WASHINGTON AREA 1999

DROUGHT OPERATIONS

Interstate Commission on the Potomac River Basin
6110 Executive Boulevard, Suite 300
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October 1999
Report No. 99-6

This report was prepared by the Interstate Commission on the Potomac River Basin, Section for Cooperative Water Supply Operations on the Potomac. Funds were provided for this report by the Washington Suburban Sanitary Commission, the Washington Aqueduct Division of the U.S. Army Corps of Engineers, and the Fairfax County Water Authority. The opinions expressed are those of the authors and should not be construed as representing the opinions or policies of the United States or any of its agencies, the several states, the Commissioners of the Interstate Commission on the Potomac River Basin, or the water utilities.

Introduction

Most of the residents of the Washington metropolitan area rely on the Potomac River as their primary source of drinking water. This summer marked the first year that stored water has been used to augment the natural flow of the Potomac River for water supply purposes. Cooperative operations among the Interstate Commission on the Potomac River Basin (ICPRB) and the area's three major water utilities ran smoothly, and the augmented flow of the Potomac provided all the water required by the utilities.

Sound planning by the ICPRB and the utilities has resulted in a system that can currently meet the demands for water even during a drought much worse than has been recorded. The drought management plans include a mechanism for alerting local jurisdictions of a need for water use restrictions in the event that stored supply would not meet demand. The ICPRB staff closely monitored river flow conditions throughout the drought and were in daily contact with the water supply utilities. However, these alert levels were never reached during this year's drought.

The summer's drought operations did highlight some needed enhancements to the system. Some parts of drought operations have been modified based on data collected and events that occurred during the summer.

This report is intended to provide factual information on the nature of water supply drought operations in the metropolitan area and provide a basis for continuing efforts for the provision of a safe water supply for the region's residents independent of climatic conditions in the area.

The Metropolitan Water Supply System and its Cooperative Solution to Drought

A separate water utility serves each major jurisdiction in the metro area (Figure 1). The U.S. Army Corps of Engineers Washington Aqueduct Division (WAD) wholesales water to the District of Columbia and portions of suburban Virginia. The Maryland suburbs in Montgomery and Prince George's counties are served by the Washington Suburban Sanitary Commission (WSSC). Most of the Virginia suburbs are served by the Fairfax County Water Authority (FCWA). The two suburban utilities own reservoirs that do not fill from the Potomac (the Patuxent and Occoquan reservoirs) and are regularly used in combination with Potomac withdrawals to meet demand. The Potomac is the sole source of supply for WAD.

Generally, water supply withdrawals from the Potomac are a tiny fraction of the river's flow. Average flow of the river over a year is about 7 billion gallons per day (bgd); average summer demand by the utilities on the river is about 500 million gallons per day (mgd), or 0.5 bgd. Under normal conditions, the utilities operate independently of each other.

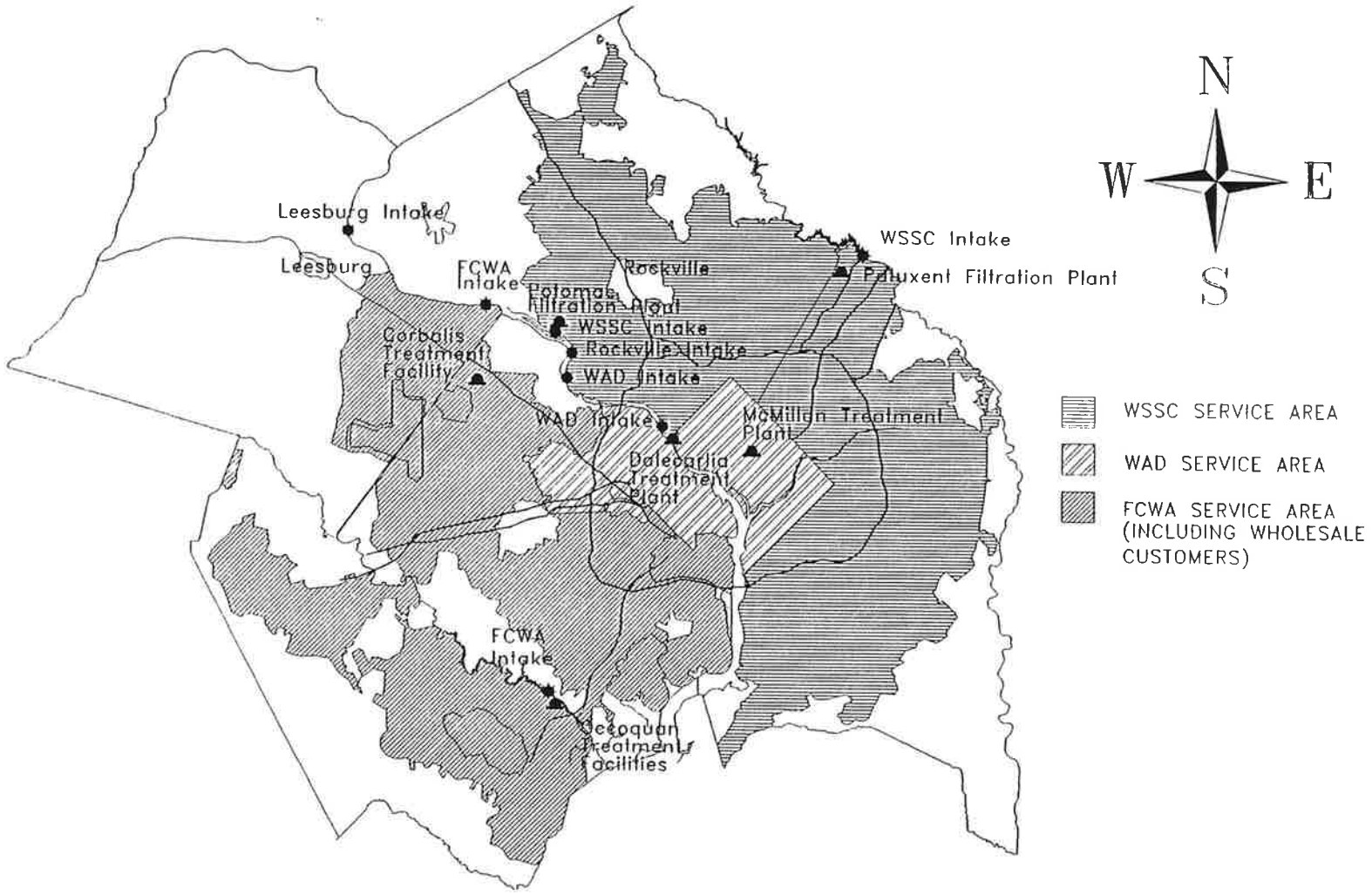

Figure 1: Washington, DC metropolitan area water supply service areas

The Potomac's flow can vary greatly, hitting an all-time low of about 388 mgd at the Little Falls stream gage in September 1966. (At that time, water demand from the Potomac was about 300 mgd) The Potomac had hit troubling low flows prior to that time, prompting studies that had once recommended construction of 16 dams throughout the basin to supply water and control flooding. Public opposition to the plan ended in the authorization of just one dam, creating in 1981 the Jennings Randolph Reservoir on the Potomac's North Branch in western Maryland and West Virginia. The utilities collectively purchased more than 13 billion gallons of storage in the reservoir for use as the metro area's water "savings account" to protect against drought conditions.

WASHINGTON AREA WATER SUPPLIERS

***Washington Suburban Sanitary Commission**. Primarily serves portions of Montgomery and Prince George's counties, Md. Average total demand (from both the Potomac and reservoirs) is about 166 million gallons per day (mgd). Its Potomac River intake is near Potomac, Md.

***Fairfax County Water Authority**. Primarily serves portions of the northern Virginia suburbs. Average total demand (both Potomac and a reservoir) is about 116 mgd Its Potomac River intake is near Great Falls, Va..

***U.S. Army Corps of Engineers Washington Aqueduct Division**. Primarily wholesales water to the District of Columbia, and Arlington and Falls Church, Va. Average demand is about 183 mgd Potomac River intakes are at Great Falls and Little Falls.

At the same time, the three utilities realized that management of the river during low flows would be required to meet demands as the region grew. Research begun at Johns Hopkins University in the late 1970s developed a basis for use of the stored water in a way that would allow for cooperative operations during droughts while meeting growing demands well into the next century.

The result was a series of agreements among the utilities that set operating rules for the use of storage at Jennings Randolph Reservoir and the Little Seneca Reservoir built later in Montgomery County, Md., and determined how operations would be coordinated so that all the utilities could meet demands. The ICPRB CO-OP Section was designated as the managing agency for the operations. Each utility realized that by giving up some of their power to make operating decisions, each could meet their demands and collectively meet the demands of the region.

The Water Supply Coordination Agreement was developed among FCWA, WSSC, WAD, and the Interstate Commission on the Potomac River Basin (ICPRB). The ICPRB was designated in the agreement to be responsible for coordination of water resources during times of low flow. ICPRB manages river flow to ensure that the flow meets or exceeds environmental flow recommendations established in a 1981 Maryland Department of Natural Resources study, and to meet utility demands in the Washington metropolitan area. The management objectives embodied in the agreement and practiced by ICPRB are to keep the off-Potomac reservoir resources balanced while meeting the environmental flow requirements and municipal demands for water. The coordinated operation of the resources allows the regional water suppliers to meet demands without imposing restrictions through at least the year 2015 even under a repeat of the

drought of record. This is possible because of synergistic gains in total yield realized under the cooperative management strategies.

The Low Flow Allocation Agreement (LFAA) was developed in 1978 prior to development of the Potomac water supply reservoirs. The LFAA provides for an equitable allocation of Potomac River flows among all users in times of shortage, i.e., in the unlikely event that Potomac storage is unavailable.

The three regional water suppliers' decision to seek a joint solution to the water supply shortage through ICPRB has made it possible to provide an adequate water supply for the Washington metropolitan area. The means of achieving this end not only satisfy the water demands; they are hundreds of millions of dollars less costly than previously proposed courses of action.

Washington's Water Supply Assets

The system of reservoirs shared by area utilities to augment Potomac River flow during drought conditions is dynamic and complex. The system's flexibility, when actively managed, allows water utilities to meet unrestricted demands during times of low Potomac River flows.

The three major regional water suppliers have collaborated to pay for storage in Jennings Randolph Reservoir and Little Seneca Reservoir, at an original cost of more than $96 million dollars plus annual operation and maintenance costs since construction. In addition, WSSC and FCWA own the Patuxent and Occoquan reservoirs, respectively. The following are the major components of the metropolitan water supply system (Figure 2).

Shared Resources

- **Jennings Randolph Reservoir.** This reservoir is the area's "savings account." It holds 13.4 billion gallons (bg) of water supply storage that is owned by the three utilities. Releases are directed by ICPRB CO-OP based on existing and projected utility demand, status of other reservoirs, and weather conditions. The reservoir is some 200 miles upstream of the utilities' intakes, and releases take more than a week to travel to them.
- **Little Seneca Reservoir**. This smaller reservoir, which stores 4.0 bg that is owned by the three utilities, is used to "fine tune" the larger releases from Jennings Randolph, which then can be operated more conservatively. Located in Montgomery County, Md., releases take less than a day to reach the utilities' intakes.

Other Assets

- **Patuxent Reservoirs**. The WSSC operates two reservoirs in the neighboring Patuxent River watershed. Total usable storage at these reservoirs is about 10.4 bg. The utility uses this stored water in tandem with Potomac withdrawals throughout the year.
- **Occoquan Reservoir**. The FCWA operates this reservoir on the Occoquan River. The reservoir contains about 8.2 bg of total usable storage, which is used in tandem with Potomac withdrawals.

Jointly and individually owned resources

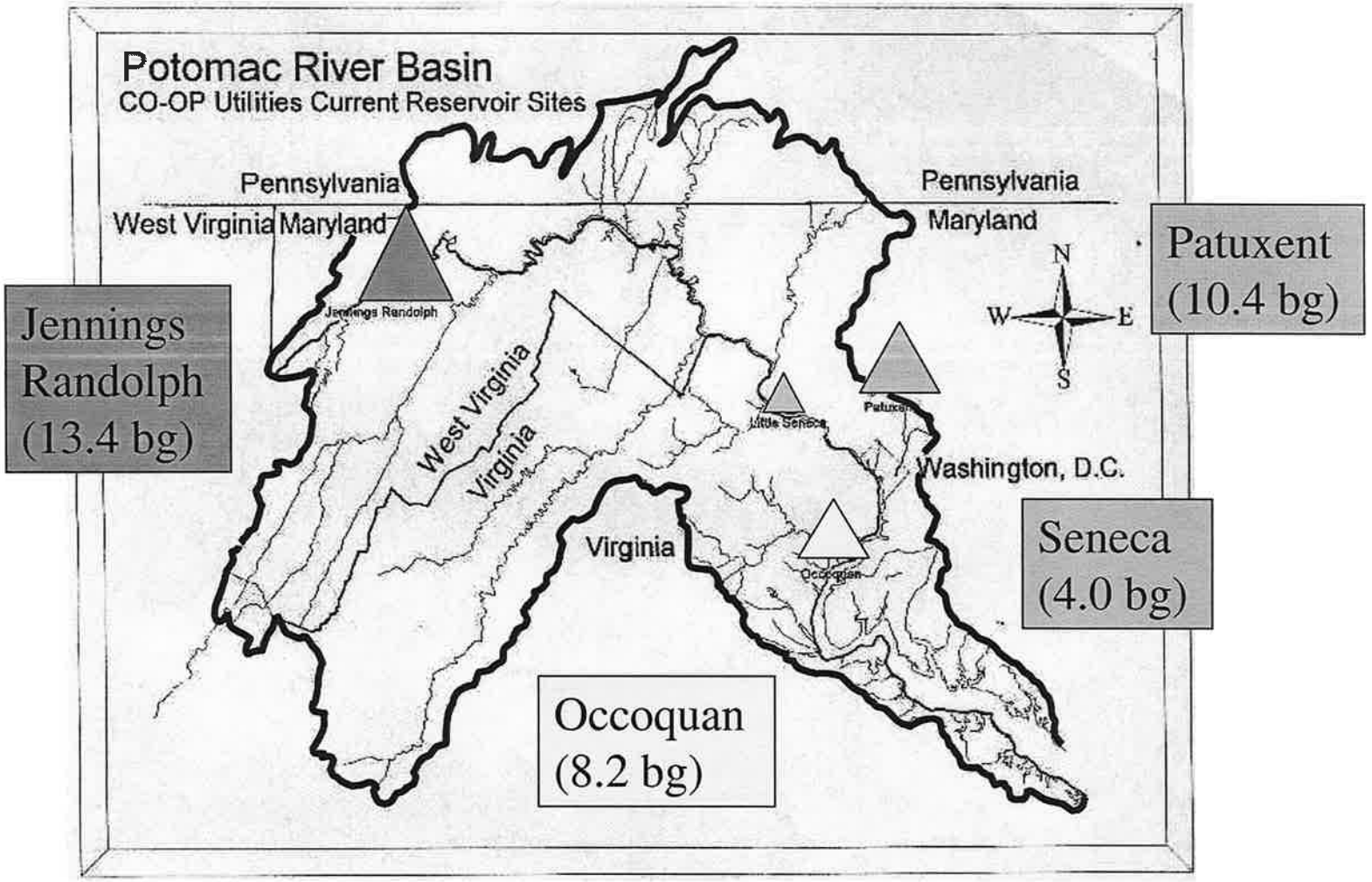

Figure 2: Washington water supply reservoirs

These reservoirs add great flexibility to the system. During drought operations, the two suburban utilities can be asked to increase or decrease their off-Potomac withdrawals to meet changing needs in the river, such as maintaining minimum flow conditions downstream of the Potomac intakes or ensuring adequate supplies to the Washington Aqueduct Division, which has no off-river storage.

Reliability of metro water supply (How much water do we have?)

The Washington metropolitan area depends primarily on the free-flowing Potomac for most of its water. Even under the worst-case flows, the Potomac can meet both recommended environmental flow targets and water supply withdrawals for most of the year (figure 3). Demands are potentially higher than Potomac flow for only a relatively short period of time (four months) from about mid-July through early-November.

The drought brought with it questions about the reliability of the area's water supply. The most-asked question has been, "*If the drought continues, how much water do we have left?*" The answer to this straightforward question is complex. An answer given in days, which has been the answer sought by the bulk of the inquiries, is based on estimating many variables, including reservoir storage levels, demand for water, weather and soil conditions, river flows, and other factors. Because of the dynamics of the system, these variables change on a daily basis. An answer given today could be considered misleading or wrong several weeks or even days later. People are interested in the methods used to reach conclusions, yet it is difficult to explain the system without giving a short course in hydrology. How can the strength and resiliency of the water supply system be explained to consumers? Perhaps the best way to describe what the water system can sustain is by simulating conditions that are far more extreme than any conditions actually experienced, and test the system's response to demands.

THE "DOOMSDAY SCENARIO"

The "doomsday scenario" was developed by CO-OP personnel to illustrate the system's resiliency. The scenario was drawn up to create a "worst drought" by using the lowest recorded river flow for each day of the year over the course of the last 100 years of gage records. The scenario also assumes drought condition rainfall, so that there is no appreciable summer-fall recharge of any of the reservoirs. Even under these conditions, normal river flow is adequate to meet demand and environmental flow recommendations until mid July, when releases would be required. Releases from Jennings Randolph Reservoir are able to meet water supply and flow recommendations through the summer. In the fall, the demand for water drops along with temperatures, and utilities would resume operations without assistance from upstream storage.

Even without appreciable precipitation, river levels will begin to elevate in fall as trees become dormant, and the groundwater they used during the summer recharges the river's base flow. The reservoir still retains well over half its water supply storage. An added cushion for water resources planners comes in assessing the winter recharge rate for Jennings Randolph. If for some reason Jennings Randolph was completely emptied of water supply storage by the time demands decreased in the fall, (which is not experienced even in the worst-case scenario), the reservoir would completely refill by the following June under weather conditions experienced in any year from 1930 to the present.

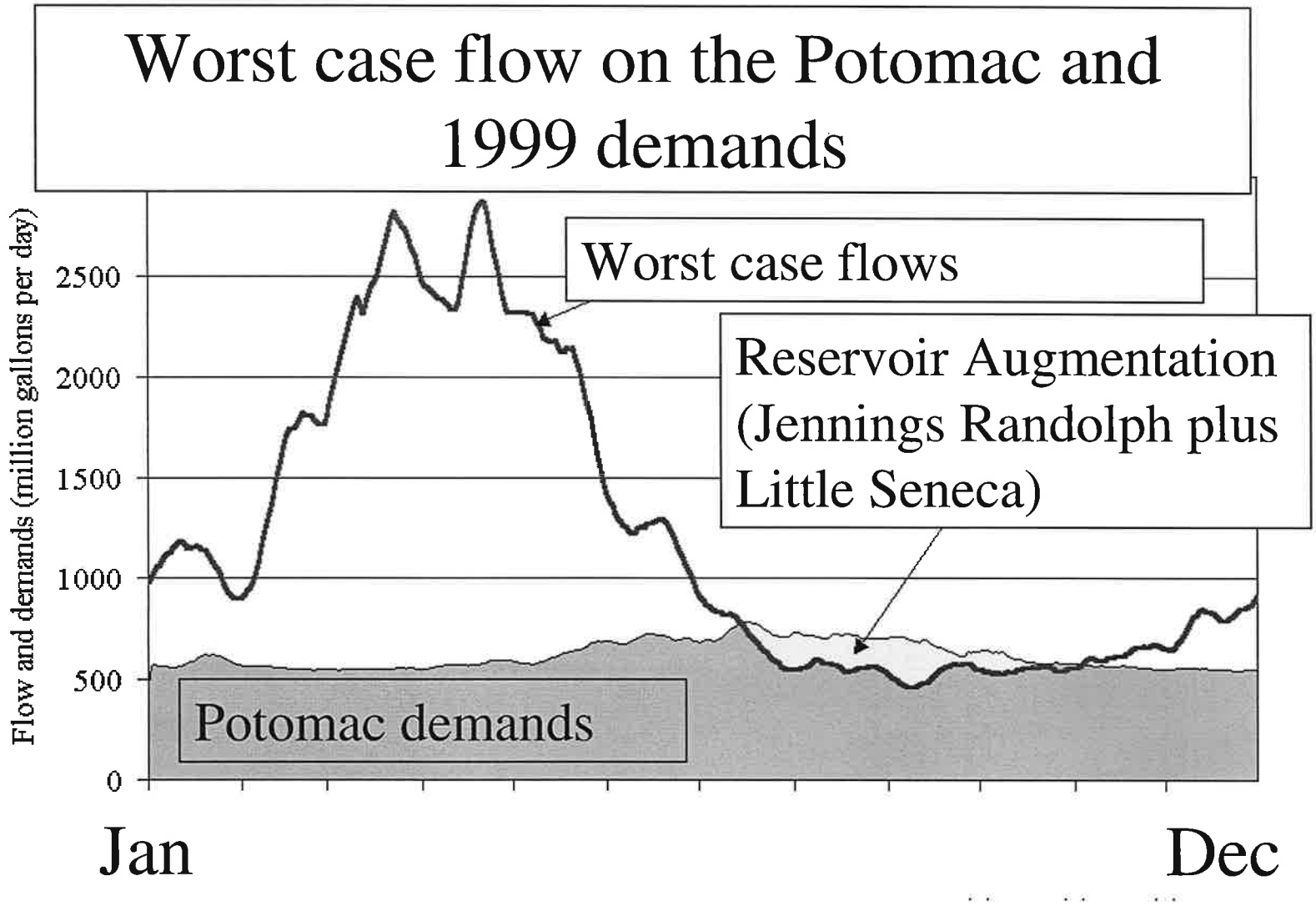

Figure 3: Potomac flow augmentation potentially necessary from mid July through early November

Drought Operations

The extended drought, which began with rainfall shortages the prior fall, caused a record low June flow in the Potomac. Although flows were more than adequate to meet metro-area demand, CO-OP personnel began daily monitoring of river flow and water demand. In early July, it became clear that water supply releases from Jennings Randolph Reservoir would be needed, even with prudent use of the Occoquan and Patuxent reservoirs by FCWA and WSSC in normal operations. The Corps of Engineers routinely makes releases from the reservoir for water quality purposes; however, the first water supply release ever made from the reservoir in its 18 years of existence was made on July 11, and continued into July 29. Showers around the basin eased river conditions, and another release was not made until August 11, which continued until August 17. Releases are summarized in Table 1 and shown in Figure 4.

Table 1: Release summary from Jennings Randolph and Little Seneca reservoirs (mgd)

Date	Jennings Randolph Release	Little Seneca Release
	First release	
July 11	360	0
July 12	360	0
July 13	200	0
July 14	100	0
July 15	100	0
July 16	200	22
July 17	200	0
July 18	100	0
July 19	100	0
July 20	100	0
July 21	50	0
July 22	50	0
July 23	50	0
July 24	50	0
July 25	50	0
July 26	50	0
July 27	31	0
July 28	25	0
July 29	12	0
	Second release	
August 11	120	0
August 12	171	0
August 13	150	0
August 14	120	0
August 15	120	0
August 16	120	0
August 17	60	0

Washington 1999 flows

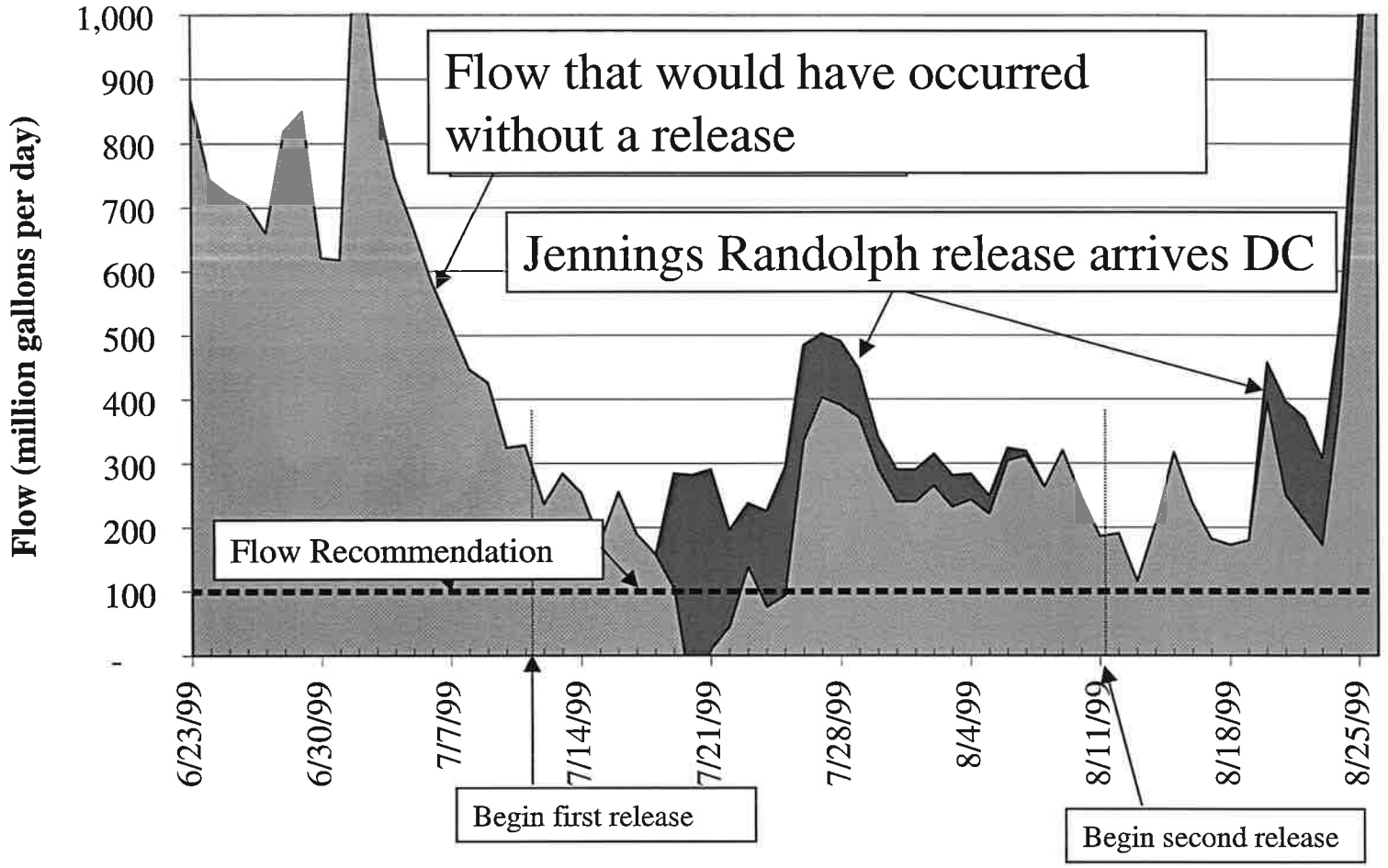

Figure 4: Jennings Randolph release, flow target, and flow below Little Falls dam.

CO-OP was responsible for two major release decisions each day. The first was to determine how to manage the system of reservoirs so as to meet the current day's demands. The second was to determine how much water, if any, to release from Jennings Randolph Reservoir in order to meet anticipated demands nine days in the future. Because Jennings Randolph Reservoir is some 200 miles upriver, releases must be made about nine days in advance to allow for travel time downstream. The Little Seneca Reservoir, less than a day's travel time from metropolitan intakes, is used in conjunction with Randolph so that releases made from the latter can be more conservative. If Randolph is a savings account, Little Seneca can be thought of as "underdraft protection"--a release can be made from the smaller, closer reservoir to make up for any temporary shortfalls that become apparent as Randolph water travels to the intakes. One adjustment release was made from Little Seneca this year.

Example of daily correspondence between ICPRB and WSSC, FCWA, and WAD on July 22, 1999

*Current flow over Little Falls is close to the minimum target of 100 mgd, at 139 mgd as of 7:30 a.m., 139 mgd again at 8:30 a.m., and 139 mgd again at 9:10 a.m. We will continue to monitor flow conditions closely throughout the day. *IF* instantaneous flows drop to the 110 mgd level we will consider requesting a Little Seneca release, and will check with the utilities to see if it is possible to cut back on the Potomac withdrawals for 10 hours, (until a Little Seneca release can make it down to the Potomac). But for now, flow at Little Falls seems to be steady at 139 mgd...*

The daily procedure included input from the water utilities. Each morning, CO-OP staff received each utility's withdrawal information as well as estimates of current day and nine-day demands. This information was compiled and a daily summary report sent back to each utility by email. As public awareness of the drought grew, more and more parties asked to be included on the distribution list for this email, including media and various local, state and federal agencies. The daily summary report became a useful mode of communication during the drought, and included information about the current river flows, the five-day and extended weather forecasts, the previous day's withdrawals, current status of Jennings Randolph and Little Seneca reservoirs including release rates and current storage levels, and river flow at several gage stations on the Potomac.

Another important component of the daily activities was to monitor streamflow throughout the watershed. The USGS's real-time flow data were invaluable in obtaining a snapshot of flow conditions and for evaluating flow trends. Up to 17 USGS graphs depicting gage readings of Potomac mainstem and tributary streamflow were printed each day. These graphs were used to estimate flow conditions at Little Falls 9 days in the future. The graphs also illustrated how local storm events affected flow throughout the watershed.

A drought management team, composed of representatives from all three utilities and the ICPRB, met on a weekly basis during the drought. Typically, these meetings were used as a forum to conduct a water supply update and to discuss issues as they arose. For example, a joint press release was developed at one of these meetings (see inset next page). Other topics

discussed at the water supply update meetings included reservoir refill analyses and CO-OP analysis of the regional reservoirs reliability under worst-case drought conditions. (CO-OP assessed the adequacy of the system of reservoirs to meet demands under a regime of various low flow scenarios, including the "doomsday" scenario noted previously.)

Operational flexibility in the system allows CO-OP other ways to ensure that minimum flows established by the agreements are met. Because both WSSC and FCWA own off-Potomac reservoirs, CO-OP can request the two utilities to use more or less from the Potomac, depending on reservoir status and Potomac targets. The WAD has two Potomac intakes, one at Great Falls, and one downstream at Little Falls. This flexibility in taking water from different locations and sources has been helpful in managing water demand, and in meeting the operating rule that requires a minimum flow of 300 mgd between Great Falls and Little Falls, and 100 mgd between Little Falls and Chain Bridge. (At Chain Bridge, the Potomac becomes a tidal estuary, filling with water from downstream twice a day.) These minimum recommended flows are established to protect the biology and water quality of the river segment between the intakes and the head of tide.

Excerpt from joint press release, July 17, 1999

No restrictions on water use are required at this time because of successful regional planning efforts initiated over 20 years ago. These efforts resulted in construction of water supply storage at Little Seneca and Jennings Randolph reservoirs at a cost of 96 million dollars paid for by water customers. These facilities are now in use.

These planning efforts resulted in the development of a management plan designed to meet the area's water needs. If the drought of record (1930 - 31) were to recur this summer, water storage in Jennings Randolph and Little Seneca Reservoirs (plus the natural flow in the Potomac River) would be adequate to meet the needs of the Washington Metropolitan Area.

The previously described agreements among the utilities specify a formula for restricted allocations of water among the utilities if demands cannot fully be met. That part of the series of agreements was designed before the upstream reservoirs were built, so the chances of these water restrictions being placed on the utilities during the current drought is extremely remote. The utilities are also charged with alerting the governing bodies of the jurisdictions they serve when supply is projected to fall below certain levels.

This process, developed about two decades ago and enhanced and rehearsed annually through drought preparedness exercises, has resulted in a reliable water supply capable of meeting demands which exceed worse conditions than have existed historically.

Lessons Learned

Even after years of practice, real-time operations always bring new challenges. As drought operations began this summer, numerous "learning experiences" challenged CO-OP and the utilities. The first release from Jennings Randolph Reservoir was estimated to take six to seven days to travel to the water supply intakes north of Washington. The estimate was based on test releases made in prior years. Of course, none of the previous tests occurred during actual low flow conditions, and the release took an extra two days to reach the intakes. A small release from nearby Little Seneca Reservoir (less than a day's travel time from the intakes) solved the problem. Extra volume is now added at the beginning of releases from Randolph to help push the water down the river to the intakes.

Some of the river gages operated by the U.S. Geological Survey (USGS) were recalibrated because of problems that weren't fully realized until the gages were used in daily operations during extreme low flows. One gage gave high readings because rapid growth of aquatic plants in the surrounding river caused changes in the relationship of river stage to flow rates. This gage was re-calibrated three times to compensate for the change. Another gage on a Potomac tributary is affected by a power generation plant. Its fluctuating use of water was not noticed on the gage during normal flow conditions, but showed up as a series of drawdown curves on graphs during low flows. The WAD pumping station at Little Falls, when in operation, affects readings of the Little Falls gage. Flow over time is averaged to yield an accurate flow volume at Little Falls.

Coordination by the USGS and the utilities quickly solved these problems. The coordination was increased through the daily summaries shared by CO-OP and the utilities. Regular meetings of the group to discuss concerns also have helped to keep everyone on the same page.

The Policy of Water Supply

Drought operation, as opposed to annual simulations, in the metropolitan area is a new phenomenon and has attracted much attention. Many questions have been raised about the need for conservation by consumers and the effects of low flows on river biology and water quality.

The need for water conservation by metro-area residents has perhaps caused the most confusion**. The metro water supply has been designed to meet the unrestricted demands of utility customers, even in the face of a drought much worse than any that has been actually observed historically.**

The drought procedures under which the utilities operate establish a framework for regional coordination when the need for restrictions arises. Those rules require CO-OP to advise the water utilities if there is less than a 95 percent probability of meeting unrestricted demands. The utilities then notify the jurisdictions they serve and recommend restrictions. During the summer's drought, the combination of river flow and storage did not approach that level.

This operational plan only addresses how restrictions might be requested of the jurisdictions by the utilities, based solely on the availability of water for the utilities, plus the flow recommendation below the intakes.

As the water system and the use of storage came under increasing public attention, the process crossed over into public policy, with a wider range of concerns, such as regionally uniform levels of conservation. Early calls for voluntary conservation were superceded in Maryland by statewide mandatory water-use restrictions. After an assessment of the situation, a state panel decided that mandatory restrictions were needed to assure adequate water statewide. The mandatory restrictions were based on an assessment of the water situation throughout the state. The Virginia suburbs and the District continued to recommend voluntary water conservation.

As the lead technical agency designated to manage the metro-area water supply drought operations, CO-OP kept the utilities informed on a daily basis. The ICPRB's commissioners were kept informed about conditions, along with their state governments. Greater coordination among the utilities, the ICPRB, and the state and local jurisdictions in getting information to the public and decision-makers will help future drought operations run more smoothly. Greater use of the commission's website and other methods could help to meet this need.

Much attention also has been given to flow levels in the segment of the Potomac between the intakes at Great Falls and the head of tide at Chain Bridge. There is a 300-mgd minimum flow recommendation for the segment between Great Falls and Little Falls, and a 100 mgd minimum flow recommendation for the mile of river between Little Falls and Chain Bridge. The environmental flow recommendations were established by a 1981 study led by the Maryland Department of Natural Resources, with input from a long list of local, state, and federal agencies. Data for the study were not collected during actual low flows.

No major negative impacts (such as fish kills) were reported during the course of the year in the Little Falls area. In addition, no significant negative impacts were observed during an ICPRB reconnaissance of the area during one of the lowest-flow periods this summer. At that time, habitat and biological conditions in the Little Falls area did not seem to veer substantially from those predicted in the 1981 study. The river segment below Little Falls was noted in the study as one of the areas most impacted by extended low flows.

At the same time that concerns have been raised about the river segment below the intakes, the other 200 miles of the Potomac downstream of Jennings Randolph have benefited. Regular water quality releases by the Army Corps of Engineers from Jennings Randolph, along with CO-OP water supply releases, have bolstered the river's low natural flow, preserving habitat and providing other benefits for the 200 miles of river between Randolph Reservoir and the water supply intakes. The water supplies of communities upriver from Washington also have benefited from the released water.

On its own, the Potomac fluctuates greatly over the course of a year. While impacting some of the river's resources, a given flow benefits others. The drought has reduced nutrient inflows to the river. The low, clear water has favored dense growths of aquatic plants, which may have mitigated decreased oxygen levels in some area. The plants also create habitat for fish and the invertebrate populations on which they feed. On the other side, natural low flows make the river water more stationary, allowing it to become hotter, lose oxygen, and concentrate pollutants.

The Future of Water Supply

While there is enough water for now, where will water come from if the area continues to grow rapidly? The question has been wrestled with for decades, and shows no signs of abating. The ICPRB is involved in a number of efforts that will provide information to decision makers in helping shape the future of water supply for the metropolitan area.

- **2020 Demand Study.** The area's water utilities are required under regional agreement to conduct a water demand study every five years. The utilities have again requested that CO-OP examine probable future water demands to be conducted in 2000. This study will

examine water demands for the next 20 years, and consider issues such as population growth, changes in per capita water consumption from use of various conservation measures, and enlist the help of an advisory committee of citizens and technical experts. The study will serve to help shape future water policy.

- **Water Supply and Demands in the Potomac Basin study.** The ICPRB is working with the Maryland Department of the Environment to conduct an analysis of water demands in the Potomac River Basin. The study will determine the current surface and groundwater users in the basin and calculate existing and future demand, and the impact of projected use on the available supply will be examined.
- **District of Columbia Source Water Assessment Study.** The ICPRB is working with the District to fulfill federal requirements to examine the continuing viability of the Potomac as the District's source of drinking water with respect to reliable yields and impacts to water quality that could affect it.
- **Future Supply Sources.** The CO-OP is involved in assessing new sources of water for supply purposes with the utilities.