum flow target of the Delaware River at Montague, N.J. was reduced from 1,750 cubic feet per second (cfs) to 1,655 cfs -- a reduction of about five percent.

Further cuts were agreed to on October 10 -- New York City's allowable take dropping to 560 mgd, New Jersey to 70 mgd, and the Montague flow target to 1,100 cfs, reverting back to 1,655 cfs the following two weekends to meet late season recreational demands.

Other adjustments were made to the diversion amounts and streamflow targets over the winter and into the spring of 1992 in response to changing hydrologic conditions, including the movement of salty water upriver from the Delaware Bay. The streamflow targets and withdrawal limits reverted back to normal when the drought warning was lifted.

The Commission's basinwide drought management plan, adopted in 1983, is geared to the combined storage in the three New York City reservoirs. When storage drops below a designated level depicted on a "drought warning" rule curve and remains there for five consecutive days, the basin automatically enters the drought warning mode, as it did on September 13. Further significant declines into a "drought zone" trigger drought emergency actions.



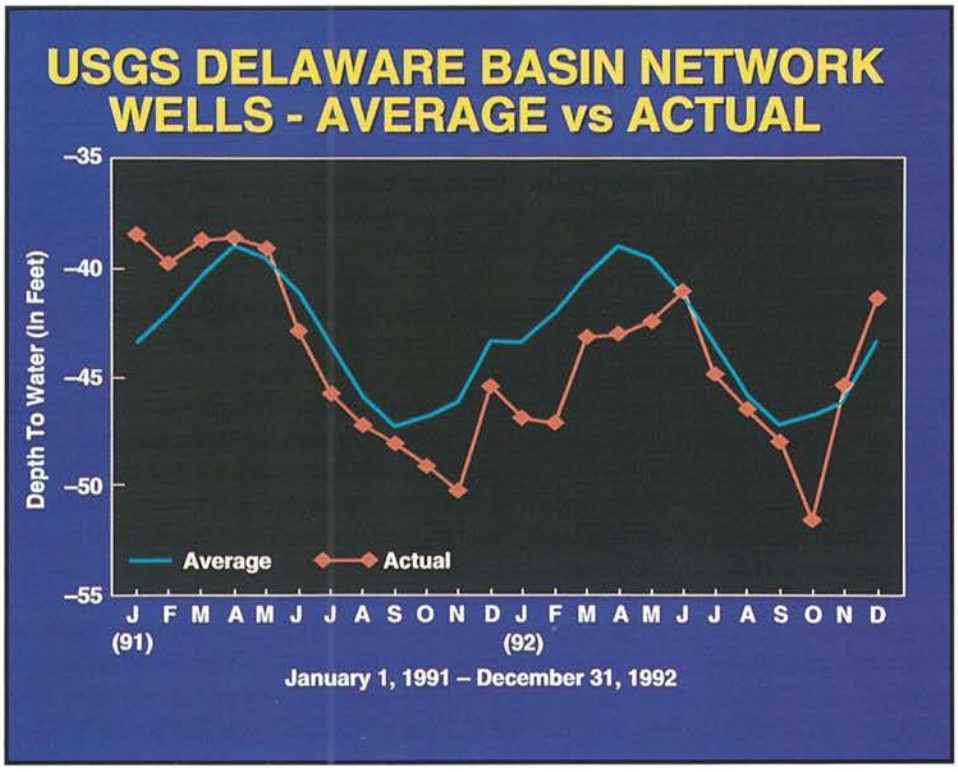
The rule curve reflects seasonal hydrology, descending in the summer when storage is expected to drop off due to reduced runoff and increased water demand, and ascending over the winter and early spring when the reservoirs normally are refilled from snowmelt and rain.

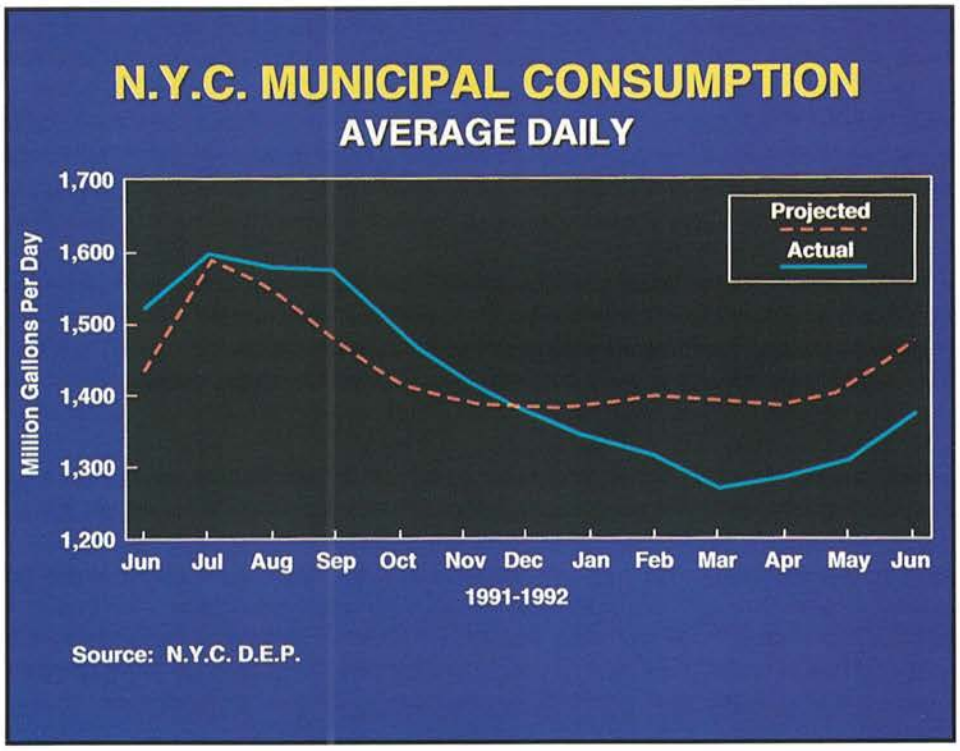
Although the drought management plan is tied to declining storage levels in the three New York City reservoirs, it is flexible in that modifications can be made based on varying hydrologic conditions in other parts of the basin. Once the plan is implemented, drought managers from the four basin states and New York City must meet every 30 days to assess conditions and make mid-course adjustments if necessary, as they did during the latest water shortage.

It's a good sign for the drought managers when the three New York City reservoirs are brimful or spilling in early June. But May and June of 1991 were dry months and storage levels fell below normal at the start of summer. They remained there for 18 months, not recovering until early December of 1992.

Basinwide there was an average precipitation shortfall in 1992 of roughly five inches, compared to a deficit of about six inches the year before.

In addition to using reservoir storage to trigger drought management actions, reservoir releases and streamflow objectives can be designed based on the location in the estuary of the so-called "salt front," defined by a seven-day average chloride concentration of 250 milligrams per liter of water.





Maximum intrusion during the drought warning of 1991-92 occurred during early November. The salty water (250mg/l isochlor), pushed by high tides from a Halloween Northeaster, migrated upstream to River Mile 86, about four miles north of Chester, Pa.

Reservoir releases and precipitation help repel the salty water which, if it advances too far north, can increase corrosion control costs for surface water users and raise sodium levels in a large aquifer underlying southern New Jersey which is used for municipal water supply. The aquifer is recharged in part by the river. The late spring rains of 1992 flushed the salt front downstream to River Mile 65, four miles south of the Delaware Memorial Bridge.

In addition to conserving water by reducing out-of-basin diversions and streamflow targets, the Commission called for voluntary water-use reductions throughout most of the watershed. Residents were encouraged to curtail such outdoor activities as lawn watering, non-commercial car washing, or hosing down driveways, patios or sidewalks -- all nonessential uses which can be highly evaporative.

In New York City, which was under its own drought warning from November of 1991 through mid-June of 1992, appeals for wise water use appeared to have been heeded.

"New Yorkers responded to our pleas for voluntary conservation by cutting their water use by 110 million gallons a day. That's a superb achievement, and one we hope to build on in the future," noted Albert F. Appleton, commissioner of the city's Department of Environmental Protection.

Even with the warning lifted, year-round water-use restrictions remained in effect in the city. The watering of lawns and the washing of sidewalks is prohibited in New York's five boroughs between November 1 and March 31, and between 11 a.m. and 7 p.m. during other months of the year. Using a hose without a self-closing nozzle for these activities, or for car washing, also is prohibited. Fines for violations start at $100.

In addition to New York City, eleven counties in the southeastern corner of New York State were under a drought warning issued by the State Department of Environmental Conservation (DEC). That warning was lifted June 17, 1992, the date DEC Commissioner Thomas C. Jorling issued his own words of caution: "As recently as 1989, Southeastern New York State was close to a drought emergency when rainfall arrived just in time to spare us from very restricted water use," he stated. "But we can't always count on such cooperation from Nature. Our communities must plan for year-round water conservation with the certainty that a drought is only as distant as the next dry spell. New York City should remain steadfast and aggressive in implementing basic water conservation programs."

In Pennsylvania, a drought emergency was declared in July of 1991 for 39 counties, including nine located either entirely or partially in the Delaware Basin, triggering mandatory water-use restrictions. Drought watches and warnings were declared in other Pennsylvania counties. The mandatory water-use bans were lifted in April of 1992.

Water Supply:

New Drought Management Plan Unveiled

The Commission held public briefings during 1992 on a revised basinwide drought management plan which assumes the availability of additional storage in the F.E. Walter Reservoir on the Lehigh River.

The plan, if adopted, would not take effect until the reservoir is expanded and would then replace the Commission's existing basinwide and lower basin drought management plans.

The briefings were held in December in Camden, N.J., Narrowsburg, N.Y. and Bethlehem, Pa.

The proposed plan is based on the premise of increased self-sufficiency in the lower basin. With the completion of the 16-billion gallon Merrill Creek Reservoir near Phillipsburg, N.J. in 1988 and the hoped for enlargement of the F.E. Walter impoundment, water supply storage below Port Jervis, N.Y. would more than double. This additional water would be used to meet future depletive uses, repel salt water intrusion, and enhance water quality and stream flows. It also would result in reduced impacts to recreation at Beltzville, Blue Marsh and Nockamixon reservoirs during times of drought.

Another benefit would be fewer curbs on water use. Computer modeling shows that under the proposed plan there is an approximate 70 percent reduction in the number of days the basin would be in drought emergency and thus be imposing mandatory, nonessential water-use restrictions like bans against lawn watering, non-commercial car washing, etc. The probability of mandatory, *essential* water-use cutbacks against municipalities and industry also would be reduced.

The F.E. Walter Reservoir is a single purpose flood control impoundment located in the Pocono Mountain region of Pennsylvania. The U.S. Congress has authorized its enlargement for water supply storage and the U.S. Army Corps of Engineers has completed an Environmental Impact Statement on plans to add the additional storage -- 22.9 billion gallons.

However, a federal reservation inserted by Congress into the Delaware River Basin Compact, which created the Commission and delineates its powers, prohibits the imposition of water use charges for water withdrawals in the basin if they lawfully could have been made without charge when the Compact was ratified in 1961. Thus, the Commission cannot charge the vast majority of water users who benefit from existing water supply reservoirs and stand to benefit from future projects like the F.E. Walter expansion.

Only federal legislation can amend the Compact to modify the "grandfather" clause. It is hoped that with the benefits of an expanded F.E. Walter Reservoir now before the public there will be a push to move legislation successfully through Congress and move forward with this important project.

A major goal of the revised plan is to retain as much as possible the existing operating rules for diversions and releases from New York City's three upper basin reservoirs. During normal operating conditions there will be no change, with some minor refinements implemented during periods of drought warning and drought emergency.

An important feature of the plan is that both the storage in the New York City reservoirs and the combined lower basin storage in F.E. Walter (once modified), Beltzville, Blue Marsh and Nockamixon reservoirs are used to determine the flow objectives of the Delaware River at Trenton, N.J.

The New York City reservoir storage would still be used as the basis to define phases of drought and trigger drought operations basinwide. In addition, a drought operations plan would go into effect if the lower basin entered drought conditions prior to a drought occurring in the upper basin. The trigger in this case would be the combined storage levels in F.E. Walter (modified), Beltzville, Blue Marsh and Nockamixon reservoirs. Nockamixon storage, however, would be used for drought management only under emergency conditions.

Other changes to the basinwide plan would be the addition of a drought watch zone, replacing the current drought warning zone on the operating curves for the New York City reservoirs. The existing drought warning and drought zones would be lowered by 40 billion gallons.

The Commission plans to hold a formal public hearing on the proposed plan in 1993, a requirement it must follow before it can take any action. Prior to that, a new set of "ballpark" water-use charging fees will be unveiled, based on the assumption the Compact has been amended so that all users in the basin pay to the extent they benefit from water supply projects.

COMPARISON OF MODELING 60 YEARS OF RECORD (10/01/27-12/31/86)

EXISTING vs. PROPOSED BASINWIDE DROUGHT MANAGEMENT PLANS

AT YEAR 2020	EXISTING PLAN	PROPOSED PLAN WITH F.E. WALTER MODIFICATION
Maximum 30-day Average Chloride at RM 98	162 mg/l	150 mg/l
New York City Vernier	Yes	No
Drought Warning/60 Years	27	14 (48% reduction of drought warning events)
Drought Emergency/60 Years	8	5 (38% reduction of drought emergency events)
Days in Drought Emergency/60 Years	4009	1213 (70% reduction of number of days in drought emergency)
Additional Recreation	No	Yes
Fisheries Enhancement	No	43% higher flow in Lehigh in worst year. Normal conservation release increases from 50 to 63 cfs at F.E. Walter. Increased frequency of normal conservation releases from Beltzville and Blue Marsh (from 80% to 95% of time).
D & R Canal Reduction in Drought Emergency	35 mgd	15 mgd
Probability of Essential Use Cutbacks	More	Less
Flood Control	No Change	Improved

Anatomy of a Drought Plan

The technical analysis for determining the reduction in frequency of drought related events as a result of the proposed basinwide drought plan was performed by the Flow Management Technical Advisory Committee (FMTAC) with the assistance of Commission staff. Committee deliberations were open to the public.

The (FMTAC) is comprised of representatives of the parties to the 1954 U.S. Supreme Court decree that apportioned the waters of the Delaware and the 1982 "Good Faith" agreement which made mid-course corrections to the court's allocation formula based on more recent hydrologic data. Those parties are the four basin states and New York City. Representatives of the federal government also attend committee meetings.

In developing the revised drought plan, computer models were used to simulate future reservoir operations and predict salinity movement in the tidal portion of the Delaware River. The flow simulation of the river and its tributaries was performed with the Daily Flow Reservoir Operation Model, originally developed by the U.S. Army Corps of Engineers, Philadelphia District.

Since its development, the model has been modified by the New York City Bureau of Water Supply, Chas. T. Main, Inc. consulting engineers and most recently by Columbia University under contract to the Commission. These recent modifications have extended the hydrologic cycle that can be analyzed from a 50-year period to a 60-year period.

The model simulates the existing Delaware Basin reservoir system including the recently completed Merrill Creek Reservoir built by Delaware Basin electric utilities to replace depletive water use at generating plants during low streamflow conditions. This model also incorporates the additional 22.9 billion gallons (bg) of storage planned for the F.E. Walter Dam. The flow regime used by the model covers the period from October 1,

1927 through December 31, 1986.

Although the drought of record occurred from 1961 to 1966, other drought events such as the one in the early 1930s also had a significant impact on the basin's water resources.

The salinity model, named the Transient Salinity Intrusion Model, is used to predict chloride levels in the estuary under the existing and proposed operating plans and was developed by Thatcher and Harleman. It was subsequently modified for the Commission by Thatcher to be applied to the Delaware Estuary.

The record drought of the 1960s was simulated in order to verify the results of the model predictions once the complete record of tidal and streamflow data was compiled by Commission staff. This model has been used extensively for planning purposes to determine the effects on salinity of various reservoir operation plans which led up to the existing basinwide and lower basin operations plans.

The model is able to predict varying salinities at 50 model points in the estuary, from the mouth of the Delaware Bay to the fall line at Trenton. Under the simulated flow conditions, chloride concentrations were predicted and then analyzed to show the maximum 30-day average concentration at River Mile 98, two miles below the Benjamin Franklin Bridge.

The Commission's current chloride standard is 180 milligrams per liter (mg/l) at River Mile 98, a point that is critical in determining the threat of increased salinity infiltration of a large aquifer underlying southern New Jersey which is used for municipal water supply. Under the proposed drought plan, with an enlarged F.E. Walter Reservoir, the chloride standard would not exceed 150 mg/l at River Mile 98 through the year 2020.

Consumptive Losses Addressed

The Commission has adopted a regulation to require the review of electric generating or cogenerating facilities in the basin that are designed to consumptively use in excess of 100,000 gallons per day of water during any 30-day period.

The regulation became effective on December 9, 1992, but its administration and enforcement will be reviewed at the completion of a survey by Commission staff to identify other users with large consumptive losses that obtain their water from secondary sources.

Water that is used consumptively is permanently removed from the basin, either through evaporation, evapotranspiration, or through incorporation into a product via a manufacturing process.

The regulation and survey were driven by plans to operate two cogeneration plants in southern New Jersey. Both plants were designed to obtain water from existing suppliers and not directly from ground or surface water sources. The Commission historically has reviewed projects involving large surface or ground water withdrawals, but, until the new regulation was adopted December 9, had not specifically addressed the oversight of any large consumptive users that purchased or obtained their water from secondary sources like municipal or regional water supply authorities.

Once the staff survey is completed and reviewed by the commissioners, the regulation will be reconsidered in light of the relative impacts of non-power plant consumptive uses in addition to the consumptive use by electric generation and cogeneration plants.

The survey was sent out in October of 1992 to 114 water purveyors distributing over one million gallons per day. At year's end, 43 replies had been received from companies serving 158 customers distributing in excess of 100,000 gallons per day. Of those, 85 were identified as users that may have high consumptive losses, including many manufacturing sites. Follow-up surveys were sent out to those customers asking for more details. Follow-up letters also were sent to the water purveyors that did not respond to the initial survey.

The Mussels Are Coming

The Commission has contributed money and staff to the Pennsylvania Department of Environmental Resources to help establish a zebra mussel monitoring program for the commonwealth and the Delaware River Basin.

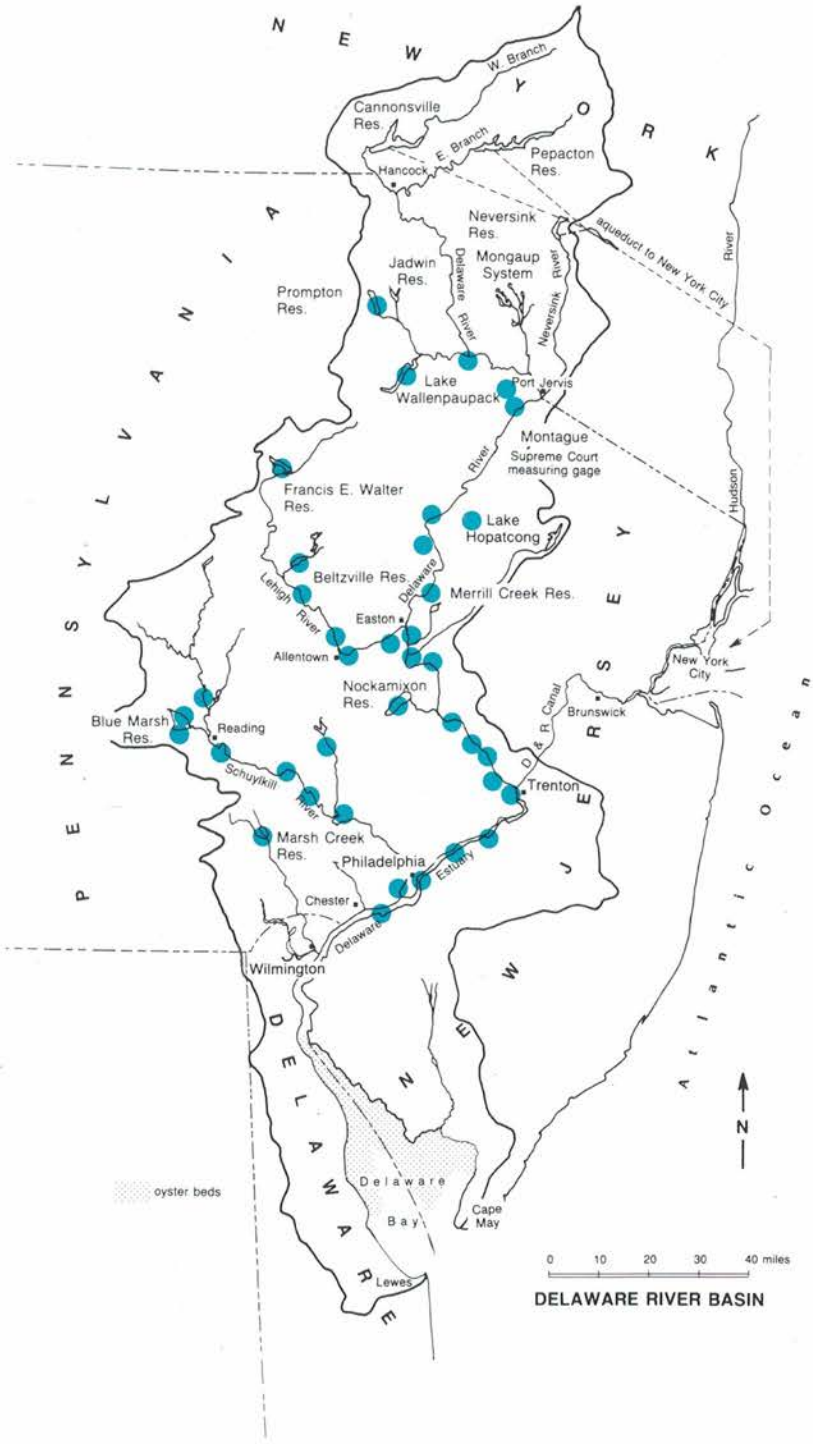
Some 40 monitoring sites were set up in the basin during 1992. At year's end no zebra mussels had been detected.

The mussels, which can clog water intakes and are expected to cost billions of dollars for industries, utilities and municipalities to control over the next decade, were introduced into the Great Lakes from Europe in the mid 1980s. They have since been spreading rapidly throughout the Midwest and eastern United States.

The mussels have been found in the Hudson River, upper reaches of the Susquehanna River, and in the Ohio River at Parkersburg, W. Va., about 80 miles from the Pennsylvania border.

To search for the mussels, small, open-sided boxes containing abrasive plexiglass panels are lowered into rivers, streams and lakes. If present, the mussels, in their free-swimming larval stage, should find the panels' rough surfaces attractive for attachment. Monitoring of the boxes is being carried out by businesses, government agencies and individuals in New Jersey, New York and Pennsylvania. Because the mussels cannot tolerate high salinity levels, monitoring is not being conducted in Delaware.

Zebra Mussel Monitoring Stations 1992

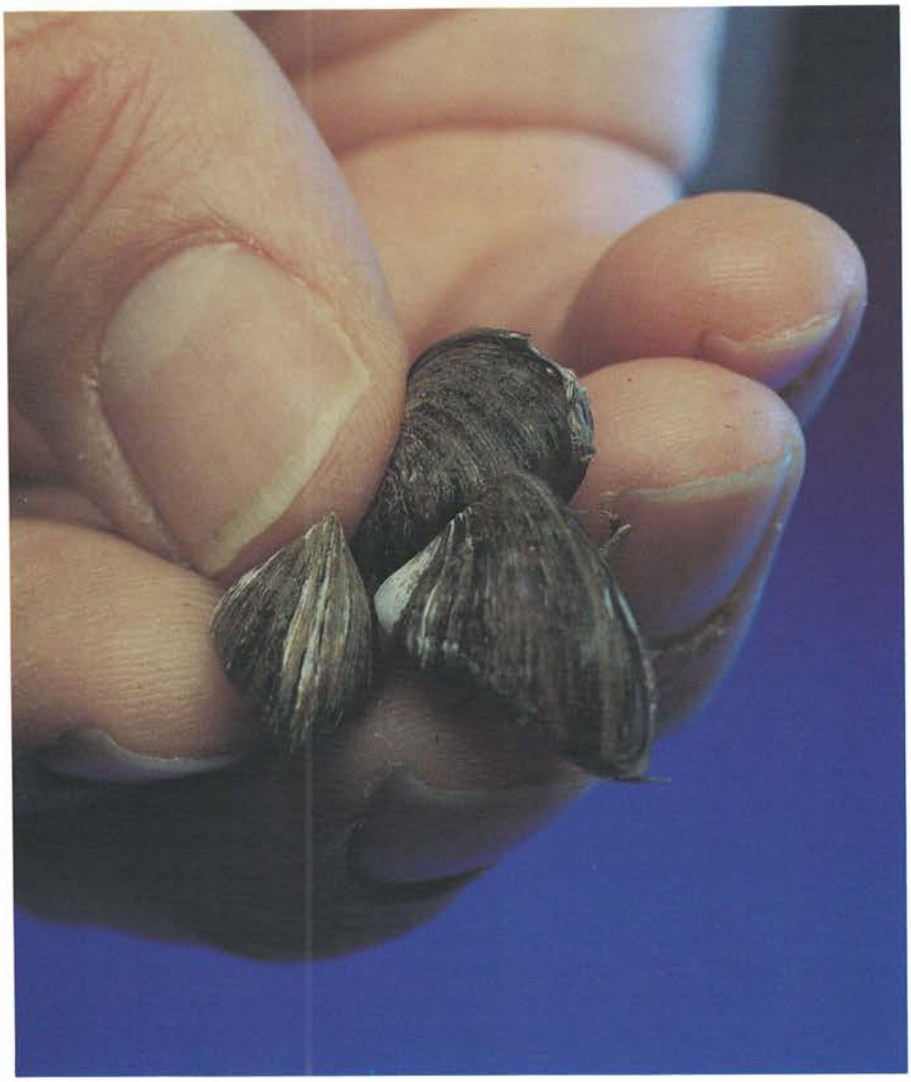


Dreissena polymorpha (that's long for zebra mussel) typically measure only about three-quarters of an inch in length and adults are identified by zebra-like lines on their shells. They reproduce at a rapid rate with an adult female producing between 30,000 and 40,000 eggs a year. They often live in dense colonies, sometimes with more than 50,000 mussels massed in a cubic meter space.

Not only do they clog intake pipes, but their hefty appetites (adults can filter about one liter of water a day) raise concerns they could effect the food chain, impacting the reproduction of fish and other species.

It is believed the first zebra mussel arrived in the United States in a ship's ballast water which was then discharged. Once established, they can be transported between waterways by attaching themselves to boats, bait buckets, outboard motors or other objects. They can live out of water for several days.

The monitoring program, suspended for the winter, will start up again in the spring of 1993 once water temperatures begin to approach 46 degrees fahrenheit.



Zebra Mussels

Basin Population on the Rise

Commission Tracks Water Use Trends

The population of the Delaware River Basin increased by 4.5 percent between 1980 and 1990, according to Census Bureau figures, with large growth spurts occurring in Pennsylvania's Pocono Mountain region and in the Philadelphia suburbs.

Analyses of U.S. Census Bureau data by Commission staff shows the basin's population rose by 312,536 over the decade with the 1990 figure standing at roughly 7.3 million people. The Delaware Basin provides water to another 9.9 million people who live outside the watershed.

In Pennsylvania, the population of Pike County, located in the heart of the Poconos, jumped from 18,271 people in 1980 to 27,966 in 1990, an increase of 53.1%. That compares to a national average growth rate of 10.2% for the period.

The populations of Monroe and Wayne counties, which flank Pike County, increased by 37.9% and 13.6%, respectively. Across the river in New Jersey, Warren County's population rose by 8.5% and neighboring Sussex County grew by 7.1%.

Overall, the population of the in-basin portion of Pennsylvania (6,469 square miles) increased by 3.0% over the ten-year span, compared to an increase of only 0.13% for the entire state. While the city of Philadelphia experienced a population dip of 6.1%, neighboring Chester County grew by 18.7% and adjacent Bucks County by 12.9%, accounting for almost one-third of the total population increase in the basin.

Growth in New York State also occurred at a faster rate within the basin (2,393 square miles) than it did statewide, notching increases of 5.9% and 2.5%, respectively.

And in New Jersey, the past decade saw a population jump of 6.9% within the basin (3,014 square miles). Statewide, the population rose by 5.0%. Cape May County was at the top of the chart with a growth rate of 23.0%.

Only in Delaware did the state growth rate outstrip the in-basin rate (11.9% to 9.6%). Of the state's three counties, Sussex grew the fastest, its population increasing by 20.6% over the ten-year period.

In all, the Delaware River Basin takes in 12,755 square miles. While it drains only 0.4% of the total continental U.S. land area, almost seven percent of the nation's population relies on the waters of the basin for drinking and industrial use.

* * *

As there have been shifts in the basin's population over the years, there also have been changes in water use trends.

In 1986, the Commission adopted a regulation that requires all large water users (those withdrawing over 100,000 gallons per day during any 30-day period) to meter and report their water withdrawals. The new requirement became effective January 1, 1987. The data obtained from this regulatory program are being used to develop patterns of water use and to improve estimates of consumptive use - the loss of water from the basin either through evaporation, evapotranspiration or through incorporation into a product via a manufacturing process.

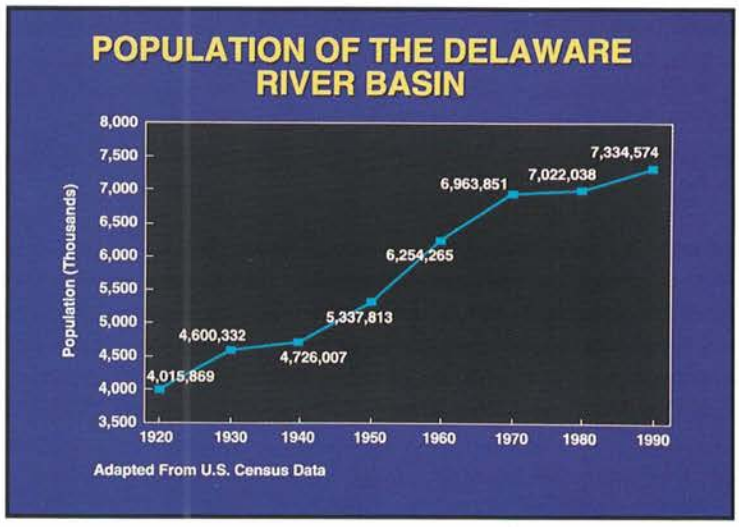


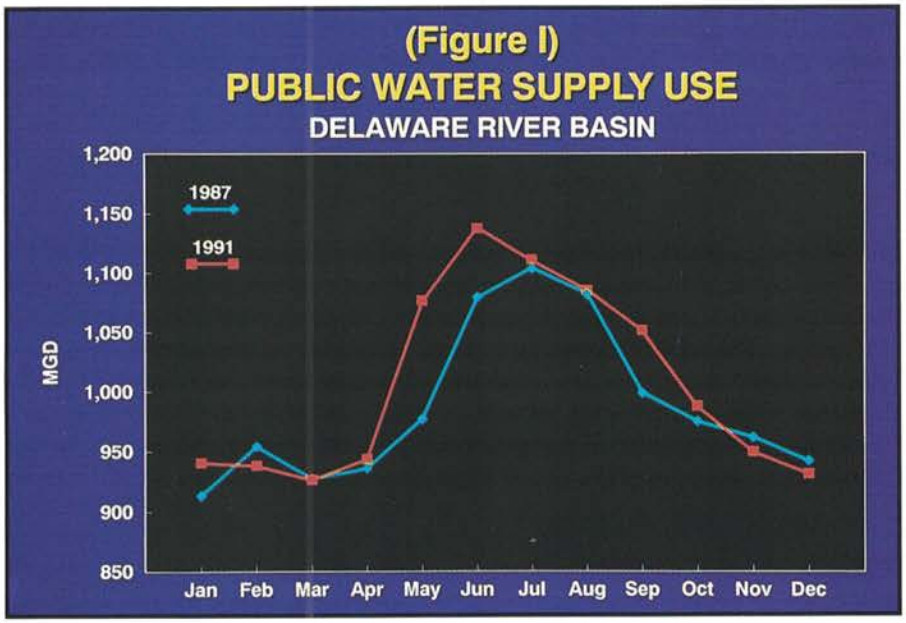
Figure I compares public water supply use in 1987 and 1991. The year 1987 was a relatively normal one in terms of temperature and precipitation; 1991 was hot and dry. Winter water use for both years was almost identical, varying only 0.1% for the period November through April.

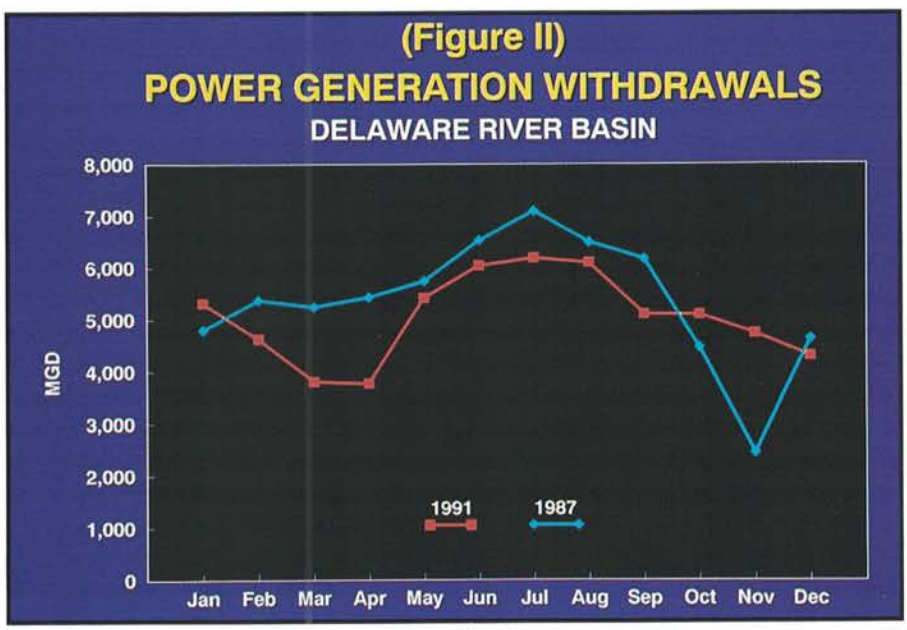
The majority of the winter water use in the public sector is residential. It is anticipated that despite increasing population growth, winter water use will decrease in the coming years as a result of Commission water conservation regulations requiring low flow plumbing fixtures and fittings.

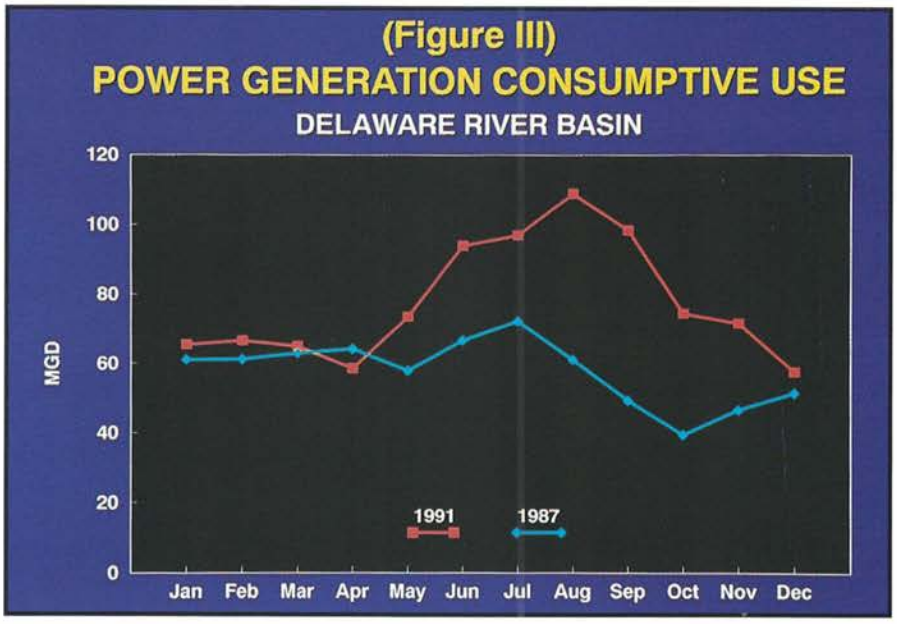
In contrast, water use over the summer (June through September) varied considerably. Commission staff estimated summer consumptive water use during 1987 at 157 million gallons a day (mgd), compared to an estimate of 195 mgd for 1991, a year when the temperature exceeded 90 degrees on approximately 30 days in much of the basin. In the Philadelphia area there were 53 days when the mercury topped 90.

Additional demands for water during hot dry years for such uses as lawn and garden watering and air conditioning create these seasonal spikes. This is of concern to the Commission because much of the water used during these periods is consumptive, and therefore, not available for re-use or instream flow protection.

Figure II depicts water withdrawals for power generation. In both 1987 and 1991, withdrawals peaked during the summer months to meet







increased demands, especially increased usage of air conditioning. Figure II also shows that total withdrawals decreased between 1987 and 1991. (The drop off in withdrawals in the fall of 1987 was caused by the temporary shutdown of a power plant.)

This trend in decreasing withdrawals by power plants mirrors a national trend brought about by a greater reliance on closed-cycle cooling systems and the use of cooling towers as opposed to once-through cooling systems which require more water to operate.

Figure III depicts estimated peak seasonal consumptive water use at basin power plants. Not surprisingly, consumptive use increased significantly during the hot summer of 1991. In fact, the 1991 figures exceed estimates for power generation consumptive use for the year 2000 contained in the 1981 Level B Study, conducted by the Commission to identify and resolve water resource problems in the basin.

Fortunately, the water that is evaporated through power generation can now be made up during dry spells by releasing water from Merrill Creek Reservoir, the basin's newest impoundment located just off the Delaware River near Phillipsburg, N.J. The 16 billion-gallon pump storage facility, completed in 1988, was built by a consortium of electric utilities at the direction of the Commission. Once the basin enters drought warning and flows fall below the normal Trenton objective of 3,000 cubic feet per second, the utilities must release water from the impoundment to make up for evaporative loses at their riverbank generating stations.

During the late summer and fall of 1991, when the basin was in drought warning, releases totaling 2.2 billion gallons were made from the reservoir.

Conservation:

Saving Water Through Retail Pricing

The Commission has approved a regulation which promotes the adoption of retail water pricing to encourage conservation and which requires water companies to submit conservation plans with applications for new or expanded withdrawals.

The regulation is the latest component in the Commission's long-range program to reduce water use throughout the 13,000 square-mile basin.

The conservation plans must describe how the water purveyors have implemented DRBC water-saving regulations already on the books, including requirements for metering programs to track water usage and programs to identify and fix leaky distribution systems.

Water companies applying to the Commission after June 30, 1992 for new or expanded withdrawals of one million gallons per day or more also must complete an evaluation of the feasibility of implementing a water conserving retail pricing structure and billing program.

The conservation plans are subject to review and approval by the basin state environmental agencies in which the water delivery system is located: the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, the New York Department of Environmental Conservation, and the Pennsylvania Department of Environmental Resources.

The regulation took effect January 22, 1992, the day it was adopted.

Water conserving rate structures provide incentives to customers to reduce average or peak water use. And they reflect the fact that water is a limited resource that should be used in an economically efficient manner.

Such pricing is characterized by rates based on metered usage with one or more of the following components:

- Rates in which the unit price of water increases as the quantity of water used increases (increasing block rates) or is constant regardless of the quantity of water used (uniform rates);

- Seasonal rates or excess-use surcharges to reduce water usage during summer months when demands peak;

- Rates based on the long-run marginal cost or the cost of adding the next unit of water supply to the system.

A non-conserving pricing structure provides no incentives to consumers to reduce water use. Such pricing may be characterized by one or more of the following components:

- Rates in which the unit price of water decreases as the quantity of water used increases (decreasing block rates);

- Rates that involve charging customers a set fee per unit of time (i.e., $40 per month) regardless of the quantity of water used (flat rates).

Although the regulation is relatively new, it appears to be taking hold. Many water purveyors in the basin have recently adopted, or are considering adopting, rate structures with built-in incentives to save water, with the increasing block rate being the most popular method of pricing.

It should be noted that the new regulation recognizes that a charging schedule with different rates for different customer classes (e.g. residential, industrial, commercial and institutional) can qualify as a water conserving rate structure.

The regulation was based on recommendations from the Commission's Water Conservation Advisory Committee, which worked closely with the public utility commissions in the four basin states in shaping its proposal.

Low Flow Plumbing

A mounting number of Pennsylvania municipalities have adopted local ordinances to comply with a Commission regulation setting performance standards for water-saving plumbing fixtures and fittings in new construction and renovations.

Unlike the three other basin states, Pennsylvania, at year's end, did not have a statewide plumbing code requiring the water conserving fixtures - 1.6 gallon-per-flush (gpf) toilets, and low-flow urinals, shower heads, sink and lavatory faucets. Consequently, it has fallen on the 505 Pennsylvania municipalities within the basin to adopt their own ordinances pending enactment of a statewide law.

As of December 31, 1992, 260 of the 505 municipalities had adopted and submitted ordinances which received Commission approval.

The Commission's regulation was passed January 13, 1988 and amended a year later to require 1.6 gpf toilets, instead of 3.5 gpf models, effective January 1, 1991. By January 1, 1992, Delaware, New York and New Jersey had statewide water conservation requirements on the books which met the Commission's standards.

In the Spring of 1991, the Commission notified the 505 Pennsylvania municipalities that they were responsible for enacting their own ordinances.

The regulation stipulates that in-basin Pennsylvania municipalities seeking permit approval or renewal for water supply or wastewater discharge projects from the Commission must document that ordinances meeting the Commission's requirements have been adopted within their jurisdictions.

The Commission began to enforce this provision of the regulation in June of 1992.

The enactment of statewide water conservation legislation in Pennsylvania was addressed during 1992. Senate Bill 1674, sponsored by Senator Richard Tilghman, was unanimously adopted by the state Senate. However, a companion measure, House Bill 2918, sponsored by Representative Ellen Harley, was never formally considered by the House Conservation Committee. It is expected the two lawmakers will introduce new bills in 1993.

Water Conservation Takes to the Highways

Water conservation in the home can help stretch a valuable resource as well as the family budget.

It's a concept that an increasing number of water utilities in the Delaware Basin are beginning to promote, particularly purveyors with a limited supply of water to go around.

And in Delaware, state government has gotten involved. The Department of Natural Resources and Environmental Control (DNREC) has hooked up with the Artesian Water Company in a program committed to reducing water use in houses, apartments and hospitals in New Castle County. The goal is to reduce consumption by 100 million gallons a year with participating customers seeing water-use savings of 15 to 20 percent.

The program is funded with a $155,000 grant from DNREC and $118,200 in matching funds from Artesian, which serves more than 50,000 customers.

A "ConserVan" travels throughout Artesian's service area with company technicians conducting household water audits to detect costly leaks and installing water-saving devices such as faucet aerators, low-flow shower heads and toilet dams.

Customers who sign up early receive the audit and water-saving devices free of charge. Others also can receive free audits and may purchase the conservation kits for a discounted price.

"This program offers a tremendous opportunity for Artesian and the state to make a significant impact on our environment," notes Dian Taylor, Artesian's president. "Our partnership will be beneficial to the long-term, well-being and growth of New Castle County."

Artesian Water Co. also has instituted a new pricing structure which encourages water conservation by charging increasing prices for increased water use. And it has a rebate program for customers who purchase and install Low Flush toilets (1.6 gallons per flush or less).

In Pennsylvania, the Valley Forge Sewer Authority also is pushing conservation. The Authority has sold thousands of water saving starter kits at discounted prices to its customers and uses its quarterly newsletter to underscore the benefits of using water wisely.

Borrowing words from the American Water Works, the Authority noted in its spring 1992 edition of *Pipeline*: "Toilets should not be used as trash cans to flush away tissues, gum wrappers, cigarette butts, spiders, diapers, or anything else that ought to go in a wastebasket or garbage can. Imagine pouring three two-gallon buckets of water on a tiny spider or piece of tissue. Ridiculous!"

Artie and Little Squirt, Artesian's Conservation Team

The Water Works

A Place Wondrous to Behold

By Christopher M. Roberts

(EDITOR'S NOTE: Philadelphia's Fairmount Water Works, site of the world's first high-pressure steam engine, is a symbol of man's technological triumphs and environmental mistakes. It served up water to a growing city for nearly a century, a cure for one generation's pollution, victim of another's.)

* * *

In the year 1793 it wasn't unusual to detect a whiff of camphor or vinegar in Philadelphia's air. It was thought the odors warded off the deadly yellow fever.

There was filth in the streets and not enough water to wash it away. And what little water there was came from the city's wells, by then fouled with waste from nearby cisterns (drains) and cesspools.

"In Philadelphia everyone has a cistern and a well, and the two are becoming indistinguishable," Benjamin Franklin had noted four years earlier.

Franklin, upon his death in 1790, willed the city 100,000 pounds to develop an abundant supply of water to "insure the health, comfort and preservation of the citizens."

Abandoning its ground water supplies, the city looked to its rivers for help.

Engineer Benjamin Henry Latrobe recommended tapping the Schuylkill, distributing water through a network of bored spruce and pine pipes. Two pumping stations were built, one at the Chestnut Street wharf, another at Centre Square where City Hall now stands.

By the end of 1801, the Schuylkill was supplying water to 63 homes, four breweries and a sugar refinery.

But the two small pumping stations couldn't meet the needs of a growing city. The crude boilers often broke down, the pumps stopped, and then the fear of fire filled the air.

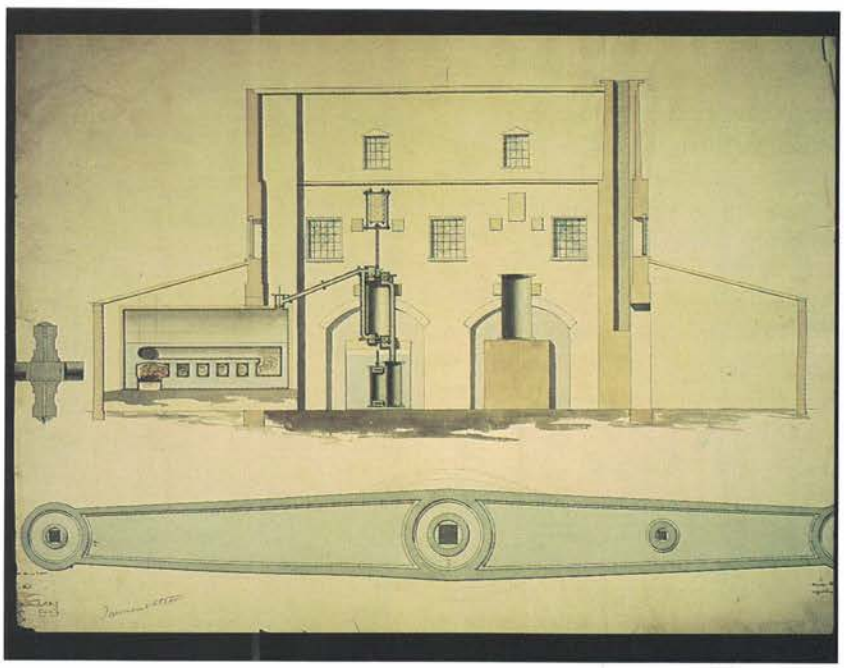
Philadelphia's Watering Committee searched for answers. In 1805, Frederick Graff, who had apprenticed under Latrobe, set out to design a larger water works on the banks of the Schuylkill at the foot of "Faire Mount," a rocky bluff that towered over the rest of the city.

From the blueprints emerged a collection of Federal and Greek revival buildings which first housed two hissing, wood and coal-eating steam engines and later giant water wheels and turbines powered by the river itself.

The buildings were surrounded by formal gardens creating a refreshing mix of new technology and old world charm. Painters and photographers captured the grace. Pictures of the stately buildings and the river, dotted with boats, appeared in 19th Century ads for ice skates, on firemen's hats, sheet music, pottery, porcelain and gilded vases.

Noted Charles Dickens after a visit from England in 1842: "In Philadelphia there is a place that is wondrous to behold, and that is the Philadelphia Waterworks."

Graff served as superintendent of Fairmount until his death in 1847, to be succeeded by his son, Frederic Graff, Jr. Both recognized the threat to water quality from upstream development and convinced the city to acquire buffer land on both sides



The interior of the Water Work's engine house, completed in 1815, showing the boiler, steam engine and pump. Original drawing by Frederick Graff. (Courtesy of the Franklin Institute Science Museum)

of the Schuylkill. In time the Water Works was surrounded by an 8,900-acre park, today the largest city park in the world.

Construction of the Fairmount Water Works began on August 1, 1812 and was completed three years later. A single Federal-style building housed the two steam engines, one a back-up. A reservoir was built atop the bluff, its earthen walls nearly as tall as the roof of the Philadelphia Museum of Art which sits there today.

Water was pumped up to the three-million gallon impoundment (later enlarged to hold 38 million gallons), then flowed by gravity through the expanding network of wooden pipes to the city below. By 1817, some 3,500 homes and businesses were receiving water from Fairmount, but at considerable cost. It took up to 20 cords of wood a day to fire the cranky boilers which exploded twice, killing three men.

It was time to find a more reliable and cheaper energy source. Why not harness the Schuylkill with a dam and use the river's power to meet the growing demand for water?

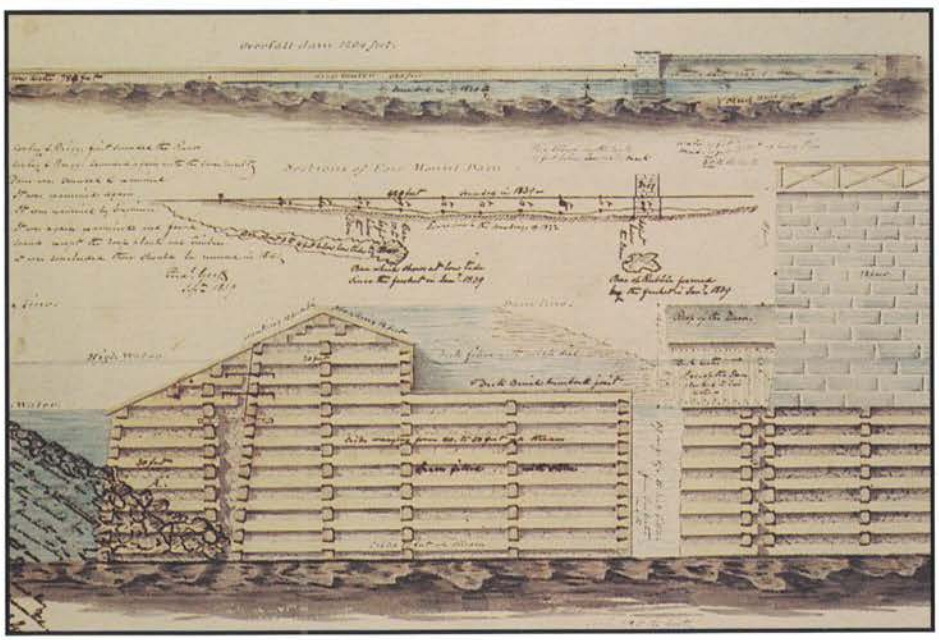
In 1819 an agreement was struck between the city and the Schuylkill Navigation Company for the city to build a dam at Fairmount and purchase the rights to the water power. In return, the city constructed a canal and locks on the far side of the river for the navigation company, agreeing to maintain a sufficient water level in the slackwater pool behind the dam for lockage.

The dam, built of hickory log cribs, was completed in July of 1821. A mill house was constructed to house the water wheels which would drive the pumps. Gates were installed to control the flow of water diverted by the dam into the forebay or mill race, carved from rock behind the new building.

The first water wheel went into operation on July 1, 1822, supplementing the steam driven pumps. Four months later the steam engines were shut down and later sold for scrap. The engine house was turned into a public saloon, serving refreshments to those who came to marvel at the new machinery from a spectator's gallery erected inside the mill house: the mammoth wheels driven by the water pouring through the rear of the building from the forebay, the connecting rods at the wheels' hubs driving the pistons in the pumps which lifted the captured water through pipes to the reservoir, the free water flowing back to the river through portals cut into the front wall of the building.

Thomas Ewbank, an inventor and manufacturer, described a visit to Fairmount in 1840:

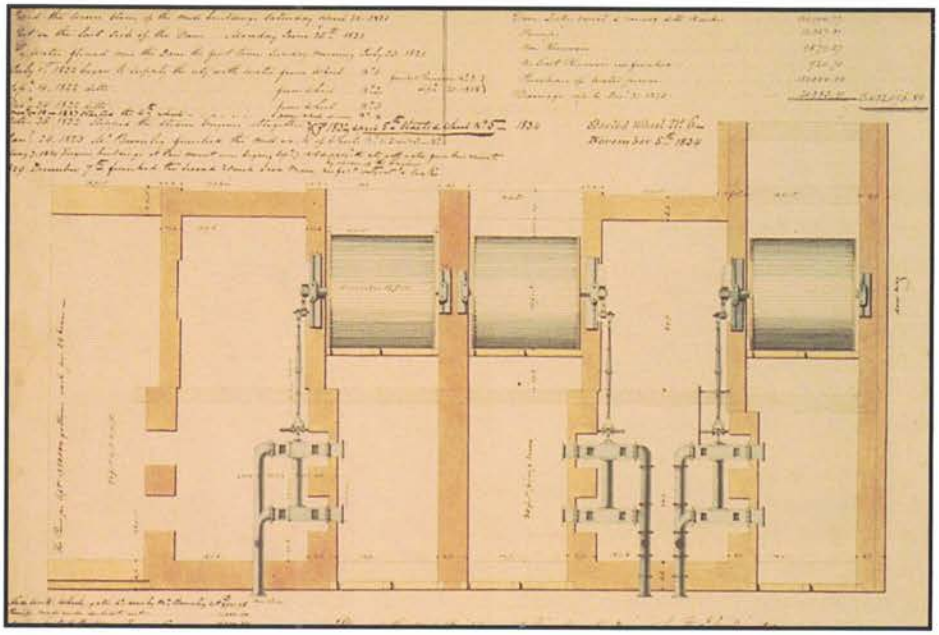
"It is impossible to examine these works without paying homage to the science and skill displayed in their design and execution; in these respects no hydraulic works in the Union can compete, nor do we believe they are excelled by any in the world. Not the smallest leak in any of the joints was discovered; and, with the exception of the water rushing on the wheels, the whole operation of forcing up daily millions of gallons into the reservoirs on the mount, and thus furnishing in abundance one of the first necessaries of life to an immense population -- was performed with less noise than is ordinarily made in working a smith's bellows!"



A Frederick Graff drawing of a section of the crib dam at Fairmount. (Courtesy of the Franklin Institute Science Museum)

Eight water (or breast) wheels were in operation by 1843 and the Water Works was now supplying 28,000 customers an average of 5.3 million gallons of water a day. And it was pretty cheap water. It cost $29,713 to operate the Water Works in 1844, compared to $30,858 spent in 1819, mostly on the 3,650 cords of wood consumed that year by the two hungry steam engines.

The city was turning a profit and it was using the money to buy up more land along the river. Gazebos and fountains were added to the gardens and a dock was built just upstream of the dam for the passenger steamboats that churned to Manayunk.



Plans of "Faire Mount's" water wheels and pumps. Original drawing by Frederick Graff. (Courtesy of the Franklin Institute Science Museum)

In 1853, Mark Twain, then an 18-year-old typesetter at the Philadelphia Inquirer, described the splendor of Fairmount in a letter to his brother back in Hannibal, Missouri:

"Unlike New York, I like this Phila amazingly, and the people in it. ...I went to the Exchange yesterday, and deposited myself in a Fairmount stage, paid my six-pence, or 'fip' as these heathen call it, and started. We rolled along until we began to get towards the outskirts of the city, where the prettiest part of a large city always is. ... We arrived at Fairmount. I got out of the stage and prepared to look around. The hill, (Fairmount) is very high, and on top of it is the great reservoir. After leaving the stage, I passed up the hill till I came to the wire bridge which stretches across the Schuylkill (or Delaware, darned if I know which!...). This is the first bridge of the kind I ever saw. Here I saw, a little above, the fine dam, which holds back the water for the use of the Water Works. It forms quite a nice water-fall. Seeing a park at the foot of the hill, I entered -- and found it one of the nicest little places about. Fat marble Cupids, in big marble vases, squirted water upward incessantly. Here stands in a kind of mausoleum, (is that proper?) a well executed piece of sculpture, with the inscription -- 'Erected by the City Council of Philadelphia, to the memory of Peter [i.e. Frederick] Graff, the founder and inventor of the Fairmount Water Works.' The bust looks toward the dam. It is all of the purest white marble. I passed along the pavement by the pump-house (I don't know what else to call it) and seeing a door left open by somebody, I went in. I saw immense water wheels ... There was a long flight of stairs, leading to the summit of the hill. I went up -- of course. But I forgot to say, that at the foot of this hill a pretty white marble Naiad stands on a projecting rock, and this, I must say is the prettiest fountain I have seen lately. A nice half-inch jet of water is thrown straight up ten or twelve feet, and descends in a shower all over the fair water spirit. Fountains also gush out of the rock at her feet in every direction. Well, arrived at the top of the hill, I see nothing but a respectable-sized lake, which is rather

Nymph with Bittern fountain figure originally carved from pine by William Rush in 1809 for the Centre Square pumping station. It was moved to Fairmount Water Works in 1827. The statue was cast in bronze in 1872. (Gelatine print by William Nicholson, c. 1895. Collection of the Library Company of Philadelphia)

out of place in its elevated situation. I can't say I saw nothing else, either: -- for here I had a magnificent view of the city."

By the mid-19th Century the Fairmount Water Works was being heralded as one of the most efficient and successful municipal water supply systems both in the United States and abroad. Yet there was a glitch at Fairmount -- the water wheels sat idle for several hours each day, swamped at high tide.

To fix the problem, the younger Graff installed an experimental French turbine which operated in conjunction with the water wheels. Because the turbine's two horizontally mounted wheels were encased in a vertical watertight cylinder it was unaffected by tidal flows.

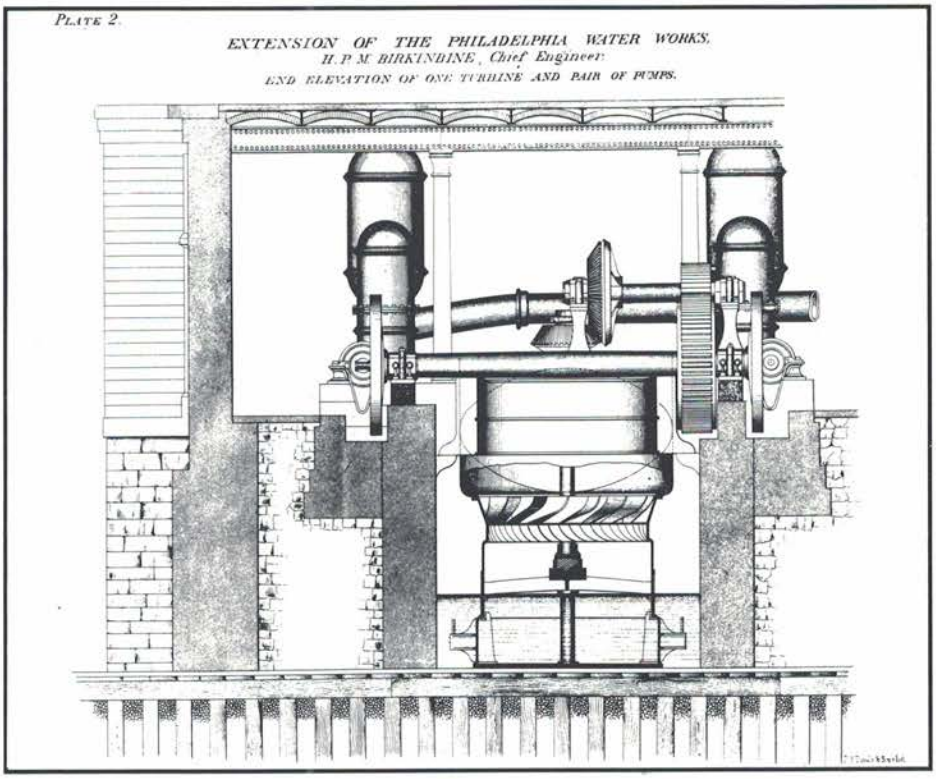
A new mill house was built and a pump room added and by the early 1870s the eight water wheels had been replaced with six Jonval turbines.

There was another problem, however, that wasn't so easy to fix.

The Schuylkill River was becoming polluted.

The buffer land that would form the biggest city park in the world wasn't big enough to protect the Water Works. The pollution flowed downstream from Schuylkill Valley coal mines and dairy farms and from upriver towns like Pottsville, Reading, Pottstown, and Conshohocken.

Again, fresh technology would be called on to remedy this latest environmental threat, but the Water Works would be left out of the scheme. Five pumping stations with sand filtration beds to purify the river water were placed in operation near



A Jonval turbine flanked by two pumps. (Courtesy of the Philadelphia Water Department)

the turn of the century. Fairmount, hugging the river and hemmed in by the rocky outcropping, did not have room for the beds.

It closed its doors in 1909, having supplied the city with water for 94 years.

But that's not the end. Two years later the Fairmount Water Works reopened as the Philadelphia Aquarium. Sea lions and seals splashed in the forebay. Fish tanks lined the walls of the mill house. The aquarium closed in 1962, but not before a debutante named Fish chose the site for her coming out ball.

The walls of the reservoir were torn down in 1924 and the Art Museum was built.

For a while a restaurant operated on the brick deck of Fairmount's old mill house and a public swimming pool, built the same year the aquarium closed, was located inside. The pool, constructed with funds from the John B. Kelly family, was used until 1973.

A lot of water has tumbled over Fairmount Dam since Frederick Graff picked his spot on the Schuylkill and built a water works which received worldwide acclaim for its engineering ingenuity and architectural charm.

Today, the Water Works sits mostly idle. The steam engines, the water wheels, the fish, Miss Fish, the swimmers, the diners, they're gone.

But there's a Jonval turbine left. And it's been restored. And the old mill house has been stabilized and

renovated and the large brick deck above it has been refurbished. An Interpretive Center has opened in the pump room of the engine house where educational programs are conducted.

Over $7 million has been raised for the restoration work by private charitable groups, local corporations and government agencies.

The U.S. Department of the Interior has declared the Fairmount Water Works a National Historic Landmark as have two professional engineering societies. Historical reports on its technology and architecture are deposited in the Library of Congress.

"It's quite a place," notes Ed Grusheski, a public affairs officer with the Philadelphia Water Department and the Interpretive Center's director. "Frederick Graff had a vision which mixed machines and Mother Nature and in doing so caught the attention of the world. Through our restoration work we hope to recapture all we can of that noble experiment."

George Lehman's 1842 watercolor depicts the eight arched openings through which the water exited the Water Works after driving the water wheels, and later the turbines. Note the stairs leading up to the reservoir atop "Faire Mount." To the right is the canal built by the City of Philadelphia for the Schuylkill Navigation Co. (Courtesy, CIGNA Museum and Art Collection)

A Staffordshire serving dish depicting the Fairmount Water Works. (Courtesy of the Philadelphia Water Department)

A sincere thank-you to Mr. Grusheski for the help he provided for this article. For more information on the Water Work's restoration efforts or on the Interpretive Center, he can be contacted at the Philadelphia Water Department: ARA Tower, 1101 Market St., Philadelphia, Pa. 19107.

Other Basin Highlights

Ice Jam Project Moves Ahead

Local cooperation agreements needed to secure funding for a project to reduce ice jam flooding on the Delaware River in the Port Jervis, N.Y. area were signed during 1992.

The Commission also began the process of acquiring real estate easements by retaining a surveyor to identify right-of-way boundaries on Mashipacong Island, the project site.

Once identification of the boundaries has been made, the easements will be appraised for fair market value and then purchased so that an ice diversion channel can be created by clearing trees along a 200-foot wide path along the island's back channel. The easements also will provide access to the project site for annual maintenance work.

The Commission already has an access permit from the National Park Service which owns property both on Mashipacong Island and on the New Jersey mainland where a habitat and wetlands mitigation site will be established to offset the loss of trees.

The local cooperation agreements were signed in June between the Commission and the Commonwealth of Pennsylvania, New York State, three municipalities in the project site area and the U.S. Army Corps of Engineers.

The agreements provide funding for the Commission, the project's sponsor, to undertake the acquisition of the real estate easements which the Corps needs prior to awarding construction contracts for the diversion channel and the mitigation site.

Total price tag for the project is $1.46 million.

Flooding in the Port Jervis area in 1981 caused severe damage and claimed one life. The Delaware River rose 14.5 feet in one hour as the result of ice which jammed against Mashipacong and Thirsty Deer Islands, which then acted as makeshift dams.

The next year the Commission, through Congress, requested that the Corps conduct a study of the flooding problem. The Commission agreed in 1986 to act as the project's sponsor after the Corps indicated the creation of the diversion channel on Mashipacong Island was environmentally sound and economically feasible.

* * *

One of the outgrowths of the 1981 flood was the establishment of an ice jam monitoring program for the Upper Delaware River. Observations of ice formations by the National Park Service and others along the river have been used by the National Weather Service's River Forecast Center to prepare river ice-condition bulletins. The bulletins, which detail existing ice jam locations and warn of potential jams and resultant flooding, are carried on the NOAA weather wire and broadcast over selected NOAA weather radio channels accessible to Delaware Basin residents.

Flood Stage Mapping

The Commission kept working its way upstream during 1992, completing flood stage forecast mapping for the Delaware River from the Scudders Falls Bridge (River Mile 139.5) above Trenton north to Holland Township, N.J. (River Mile 172.5) above Milford, N.J. Mapping for the final reach in the study, between Holland Township and Belvidere, N.J., is expected to be completed in 1993.

The U.S. Army Corps of Engineers, Philadelphia District, began the project in 1990, mapping the reach between Trenton and the Scudders Falls Bridge. The Commission since has been working under contract with the Corps to complete the study, which was requested by the New Jersey Department of Environmental Protection and Energy and the Pennsylvania Emergency Management Agency.

The flood stage forecast maps draw from topographic mapping and aerial photography. The maps are designed to identify areas of potential inundation based on flood stage forecasts generated from rising river gage readings and anticipated rainfall.

The National Weather Service broadcasts the river stage forecasts over NOAA weather radio and communications networks maintained at county and state emergency operations centers.

Once mapping on the Delaware River mainstem is completed, the Commission expects to assist the Corps with a similar flood stage mapping project for the Lehigh River.

DRBC Lends a Hand

The Delaware River Basin Commission participated in a U.S.-sponsored program during the fall of

1992 aimed at helping eastern European countries deal with environmental problems.

The program is run by the U.S. Environmental Protection Agency under the Support for Eastern Europe Democracy Act.

Gerald M. Hansler, the Commission's executive director, joined officials from EPA, the Environmental Law Institute, and the Middlesex County (N.J.) Sewerage Authority on an 11-day trip to Bulgaria to inspect and offer advice to Bulgarian officials on ways to upgrade their water resource programs. Areas of concentration included municipal waste treatment and water supply, industrial waste control, beach pollution, and water resources management on a watershed basis. Recommendations on ways to correct Bulgaria's pollution problems were presented at a three-day Bulgarian Water Law Seminar.

"Mr. Hansler's presentations at the seminars and his discussions with various wastewater treatment plant managers and Ministry officials provided the hands-on experience of an individual who deals with the administrative and fiscal responsibilities associated with the management of a complex river basin," noted EPA Administrator William K. Reilly on the group's return. "His straight-forward comments on mechanisms and budgets of the Commission provided the Bulgarian participants with a unique opportunity to analyze for themselves the proposed changes to their laws and systems."

Cannonsville Valve

The New York State Department of Environmental Conservation and New York City have agreed to install a variable flow valve at the Cannonsville Reservoir to increase the range of releases from the impoundment.

Cannonsville Reservoir

The $5.5 million cost of the project will be split between New York State and the city, with the state's share limited to $546,000.

The reservoir currently can only release water at a rate of 45 cubic feet per second (cfs) or less, or at 325 cfs. The new valve will enable releases to be made at increments between 45 and 325 cfs, resulting in tighter control of flows in the Delaware River.

The Cannonsville Reservoir, part of New York City's water supply system, is located on the West Branch of the Delaware just upstream of the village of Deposit. It was financed and constructed by the city and placed in operation in 1967.

Design work on the installation of the new valve was well along at year's end. Once completed, the city will hire a contractor to perform the work which is expected to take about two years.

Award Winners

The Delaware River Basin Commission was the recipient of two awards during 1992 for its work in river management.

The Upper Delaware Council presented the Commission with its Certificate of Merit at a banquet at Glen Spey, N.Y. on March 7. It was the third year in a row that the commission had won the award.

In presenting the certificate, the Council singled out the Commission for its Delaware River study to simulate the movement of potential waterborne pollutants under varying streamflow conditions and efforts to protect existing high water quality in the middle and upper reaches of the river.

Congressman Benjamin A. Gilman of New York also awarded the Commission a certificate for its role in Council programs.

Financial Summary

Statement of Revenues and Expenditures-General Fund

Year Ended June 30, 1992

REVENUES	**Budget**	**Actual**
Signatory parties:		
State of Delaware	$253,500	$253,500
State of New Jersey	510,000	510,000
State of New York	269,600	246,700
Commonwealth of Pennsylvania	625,400	625,400
United States	475,000	470,500
Water Pollution Control Grant	240,000	240,000
Reimbursement of overhead-Agency Fund	35,000	35,000
Sale of publications and sundry	9,000	23,993
Project review fees and other income	110,000	130,290
Interest income	80,000	80,470
Fines and assessments	53,000	23,289
Working capital and reserve for physical plant	102,100	0
TOTAL REVENUES	$2,762,600	$2,639,142
EXPENDITURES		
Personal services	$1,664,500	$1,627,050
Special and contractual services	155,000	137,406
Other services	61,900	55,833
Supplies and materials	58,000	55,559
Space	140,500	123,378
Communications	38,200	36,339
Travel	32,000	26,695
Maintenance, replacements and acquisitions	157,000	162,915
Equipment rental	21,000	18,971
Fringe benefits and other	434,500	480,942
TOTAL EXPENDITURES	$2,762,600	$2,725,088
Excess (deficiency) of revenues over expenditures	$0	($85,946)
Other financing sources:		
Operating transfers in	$0	$276,785
Operating transfers out	0	(5,005)
Total other financing sources	$0	$271,780
EXCESS OF REVENUES OVER EXPENDITURES	$0	$185,834

Schedule of Changes in Special Projects Advance/(Receivable) Balance - By Project

Project	Advance Balances July 1, 1991	Cash Receipts (A)	Transfers	Expenditures (B)	Balances at June 30, 1992
Advances:					
Ground water-PA Protected Area	$37,259	$229,600	($69,091)	($131,231)	$66,537
Salinity-U.S. Army Corps of Engineers	13,226	—	—	(6,343)	6,883
USGS Monitors	879	28,880	78,052	(107,811)	0
Nutrient Study	2,359	—	(2,359)	—	0
Zone II Dissolved Oxygen	1,238	—	(1,238)	—	0
Delaware Fish Study	851	—	(851)	—	0
Ground Water-Withdrawal Fees	1,135	—	(1,135)	—	0
Subtotal advances	$56,947	$258,480	$3,378	($245,385)	$73,420
Accounts Receivable:					
Toxics Management Study	$0	$101,503	($60,161)	($124,106)	($82,764)
Delaware Estuary-PA	—	73,422	(2,515)	(86,425)	(15,518)
Ichthyoplankton Study	—	—	—	(32,667)	(32,667)
Delaware Estuary-EPA	3,413	424,800	(24,808)	(517,100)	(113,695)
Upper Delaware Ice Jam	—	—	—	(805)	(805)
Dispersion Study	5,410	25,200	(19,733)	(13,677)	(2,800)
Comp CSO Assessment	—	—	—	(17,548)	(17,548)
Daily Flow Model	79,406	10,000	(94,894)	(20,887)	(26,375)
Subtotal Accounts Receivable	$88,229	$634,925	($202,111)	($813,215)	($292,172)
Totals	$145,176	$893,405	($198,733)	($1,058,600)	($218,752)

(A) Cash receipts were derived from:

United States Government	$460,000
Commonwealth of Pennsylvania	359,651
State of New Jersey	44,874
Third party fees for services	28,880
Total	$893,405

(B) Expenditures were primarily for payroll costs and contractual services.

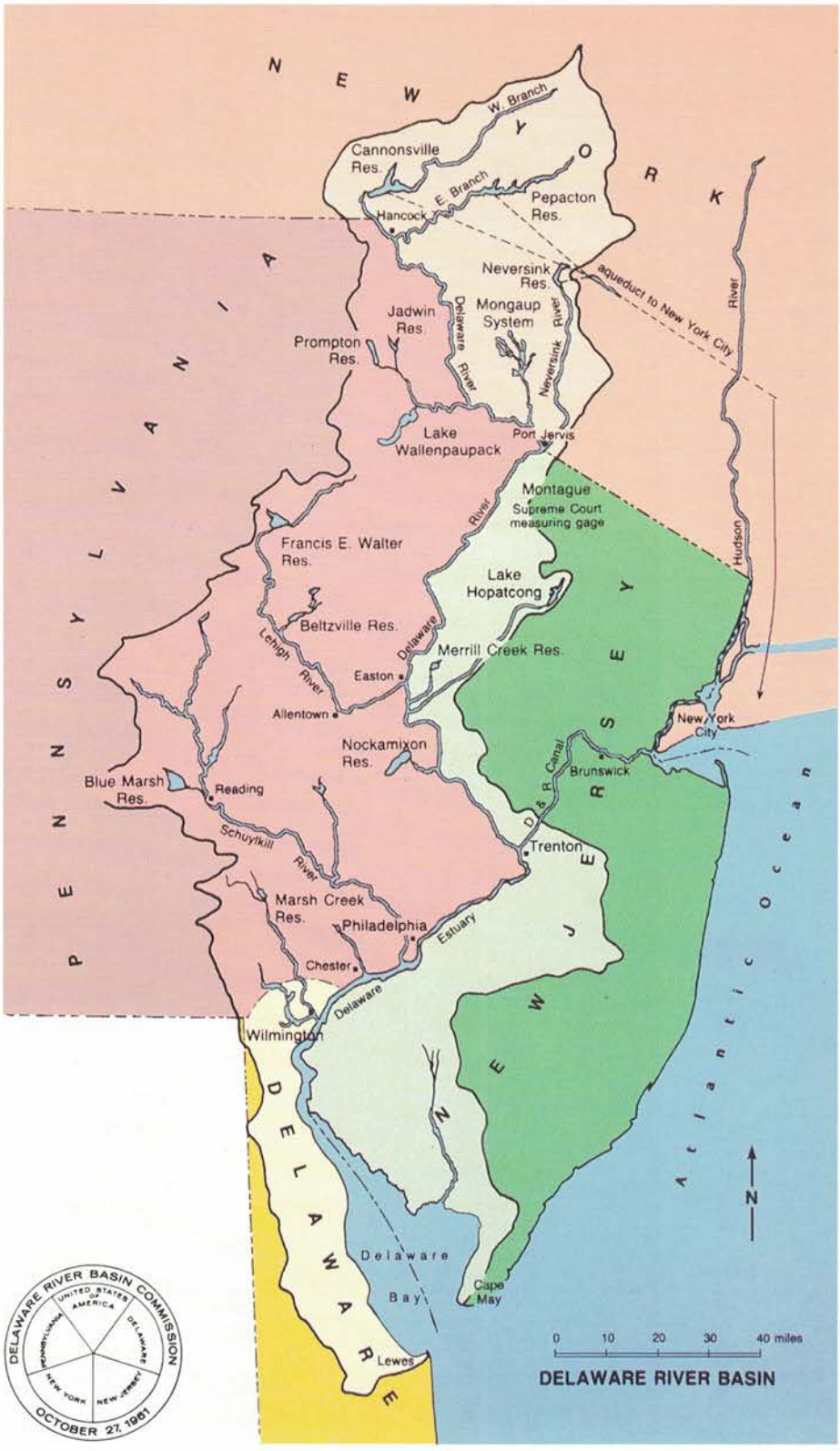
The records of the Commission are audited annually as required by the Commission's Compact.

Statement of Revenues and Expenditures-Capital Projects

Year Ended June 30, 1992

REVENUES	**Budget**	**Actual**
Commonwealth of Pennsylvania	$25,000	$25,000
Water Charges	1,350,000	1,331,446
Interest Income	190,000	254,733
Western Berks-Facilities Use	20,500	20,500
TOTAL REVENUES	$1,585,500	$1,631,679
EXPENDITURES		
Debt Service on Projects	$862,000	$861,142
Operation and Maintenance Cost on Projects	235,000	159,071
Administrative Cost	148,100	130,953
TOTAL EXPENDITURES	$1,245,100	$1,151,166
Excess of revenues over expenditures (Budgetary Basis)	$340,400	$480,513

NOTE: Debt services and operating and maintenance costs are for the Beltzville Reservoir Project and the Blue Marsh Reservoir Project. Payments are made to the United States Army Corps of Engineers.


NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
W. Branch
Cannonsville Res.
E. Branch
Pepacton Res.
Hancock
Neversink Res.
aqueduct to New York City
Jadwin Res.
Mongaup System
Delaware River
Neversink River
Prompton Res.
Lake Wallenpaupack
Port Jervis
Hudson River
Montague
Supreme Court measuring gage
Francis E. Walter Res.
Lake Hopatcong
Beltzville Res.
Lehigh River
Delaware
Merrill Creek Res.
Easton
Allentown
New York City
Nockamixon Res.
Blue Marsh Res.
Reading
D & R Canal
Brunswick
Schuylkill River
Trenton
Marsh Creek Res.
Philadelphia
Estuary
Chester
Delaware
Wilmington
Atlantic Ocean
N
Delaware Bay
Cape May
Lewes
0 10 20 30 40 miles
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