Report on the 2004 Drought Exercise

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Interstate Commission on the Potomac River Basin

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The Interstate Commission on the Potomac River Basin

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September 8-14

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Section for Cooperative Water Supply Operations (CO-OP)
Interstate Commission on the Potomac River Basin (ICPRB)

Introduction

The three largest water utilities in the Washington, D.C. metropolitan area (WMA) rely on the Potomac and Patuxent rivers and their reservoirs for water supply. These water suppliers cooperate on water supply operations, essentially operating as one entity in sharing water across the Potomac, Patuxent and Occoquan reservoir and riverine system during periods of low flow.

The Interstate Commission on the Potomac River Basin (ICPRB) annually coordinates a week-long drought management exercise that simulates water management operations and decision-making under drought conditions for the WMA water suppliers. Annual simulation allows for renewal of coordination procedures with the water suppliers and other agencies, an opportunity for public education and outreach, and review and improvement of operational tools and procedures.

This exercise is coordinated by a special section of ICPRB, the Section for Cooperative Water Supply Operations on the Potomac (CO-OP). Using simulated drought data, CO-OP coordinates hourly demands for water with available river flow, and determines virtual release rates from storage at Jennings Randolph Reservoir, Little Seneca Reservoir, Occoquan Reservoir, and the Patuxent reservoirs.

The 2004 Drought Exercise took place September 8-14, 2004. This report documents the findings and operational suggestions that resulted from the drought exercise. It is hoped that the report will be a useful resource for next year's exercise, or in the event of a real drought, to both utility personnel and to ICPRB staff.

The Scenario at the beginning of the exercise

Simulated flow levels in the Potomac are dropping, and as of September 8, 2004 are approaching levels requiring low-flow augmentation from Little Seneca Reservoir, a day's travel time from the most downstream intake. In anticipation of the low-flow, a simulated release from Jennings Randolph and Savage reservoirs was initiated on September 4, but the release had not yet arrived in the Washington, D.C. area due to the 9-day travel time from these upstream reservoirs.

There have been only small, isolated rain events for the last several days and there is no appreciable rain in the meteorological forecast...

Background

The majority (approximately 90 percent) of the WMA's population relies on water furnished by the three water suppliers (collectively, WMA Water Suppliers):

- The Washington Aqueduct Division of the U.S. Army Corps of Engineers (Aqueduct) serving the District of Columbia and portions of northern Virginia.
- Fairfax Water, serving northern Virginia.
- The Washington Suburban Sanitary Commission (WSSC) serving the Maryland suburbs

The WMA Water Suppliers provide treated water either directly to customers or through wholesale suppliers to a total of approximately 3.6 million people (Hagen & Steiner, 2000). The WMA Water Suppliers jointly own water storage in upstream Jennings Randolph and Little Seneca reservoirs that they have agreed to operate for their common benefit during droughts (Figure 1). Additional regional resources include the Triadelphia and Duckett reservoirs on the Patuxent River (Patuxent reservoirs) owned by WSSC, and the Occoquan Reservoir on the Occoquan River (a tributary to the tidal Potomac) owned by Fairfax Water which are operated cooperatively to improve regional water supply reliability during droughts. Water quality releases from Savage Reservoir, owned by the Upper Potomac River Commission, also benefit the downstream WMA water suppliers during droughts.

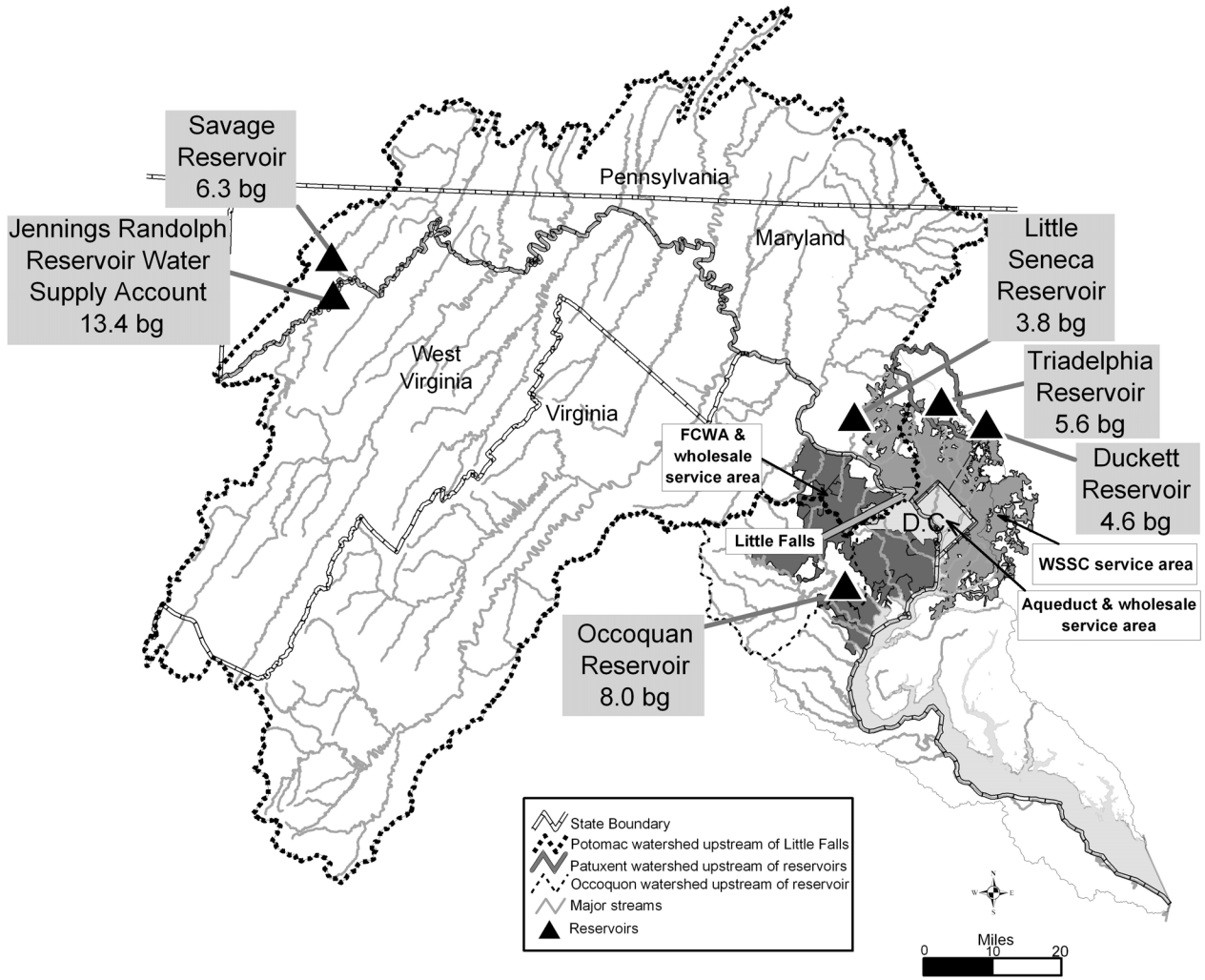

Figure 1: Potomac basin, Patuxent basin, basin states, water supply service area, and regional supply reservoirs

Coordination

The drought exercise allows for the regular exchange of information among the utilities and CO-OP, as well as between this group and the public. At a practical level the exercise allows for updating contact information and sharing relevant information about the physical plants, and for training new personnel and refreshing coordination procedures with current personnel. Just as importantly, the exercise and pre-exercise meeting refreshes the commitment of water managers to regional operations of the shared resource.

Coordination between WMA Water Suppliers and CO-OP

A meeting of the CO-OP and the WMA Water Suppliers was held on August 26, 2004 in advance of the drought exercise, and a conference call was held to simulate decision making prior to the first water supply release.

The purpose of the meeting was to:

- Share information about current production capacities at each plant (Table 1).
- Meet the other operational personnel from the other utilities.
- Discuss the drought exercise procedures.
- Update contact information.

Table 1: WMA Water Suppliers rated production capacities

Rated Production Capacity [MGD]	
WSSC	
Potomac	Rated at 285, but 240 is perhaps closer to actual capacity according to Doug Grimes, Potomac plant Superintendent.
Patuxent	52 for a day or two, 42-45 continuously [a]
Fairfax Water	
Potomac	150 (future: 225 with expansion)
Occoquan	112 (future: 160 with expansion)
Aqueduct	
Dalecarlia	200
McMillan	120
TOTALS	
Total Potomac	755
Total System	919

[a] Renovated Patuxent plant will have 72 mgd capacity with emergency maximum of 120 mgd.

The information in Table 1 is important for making operational decisions during the drought exercise, and should be updated each time a drought occurs or for each exercise.

Appendix A summarizes the contact information for each of the WMA Water Suppliers, the Water Resources Section of the Baltimore office of the U.S. Army Corps of Engineers (Baltimore COE), and ICPRB. Appendix B provides a detailed chronology of the daily operations for 2004. An important feature of the drought exercise is that it continues through a weekend in order to ensure a realistic involvement of personnel within all concerned agencies.

A conference call of the CO-OP, Operations Committee, and water supplier technical staff takes place during droughts when water supply releases are imminent. The Operations Committee is currently comprised of the Chief of the Washington Aqueduct, the Chief of Production for WSSC, and the General Manager of Fairfax Water. Duplicating real conditions, a conference call of the Operations Committee was held on short notice at 9:45 a.m. on Tuesday, September 7 to discuss the Little Seneca release. The Operations Committee authorized an actual release from Little Seneca, as well as virtual releases from Jennings Randolph and Little Seneca for the duration of the drought exercise. This part of the exercise was useful for practicing communication procedures and maintaining emergency contact information for the Operations Committee.

Coordination between CO-OP and the U.S. Army Corps of Engineers

The Baltimore COE implements water supply releases from the North Branch system, which includes Jennings Randolph Reservoir and Savage Reservoir. Releases are made at the request of the CO-OP. During the exercise, operational requests for reservoir releases were conveyed by 10:00 A.M. each morning by CO-OP staff, as would be the case during actual drought operations. Reservoir release rates from the North Branch system are modified daily. Given the 9-day travel time to Little Falls, more frequent updates are unnecessary. For after-hours communications, CO-OP staff referred to the "Priority Call List" maintained internally by Baltimore COE staff. The list provides home contact information for Baltimore Staff and prioritizes the call order. Coordination with the Baltimore COE went smoothly, and it was useful to renew drought related communications.

Public Outreach

An important feature of the drought exercise is communication and outreach with the press and local elected officials, and public education of regional water supply reliability. This year marked the first time that a Little Seneca release was made as part of the drought exercise, affording new opportunities for public education and outreach.

Little Seneca release

As part of the drought exercise, a release was made from Little Seneca reservoir on Wednesday morning, September 8. The release achieved several objectives, including

- Exercising coordination with staff from Black Hill Regional Park, which surrounds Little Seneca Reservoir. Black Hill Regional Park is staffed by the Maryland National Capital Park and Planning (MNCPPC).
- Practicing communication and outreach with the press and local elected officials.
- Educating the public about regional water supply reliability.
- Conducting a time of travel study.

A press release was issued by ICPRB with input from MNCPPC (Appendix C). The issue of the release is useful as it provides a template which could be applied during a real drought on short notice – which is in itself very useful, since staff are very busy during droughts. The press release achieved broader objectives, including public education and maintaining contacts with the press. The September 8, 2004 Montgomery County version of the Gazette ran the following story on the Little Seneca release (reported by Jacqueline Mah):

> The release of about 140 million gallons of water from a reservoir in Black Hill Regional Park into Seneca Creek began Tuesday, as part of a weeklong drought management exercise run by a Rockville-based Potomac River commission, according to a news release. The water release, which began Tuesday morning and ended this morning, was conducted by the Section for Cooperative Water Supply Operations at the Interstate Commission on the Potomac River Basin. Officials are testing the drought management operation and documenting how long it takes for water to arrive at Little Falls, the site of the most downstream water supply intake on the Potomac River, according to the news release. The water level at the Black Hill reservoir would drop about 12 inches over 24 hours, but forecasted rains should soon replenish the reserve, according to the press release. Seneca Creek joins the Potomac River near Riley's Lock on the C&O Canal. The Potomac River provides more than 75 percent of the area's drinking water supply.

CO-OP also distributed a letter to Montgomery County Council and the office of the Montgomery County Executive, providing information about the purpose of Little Seneca Reservoir as a water supply reservoir and of the planned reservoir release (Appendix D).

Web links

During droughts, CO-OP staff depend on several websites for information and to evaluate precipitation forecasts and other weather related information (Table 2).

Table 2: Websites for weather information

Description/ agency	Website/directions
Aerial map showing quantitative forecast of precipitation, 1- and 2- days ahead / Middle Atlantic River Forecast Center	http://www.erh.noaa.gov/er/marfc/ Look for "Maps" heading, and click on "Forecasted Precipitation." The "Gridded QPF Images" are best, especially the 24 and 48 hour totals.
Aerial map showing precipitation that has fallen in the region for the prior 24, 48 or 72 hours / Middle Atlantic River Forecast Center	http://www.erh.noaa.gov/er/marfc/ Look for "Multisensor maps" heading, and click on "Java." The "Past 24 hour total" is helpful.
Aerial map showing quantitative forecast of precipitation, 3, 4, and 5 days ahead / National Weather Service Hydrometeorological Prediction Center	http://www.hpc.ncep.noaa.gov/qpf/qpf2.shtml Click on appropriate time interval.
Table showing daily average precipitation at each of the three regional airports / National Weather Service Forecast Office Baltimore/Washington	http://www.erh.noaa.gov/er/lwx/climate.htm Click on "x" in table for the airport and month of interest.

Daily Summaries

Exchange of information with the WMA Water Suppliers was implemented via email. Daily summaries of operational changes were sent out to each of the water utilities. The distribution of the summaries follows.

Distribution:
kWright@wsscwater.com; tsupple@wsscwater.com; Tgoldberg@fairfaxwater.org; John.W.Peterson@wad01.usace.army.mi; epetrovitch@fairfaxwater.org; Leo.J.Nolan@usace.army.mil; Lloyd.D.Stowe@usace.army.mil; Gprelewicz@fairfaxwater.org; Stan.A.Brua@nab02.usace.army.mil; rsteine@wsscwater.com.

With copies to:
Thomas.P.Jacobus@wad01.usace.army.mil; ccrowder@fairfaxwater.org; cmurray@fairfaxwater.org; theikki@wsscwater.com; jhoffman@icprb.org.

Summaries were written so that any updates were at the top of the page, so readers could quickly identify new information. An example summary is provided in Appendix E.

The daily summaries were provided on the ICPRB website to simulate public outreach as part of the exercise. Additional information on the website shows relevant water supply conditions and associated graphics (Figure 2) and is accessible through the water supply link at ICPRB's website (www.potomacriver.org). This website is regularly updated during the active water supply months of April through October.

For the next drought exercise, CO-OP recommends including a more general water supply status daily report, simulating what would go out to the general public. Such a report might include an overview of conditions as well as more specific information about reservoir levels, water supply release rates from Jennings Randolph and Little Seneca, predicted flows at Little Falls, and current and predicted water supply demands. In addition, the daily report could include a short segment on the history of cooperative water supply in the Washington area, with a special emphasis on water supply reliability.

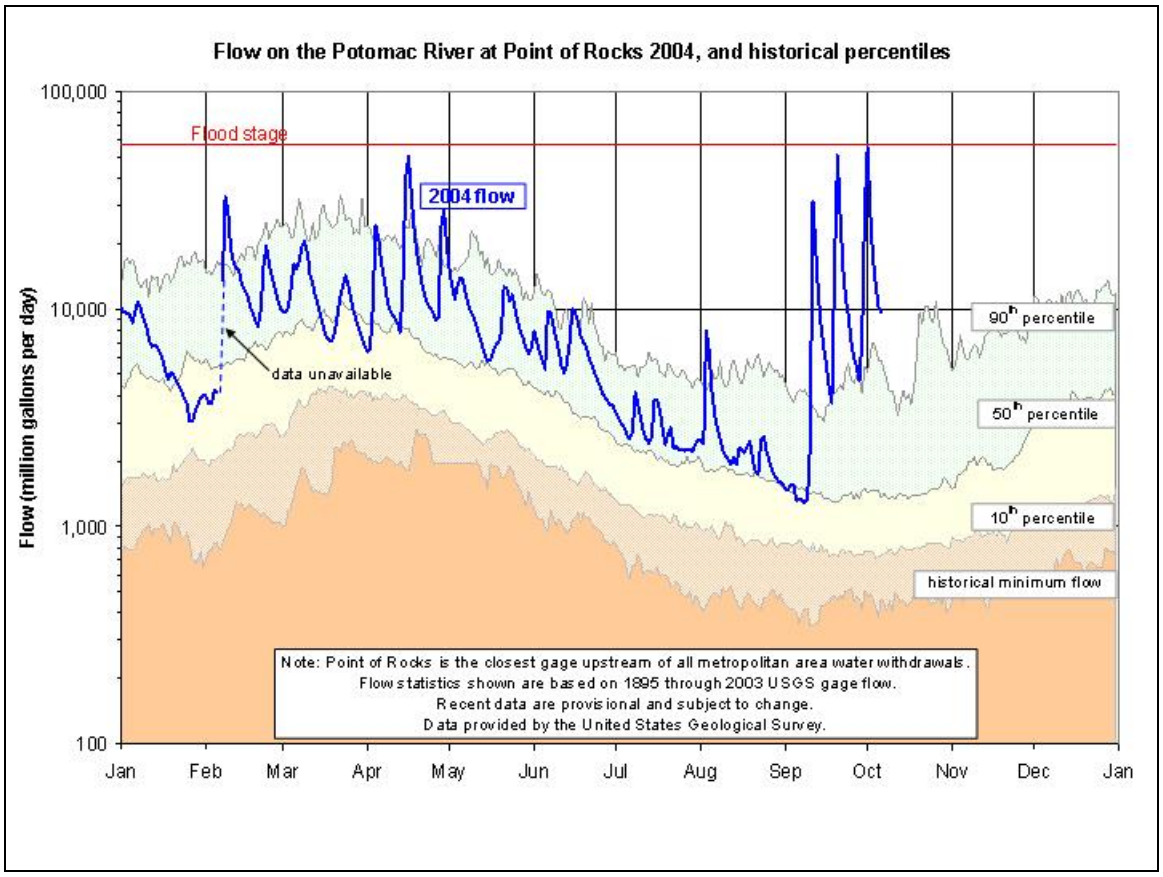

Figure 2: Example graphic from CO-OP water supply status website, showing 2004 Potomac flow and historic flow percentiles

Operational issues

The annual exercise ensures that operational procedures and tools are well practiced, understood, and even improved despite the potential for many years between droughts.

Several operational issues were investigated in this year's drought exercise. Special attention was given to the demand forecast. The issue of flow variability and its link to operations was explored, and a strategy was developed to help mitigate this variability. New procedures to obtain hourly operational data for the upstream WMA Water Supplier intakes were proposed, and will help in mitigating flow variability and in improving reservoir release efficiency. The Little Seneca reservoir release was tracked to test travel time.

Demand forecasting

CO-OP developed a model that predicts daily demand at each utility. The model was developed using an Excel spreadsheet tool that can predict daily demand at each utility, based on multivariate linear regression. This tool was compared with operator estimates of demand. The independent variables used in the regression and used as inputs for estimating the current day's demand include:

- the number of consecutive days rainfall is less than 0.15 inches
- the prior day's demand
- the day-of-week
- soil moisture (Palmer drought severity index)
- today's estimated maximum temperature
- tomorrow's forecast maximum temperature
- today's estimated rainfall
- tomorrow's forecast rainfall

The model can also be used to estimate tomorrow's estimated demand. The interface for the tool is shown in Figure 3.

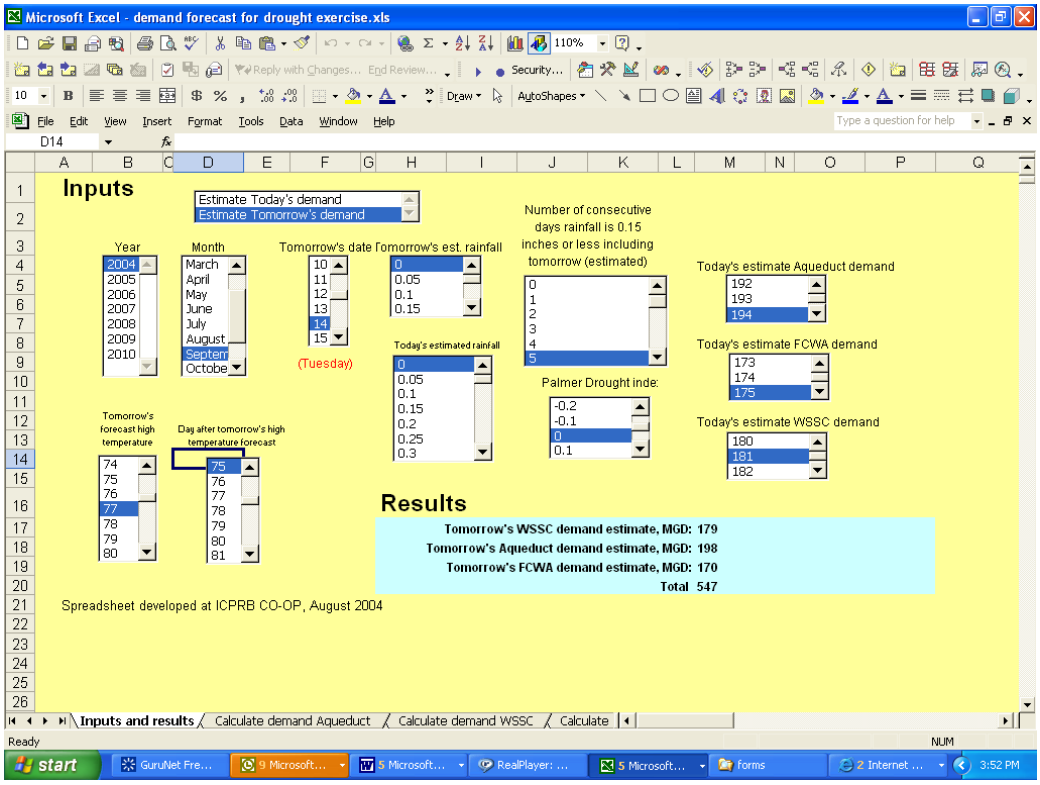

Figure 3: User interface of demand forecast model showing user inputs

Operators competed with ICPRB's demand forecasting tool. The average bias (average of all errors) for the COOP system is shown in Table 3 for both operators and for the demand forecasting tool. Of the utilities, WSSC had the smallest bias in their estimates. Overall, utility operators did a better job than the CO-OP spreadsheet model. The model over-predicted demands during this time period. CO-OP will improve the forecast model, but at present operator estimates are preferable for system operations. Operators currently use best professional judgment to predict demand for the current day and for the next day. Appendix H provides a daily summary of results for the demand forecasting model and the operators forecasts.

Table 3: Bias in estimates of demand projections for operators and for demand forecast model

	Bias in estimate (average of forecast demand minus actual demand), MGD			
	Operator		Model	
	Current day forecast	next day forecast	current day forecast	next day forecast
WSSC	**0.1**	**0.2**	**5.3**	**7.2**
Fairfax Water	**-6.5**	**-2.0**	**3.7**	**8.2**
Aqueduct	**-2.2**	**-1.7**	**8.8**	**13.3**
CO-OP total	**-8.5**	**-3.5**	**17.8**	**28.6**

Figure 4 shows the model forecast of demand versus the operator forecast of demand, for each day that a forecast was conducted.

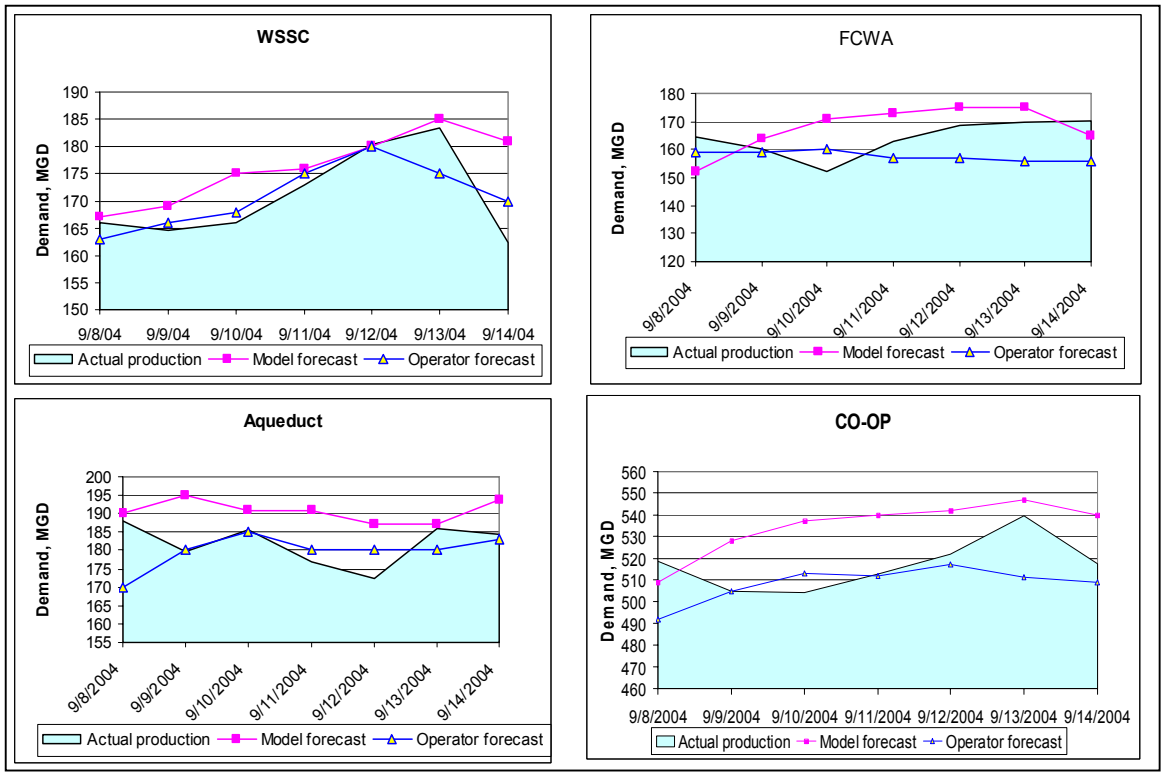

Figure 4: Demand forecast results for operators and for demand forecast model

Forecasts are also needed for 9-day forecast, and more work is warranted to develop forecasting skill for this forecast interval.

Flow variability

A significant problem with extreme flow variability at Little Falls was first encountered in operations during the drought of 1999. In 2002, the same problem occurred and operators observed that the problem correlated with a decrease in withdrawals at the upstream Great Falls intake combined with an increase in withdrawals at Little Falls intake. River flow at Little Falls was observed to drop by more than the quantity of water pumped from the river at that intake. As the drought of 2002 progressed, and operators observed the phenomena in more detail, it became clear that shifting withdrawals from Great Falls to Little Falls intakes can lower flows by a margin greater than the value of the quantity of water shifted. **This consequence is very important for current (and any future) CO-OP staff to understand, otherwise their actions could cause the instantaneous flow to drop below desired levels.**

CO-OP staff linked the variability issue to differences in travel time between Great Falls intake to the Dalecarlia treatment plant via the aqueduct, and the travel time from Great Falls intake to Little Falls intakes via the Potomac River. This phenomenon can be explained as follows. Withdrawals at Great Falls take 4 hours to travel through the aqueduct and reach Dalecarlia water treatment plant near Little Falls (Woody Peterson, personal communication), however travel time of flow in the river from Great Falls to Little Falls is about 9 to 10 hours (Kiang and Hagen, 2003). When Great Falls withdrawals are reduced or stopped, it takes about 4 hours for the change in operations to be reflected at the end of the aqueduct at Dalecarlia. At this time, pumping must begin at Little Falls to make up for the reduced flow in the conduit. However, the pumps are withdrawing from flow in the river that has already experienced the full withdrawal from Great Falls. For five hours, the pumps will be withdrawing water from flow that has already been reduced by withdrawals at Great Falls. Therefore, shifting x amount of demand from Great Falls to Little Falls can result in a flow reduction that is twice the amount of the load shifted, i.e., $2x$, which lasts for a period of about 5 hours. The travel times to Little Falls intake used in the hourly operational model varied from 9 to 28 hours (Table 4).

Table 4: Travel time assumed in hourly operational spreadsheet model

Location	Travel time to Little Falls, hours
Little Seneca Reservoir	28
Fairfax Water intake	15
WSSC intake	9.6
Great Falls intake	9

The 2003 drought exercise addressed the issue of flow variability through the incorporation of an hourly operational model. The ability to view simulated effects of water supply operations on flow was an important improvement. The consequences of operational decisions, good or bad, were reflected in subsequent flow, lending more realism to the drought exercise and thus creating better opportunities to refine decision making procedures in the 2003, and subsequently, 2004 drought exercises.

In the hourly model, gage flows at Little Falls rose and fell precipitously (Figure 5), just as they did during actual drought operations in 1999 and in 2002. Of particular note, the simulated flow rates in the drought exercise dropped well below the minimum recommended flow of 100 MGD for portions of the day. This occurred because withdrawals were shifted from Great Falls to Little Falls when flow was close to 100 MGD at Little Falls.

This result illustrated the importance of using the spreadsheet tool to model operational changes ahead of their implementation. This approach should help in resolving the problem by allowing managers to craft a withdrawal strategy that reduces flow variability. This tool will be used in droughts to help minimize the chances of this happening in future droughts. Graphical output can be examined to see how proposed changes in operations affect flow at Little Falls, before problems occur (Figure 6).

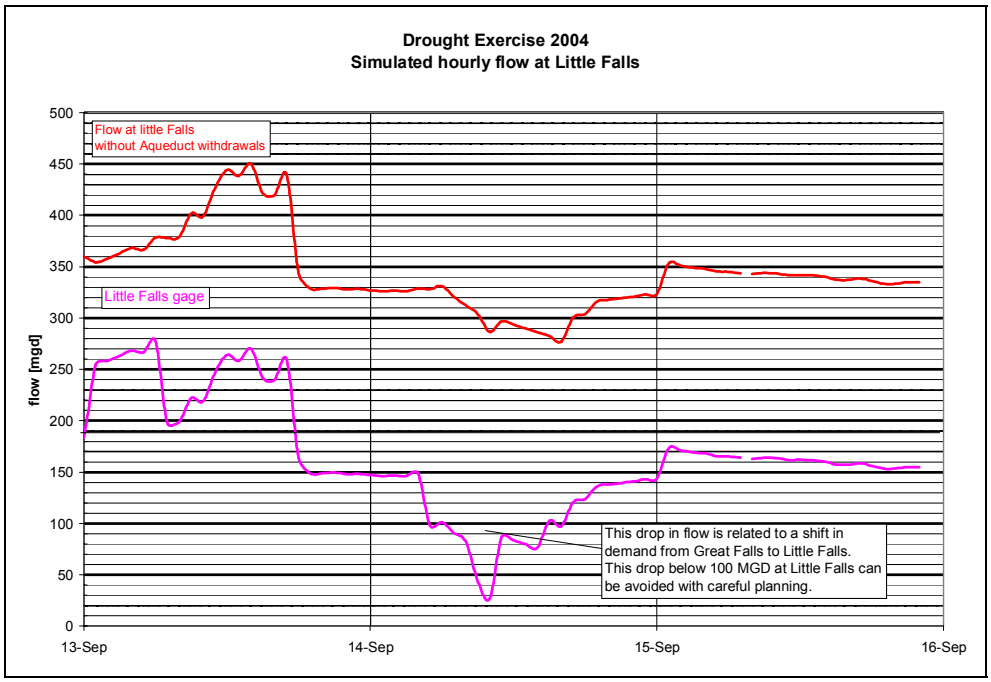

Figure 5: Simulated hourly flow at Little Falls, illustrating the flow variability at Little Falls gage after shifting withdrawals from Great Falls to Little Falls

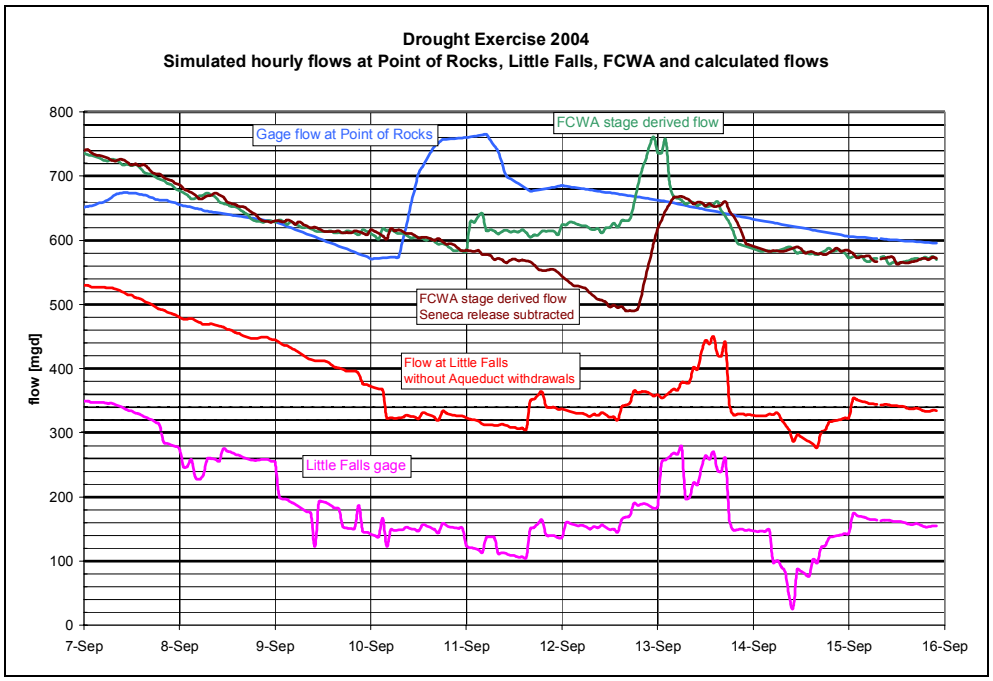

Figure 6: Graphical output of the tool used to track hourly withdrawals and flows, to make predictions of the flow that would have occurred at Little Falls prior to withdrawals or changes in withdrawals at the Aqueduct, and to observe the effects of proposed changes in hourly operations

Hourly withdrawal information

Variations in Potomac withdrawals at WSSC's and Fairfax Water's upstream intakes affect flow downstream at Little Falls. Without careful management, this resulting flow variability can affect the ability of ICRPB staff to measure and calculate how much water is in the river. This information is critical for calculating the amount to release from Little Seneca and other operational requirements.

To make 2005's drought exercise more relevant and to improve future drought operations, CO-OP proposes that it tracks the hourly operations for:

- WSSC Potomac plant
- Fairfax Water's Potomac plant
- Aqueduct's Great Falls gate settings and Little Falls pumping.

ICPRB has developed spreadsheets for 2005 which show exactly what information is needed. The information would need to be updated during drought exercises at 7:30 a.m. and at 1:00 p.m. The forms in Appendices E, F, and G were developed to clarify what information is needed from each utility.

During droughts, WSSC maintains fairly steady Potomac demand. They have a large storage relative to their withdrawal and therefore their storage tanks act as a buffer. WSSC withdrawals tend to be less variable than Fairfax Water's withdrawal for this reason, but nonetheless can vary significantly as occurred during this year's drought exercise (Figure 7).

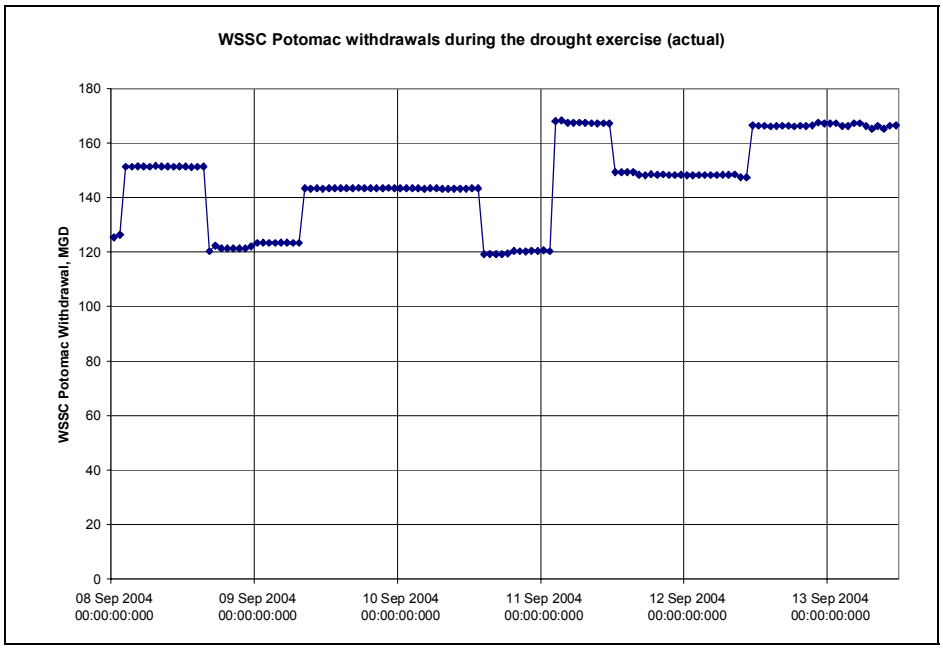

Figure 7: WSSC withdrawals from the Potomac during the drought exercise

Fairfax Water has less storage relative to their Potomac withdrawal and therefore they have a more limited ability to keep their Potomac demand steady. Both Fairfax Water and WSSC keep their withdrawal levels as constant as possible during droughts in order to minimize effects on Little Falls flow.

Without hourly withdrawal information from the utilities, it is impossible to measure and calculate how much water would have been in the river absent water supply withdrawals on an hourly basis. Managers can reduce uncertainty in the estimate of river flow and make the appropriate reservoir release in light of better information. This should allow CO-OP staff to make more conservative reservoir releases in meeting flow targets, thereby preserving storage in the reservoirs.

Little Seneca release, travel time

The travel time of the release from Little Seneca was not well determined because of a precipitation event that altered flow levels and obscured the arrival of the release at some downstream gages. The first gage downstream of the reservoir is maintained by the United States Geological Survey (USGS), *Seneca Creek at Dawsonville*. The travel time from Little Seneca Reservoir to Dawsonville gage is approximately 2.4 hours (Figure 8), but the arrival of the release at WSSC's intake is harder to determine due to variability in Potomac stage. It is possible that the release took about 14.4 hours to arrive at the WSSC intake (Figure 8). Flow at Little Falls was too variable to observe the arrival of the Little Seneca release there. Note that travel time is a function of flow: flow at Little Falls was approximately 1,300 MGD during the test release, and flow in Seneca Creek at Dawsonville was about 30 MGD.

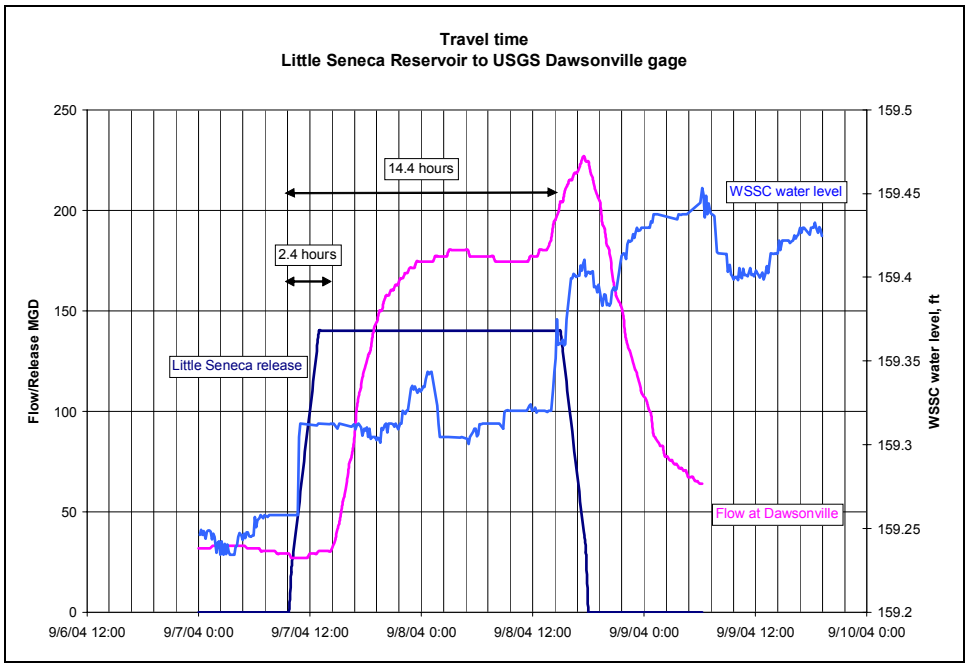

Figure 8: Flow and stage downstream of Little Seneca reservoir and estimated travel time

Staff from Black Hill Regional Park expressed concern about how much the Seneca Creek stage would increase because of the release. The concern was that local anglers might be overwhelmed by a sudden rise in creek elevation. A release of 140 MGD from Little Seneca Reservoir increased the stage at Dawsonville by about 0.7 feet (Figure 9).

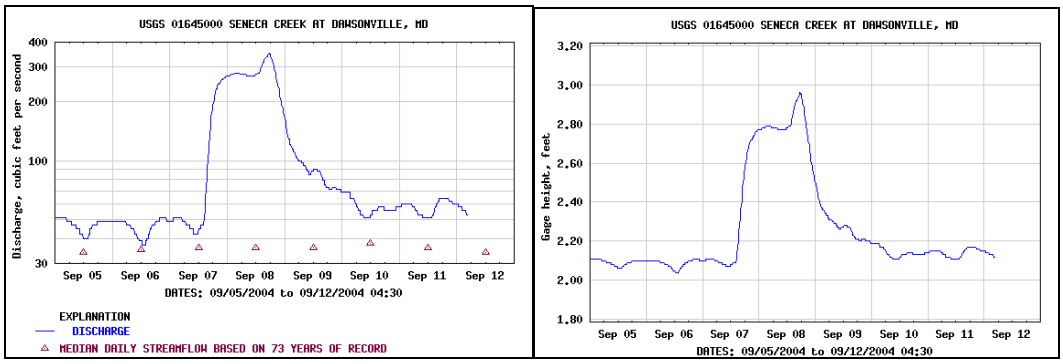

Figure 9: Flow and stage downstream of Little Seneca during the water supply release at Dawsonville gage (USGS graphic)

Results/Recommendations

Each year's drought exercise provides opportunities for refined coordination, outreach, and operations. This exercise is no exception, and accomplished the following results:

- Improvements in the hourly operational tools and procedures.
- A test of a new demand forecasting tool.
- Creation of new worksheets to clarify information needs from operators.
- A refresher course for CO-OP staff and utility operators regarding critical operational awareness points, such as load shifting during low flows.
- Improved public outreach and enhanced public understanding of regional water supply reliability and Little Seneca Reservoir operations.
- Practiced coordination between the relevant agencies.

CO-OP staff suggests the following laundry list of practical recommendations for future drought exercises and low-flow operations:

- Track the hourly operations for WSSC's Potomac plant, Fairfax Water's Potomac plant, and the Aqueduct's Great Falls gate settings and Little Falls pumping.
- Distribute operator forms prior to the exercise or prior to drought operations.
- Appoint a single Fairfax Water representative to provide summary of operational data, similar to more effective communications at WSSC and Aqueduct.
- Implement changes in Aqueduct operations more gradually.
- Conduct a Little Seneca travel time release when there are low flows in the fall.
- Develop 9-day flow regression equations for different months, using additional data from most recent drought years.
- Obtain WSSC stage data on a real time basis.
- Continue to work with Aqueduct towards implementing a gage at Great Falls.
- Use the CO-OP remote stream-level sensors to measure stage at the mouth of Little Seneca during the Little Seneca release and if possible at Great Falls.
- Maintain an hourly operational spreadsheet for drought exercises and operations.
- Copy all files to a cd or portable drive at the end of each day in the event of a power shortage or an inability to connect to the ICPRB server.
- Ask utility operations personnel to include all CO-OP staff on email distribution.
- Hold a pre-exercise meeting to establish minimum and maximum treatment capacity information for load shifting purposes.
- Use an optimization spreadsheet tool to better estimate travel times. The optimization tool can solve for optimal travel times which minimize the difference between measured Little Falls flow and that flow calculated assuming different travel times for each upstream intake. Whenever flow drops to very low levels (e.g., less than 1,000 cfs at Little Falls), obtain hourly flow data from Fairfax Water, WSSC, and the Aqueduct to conduct the above analysis.
- Schedule a third CO-OP staff person during both drought exercises and for actual drought operations. During dry springs, this might take the form of a summer intern.

- Start the exercise on a Wednesday, to allow 3 full days of operations before the weekend. Also, mock the exercise in-house the day before.
- Consider MWCOG role in advance of the drought exercise.
- Continue to copy all utility staff on all correspondence so that everyone is aware of changes in operations at other facilities.
- Review 2004 drought operations report and operations manual prior to the beginning of the 2005 exercise.
- Consider using position analysis based on OASIS modeling tool to determine sustainable rates of withdrawal for Patuxent and Occoquan reservoirs.
- Maintain steady Potomac withdrawals at Fairfax Water and WSSC as much as possible
- Hold a meeting similar to the proposed pre-exercise meeting if reservoir releases and active drought management appear likely.
- Review the Mirant and Sempra settlement agreements, with special attention to the notification provisions therein. (For example, see page 4, Section 1.A, and page 8, section 1.G. of the Sempra settlement agreement detail communication obligations of CO-OP.) Consider involving both power plant companies as part of the annual drought exercise.
- For the next drought exercise, CO-OP recommends including a more general water supply status daily report, simulating what would go out to the general public. Such a report might include an overview of conditions as well as more specific information about reservoir levels, water supply release rates from Jennings Randolph and Little Seneca, predicted flows at Little Falls, and current and predicted water supply demands. In addition, the daily report could include a short segment on the history of cooperative water supply in the Washington area, with a special emphasis on water supply reliability. [see page 12]

Conclusions

CO-OP recommends the continuation of annual drought exercises since they result in the tools and practice necessary to successfully manage the Potomac system. The drought exercise afforded an opportunity to improve in three major areas: 1) interagency coordination, 2) better public communications, and 3) refined operations.

Coordination

The drought exercise allows for the regular exchange of information among the utilities and CO-OP, as well as between this group and the public. At a practical level the exercise allows for updating contact information and sharing relevant information about the physical plants. More importantly, the exercise and pre-exercise meeting refreshes the commitment of water managers to regional operations of the shared resource.

Public outreach

Communications were practiced between agencies, elected officials, and the press in coordination with the first Little Seneca release made as part of a drought exercise. The public and elected officials were educated with regards to operation of that reservoir, enhancing regional understanding of WMA water supply reliability.

Operational issues

A demand forecasting model was tested against the skills of operators and found to be in need of improvement, as the operators' skill in forecasting demand was superior.

An hourly simulation was conducted in the 2004 drought exercise, allowing managers to practice managing the system with special consideration given to the issue of flow variability. Managers understood the importance of using a spreadsheet tool to model hourly operational changes ahead of their implementation. This approach should help managers to craft a withdrawal strategy that reduces flow variability.

The 2004 exercise illustrated the importance of obtaining hourly data from the upstream utilities. Changes in upstream withdrawal rates are reflected in downstream gage measurements at Little Falls. Without hourly withdrawal information from the utilities, it is difficult to calculate river flow upstream of the intakes, and hence to make appropriate reservoir release decisions. With this information, CO-OP staff can make more conservative reservoir releases in meeting flow targets, thereby preserving storage in the reservoirs.

References:

Hagen, E.R., R.C. Steiner, 2000. Year 2000 Twenty-Year Water Demand Forecast and Resource Availability Analysis for the Washington Metropolitan Area, Interstate Commission on the Potomac River Basin, ICPRB 00-6, Rockville, Maryland.

Hagen, E.R., J. E. Kiang, 2003. 2002 Drought Operations and Lessons Learned Washington Metropolitan Area. Interstate Commission on the Potomac River Basin, ICPRB 04-8, Rockville, Maryland.

Appendices

A. Contact information
B. Daily schedule
C. Little Seneca press release
D. Letter to Montgomery County Council and County Executive
E. Example summary of daily operations
F. Operator form for Washington Aqueduct
G. Operator form for WSSC
H. Operator form for Fairfax Water
I. Demand forecasting results

Appendix A: Contact information

Name	Phone	Email/comments
ICPRB CO-OP		
Erik Hagen	301-984-1908 x 116 (w)	ehagen@icprb.org
Julie Kiang	301-984-1908 x 114 (w)	jkiang@icprb.org
CO-OP Pager	301-647-2000	icprb@myairmail.com
Aqueduct		
Woody Peterson	202-764-0009 (w)	John.W.Peterson@.usace.army.mil
Jay Nolan	202-764-0709 (w)	Leo.J.Nolan@.usace.army.mil
Aqueduct control room		
Fairfax Water		
Ed Petrovich	703-289-6567 (w)	epetrovitch@fairfaxwater.org
Lorton Operations (Occoquan)		
Corbalis Operations (Potomac)		
WSSC		
Karen Wright	301-206-8416 (w)	kwright@wsscwater.com
Todd Supple	301-206-8858(w)	tsupple@wsscwater.com
WSSC Operations		
Baltimore COE		
Stan Brua	410-962-4894 (w)	Stan.A.Brua@nab02.usace.army.mil
Call diverter		after hours/weekends
Duty cell phone		
Fairfax Water stage monitoring		
Jason Chiu	703 289 6532 (w)	Can confirm password and user info, and debug connection
Dial up connection		(Enter commas between 9 and telephone number in modem interface)
Internet address		

Appendix B: Daily Schedule for 2004 operations

7:30 am CO-OP:

1. Obtain latest gage flows for Potomac River at Point of Rocks and Little Falls.
2. Obtain the latest stage readings from Fairfax Water and WSSC.
3. Obtain WSSC, Fairfax Water, Aqueduct operator forms filled out for prior 12 hours.

7:30 am Aqueduct, Fairfax Water and WSSC:

1. Provide the previous day's water use data (mgd) to CO-OP by email. Please copy both ehagen@icprb.org and jkiang@icprb.org.
2. Provide the current day's forecast of water use (mgd) to CO-OP by email.
3. Provide the current storage in the Occoquan and Patuxent reservoir systems, and in Little Seneca Reservoir (billions of gallons) to CO-OP by email.

7:45 am CO-OP:

1. Check to see if all water use, forecast, and storage data has been received by email at CO-OP. If not, call the designated staff contact at their office phone number. If contact cannot be made, call the appropriate operations control center.

8:00 am CO-OP:

1. Determine the sustainable safe withdrawal from the Occoquan and Patuxent reservoirs, and estimate Potomac flow withdrawal rates.
2. Determine the appropriate Little Seneca and Jennings Randolph reservoir release rates, and withdrawal rates for the Aqueduct at Great Falls and Little Falls.

9:00 am CO-OP:

1. Provide Potomac withdrawal rates to Fairfax Water and WSSC (remainder of demand to be met from Occoquan and Patuxent) (mgd).
2. Provide Little Seneca Reservoir release rate to WSSC (mgd).
3. Provide withdrawal rates for the Aqueduct at Great Falls and Little Falls (mgd).

10:00 am CO-OP:

1. Provide upstream release target for Jennings Randolph to the Baltimore District of the Corps of Engineers (cfs and mgd) after obtaining concurrence from the Operations Committee.

1:00 pm Aqueduct, Fairfax Water and WSSC:

1. Update your forecast of the current day's water use to CO-OP by email. Please copy both ehagen@icprb.org and jkiang@icprb.org .
2. Update WSSC, Fairfax Water, Aqueduct operator forms.

1:15 pm CO-OP:

1. Check to see if all revised water use forecasts have been received by email at CO-OP. If not, call the designated staff contact at their office phone number. If contact cannot be made, call the appropriate operations control center.
2. Update flows and re-run the scheduling program and advise WSSC of any needed change in the release rate for Little Seneca Reservoir.
3. Advise Fairfax Water and WSSC if any adjustments are necessary for off-Potomac reservoirs.

4:00 pm CO-OP

1. Calculate tomorrow's recommended withdrawal targets for Great Falls and Little Falls.
2. Provide the withdrawal rates to the Aqueduct.
3. Update website with a summary of the day's operations.

Appendix C: Little Seneca Press Release

Upstream Reservoir Release Bolsters Potomac Flow
Interstate Commission on the Potomac River Basin
9/7/2004 - For immediate release

Water stored by Washington-area water supply utilities is being released from Little Seneca Reservoir in Black Hill Regional Park near Germantown, Md., during this year's annual drought management exercise conducted by the Section for Cooperative Water Supply Operations (CO-OP) at the Interstate Commission on the Potomac River Basin (ICPRB).

The release commenced at about 10:15 a.m. on Tuesday, September 7, 2004 and will continue through Wednesday morning. The release is being conducted to test operating procedures and to document how long the released water takes to arrive at Little Falls, the site of the most downstream water supply intake on the Potomac River. Flow from Seneca Creek joins the Potomac River near Riley's Lock on the C&O Canal. Utilities use the Potomac River to provide more than 75 percent of the metropolitan area's drinking water.

The Little Seneca release will put additional water into Seneca Creek at a rate of about 140 million gallons per day (mgd). This release is expected to lower the level of the reservoir by approximately 12 inches over 24 hours. Forecast rain on Wednesday and Thursday may quickly replenish the reservoir storage and additional releases may be initiated as part of the drought management exercise.

The releases are being coordinated with staff from The Maryland-National Capital Park and Planning Commission (M-NCPPC). M-NCPPC manages recreational facilities and conservation areas at Black Hill Regional Park, which surrounds Little Seneca Reservoir. A 12-inch drop in the reservoir level should not have a significant impact on recreation.

The CO-OP annually coordinates a week-long drought management exercise that simulates operational procedures and decision-making under drought conditions. The test ensures that operational procedures are well practiced and understood, and keeps operations personnel familiar with drought operations. Annual simulation also helps all parties to continually improve and refine procedures. Another important feature of the test is that it continues through a weekend in order to ensure a realistic involvement of personnel within all concerned agencies.

The releases are being coordinated by CO-OP and are considered a part of normal operations during low river flow conditions. When flow levels in the river drop below a certain point, a series of agreements guides the release of water stored for water supply and establishes the method for sharing the water among the metropolitan area's major water suppliers. Cooperative use of the river by the independent water suppliers allows for the demands of each to be met well into the future.

"Announcement of these water releases is a testament to the level of planning, over several decades, that allows the Washington area the water it needs," noted ICPRB Executive Director Joseph Hoffman. "It is a testament to area governments, water suppliers, and ICPRB, which have worked cooperatively to create a regional solution to water concerns, and have left the Washington area able to withstand the effects of extended low-flow periods."

If the drought of record (1930-1931) were to recur, water storage would be more than adequate to meet the needs of the Washington metropolitan area.

If combined water supply storage in Jennings Randolph and Little Seneca reservoirs dropped below 60% full, voluntary restrictions would be implemented under regional agreements. Water supply storage in these two reservoirs is currently 100 percent full. More information on current water supply status, the drought exercise, and the water supply system for the metropolitan area can be found on the ICPRB website at www.potomacriver.org.

Appendix D: Letter to Montgomery County Council and County Executive

September 8, 2004

Dear members of the Montgomery County Council,

We are writing to give you an advance notification of an upcoming water supply release planned for Little Seneca Reservoir. Water stored by Washington-area water supply utilities will be released from Little Seneca Reservoir in Black Hill Regional Park near Germantown, Maryland, during this year's annual drought management exercise conducted by the Section for Cooperative Water Supply Operations (CO-OP) at the Interstate Commission on the Potomac River Basin (ICPRB).

The Little Seneca release will be made at a rate of about 135 million gallons per day (mgd). This release is expected to lower the level of the reservoir by approximately 12 inches over 24 hours. The release is being coordinated with staff from The Maryland-National Capital Park and Planning Commission (M-NCPPC). M-NCPPC manages recreational facilities and conservation areas at Black Hill Regional Park, which surrounds Little Seneca Reservoir. A 12-inch drop in the reservoir level should not have a significant impact on recreation.

Preliminary plans call for a release of water from the reservoir on Thursday, September 9, to begin around noon and ending on Friday afternoon. A significant rain forecast or actual rainfall could alter the timing of the release. The release is being conducted to test operating procedures and to document how long the released water takes to arrive at Little Falls, the site of the most downstream water supply intake. Utilities use the Potomac River to provide more than 75 percent of the metropolitan area's drinking water.

The CO-OP annually coordinates a week-long drought management exercise that simulates operational procedures and decision-making under drought conditions. The test ensures that operational procedures are well practiced and understood, and keeps operations personnel familiar with drought operations. Annual simulation also helps all parties to continually improve and refine procedures. Another important feature of the test is that it continues through a weekend in order to ensure a realistic involvement of personnel within all concerned agencies.

The release is being coordinated by the CO-OP and is considered a part of normal drought operations during low river flow conditions. When flow levels in the river drop below a certain point, a series of agreements guides the release of water stored for water supply and establishes the method for sharing the water among the metropolitan area's major water suppliers. Cooperative use of the river by the independent water suppliers allows for the demands of each to be met well into the future.

No releases were made from Little Seneca in 2000, 2001, or 2003, and no releases were made in 2004 prior to the currently planned release. In the summer of 2002, a total of 1 billion gallons was released to meet the metropolitan area's needs.

Please do not hesitate to call with questions, concerns, or comments.

Sincerely,

Erik Hagen
Director CO-OP Operations

Appendix E: Example summary of daily operations

THE FOLLOWING INFORMATION IS PART OF THE DROUGHT EXERCISE!
OPERATIONAL CHANGES SHOULD NOT BE IMPLEMENTED!

Late P.M. Operations (5:00 p.m.)

Change both Aqueduct conduit gate settings to 0.75 feet.
These settings are equal c. 70 MGD from Great Falls and 110 MGD from Little Falls.
No other changes in operations are necessary.

P.M. Operations (2:00 p.m.)

No changes to the A.M. operations.
Today's p.m. demand estimates are higher for WSSC and the Aqueduct for today, but not enough to have an impact on operations.

A.M. Operations (10:00 a.m.)

Baltimore District, USCOE
Jennings Randolph Luke target: 275 CFS (178 MGD)
Note: 100 mgd flow target at Little Falls met from water quality storage

WSSC
Potomac withdrawal (firm): 126 MGD
Patuxent (can vary to meet changing demand): 37.5 MGD
Simulated Seneca release: 0 MGD

Fairfax Water
Potomac withdrawal (firm): 89 MGD
Occoquan (can vary to meet changing demand): 70 MGD

Aqueduct
Old Conduit: set to 1 foot
New Conduit: set to 1 foot
Little Falls pumping: 50 MGD from 11:00 a.m. to 3:00 p.m.; 75 MGD from 3:00 p.m. to midnight
(These settings should result in a Great Falls average daily withdrawal of 125 MGDand a Little Falls average daily withdrawal of 65 MGD.)

Appendix F: Example operator form for Washington Aqueduct

Drought Operations/ Drought Exercise
ICPRB Operator Form for the Aqueduct
Please email to ehagen@icprb.org, jkiang@icprb.org, akameenui@icprb.org
Please update at 7:30 a.m. and 1:00 p.m. during drought exercises
Operator inputs in yellow

Date	9/7/04	A.M. estimate of today's demand, MGD	188
Time sent	1300	P.M. estimate of today's demand, MGD	190
		(Note: P.M. estimate provided at 1 p.m. only)	
		Tomorrow's estimated demand, MGD	195

Yesterday's net withdrawal from Great Falls (MGD)	115
Yesterday's pumpage from Little Falls (MGD)	81.2
Total	196.2

Summary, Little Falls Pumping Station

RAW WATER

NO. 1			NO. 2		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0	0900	1300	4.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

NO. 3			NO. 4		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0	0000	0630	6.5
		0.0			0.0
		0.0			0.0
		0.0			0.0

NO. 5			NO. 6		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

Comments: Pump no. 2 presently pumping.

Great Falls gate settings

HOUR	Old conduit	New conduit
0	1.00	1.00
1	1.25	1.25
2	1.25	1.25
3	1.25	1.25
4	1.25	1.25
5	1.25	1.25
6	1.25	1.25
7	1.25	1.25
8	1.25	1.25
9	1.25	1.25
10	1.25	1.25
11	1.25	1.25
12	1.25	1.25
13	1.25	1.25
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

Appendix G: Example operator form for WSSC

Drought Operations/ Drought Exercise
ICPRB Operator Form for WSSC
Please email to ehagen@icprb.org, jkiang@icprb.org, akameenui@icprb.org
Please update at 7:30 a.m. and 1:00 p.m. during drought exercises
Operator inputs in yellow

Date	9/7/04
Time sent	1300

A.M. estimate of today's demand, MGD	145
P.M. estimate of today's demand, MGD	148
(Note: P.M. estimate provided at 1 p.m. only)	
Tomorrow's estimated demand, MGD	150

Storage in Little Seneca (bg)	3.7
Storage in Brighton (bg)	4.92
Storage in Duckett (bg)	4.27

Yesterday's net withdrawal from Potomac (MGD)	126.4
Yesterday's pumpage from Patuxent (MGD)	38.2
Total	164.6

Net Potomac River Withdrawal at Potomac Plant, MGD			
Midnight	withdrawal		withdrawal
12:00 AM	**50**	12:00 PM	**50**
12:30 AM	**50**	12:30 PM	**100**
1:00 AM	**50**	1:00 PM	**100**
1:30 AM	**50**	1:30 PM	
2:00 AM	**50**	2:00 PM	
2:30 AM	**50**	2:30 PM	
3:00 AM	**75**	3:00 PM	
3:30 AM	**75**	3:30 PM	
4:00 AM	**75**	4:00 PM	
4:30 AM	**75**	4:30 PM	
5:00 AM	**75**	5:00 PM	
5:30 AM	**75**	5:30 PM	
6:00 AM	**75**	6:00 PM	
6:30 AM	**50**	6:30 PM	
7:00 AM	**50**	7:00 PM	
7:30 AM	**50**	7:30 PM	
8:00 AM	**50**	8:00 PM	
8:30 AM	**50**	8:30 PM	
9:00 AM	**50**	9:00 PM	
9:30 AM	**50**	9:30 PM	
10:00 AM	**50**	10:00 PM	
10:30 AM	**50**	10:30 PM	
11:00 AM	**50**	11:00 PM	
11:30 AM	**50**	11:30 PM	

Potomac River Level (ft)	
Date and Time	Level
9/7/04 12:08 AM	159.2462
9/7/04 12:17 AM	159.2491
9/7/04 12:26 AM	159.2463
9/7/04 12:35 AM	159.2483
9/7/04 12:44 AM	159.2437
9/7/04 12:53 AM	159.248
9/7/04 1:02 AM	159.2489
9/7/04 1:11 AM	159.2489
9/7/04 1:20 AM	159.2481
9/7/04 1:29 AM	159.2436
9/7/04 1:38 AM	159.2471
9/7/04 1:46 AM	159.245
9/7/04 1:55 AM	159.2356
9/7/04 2:04 AM	159.2417
9/7/04 2:13 AM	159.2425
9/7/04 2:22 AM	159.2344
9/7/04 2:31 AM	159.2422
9/7/04 2:40 AM	159.2344
9/7/04 2:49 AM	159.2407
9/7/04 2:58 AM	159.2348
9/7/04 3:07 AM	159.2402
9/7/04 3:16 AM	159.2363
9/7/04 3:25 AM	159.2344
etc.	etc.

Appendix H: Example operator form for Fairfax Water

Drought Operations/ Drought Exercise
ICPRB Operator Form for FCWA
Please email to ehagen@icprb.org, jkiang@icprb.org, akameenui@icprb.org
Please update at 7:30 a.m. and 1:00 p.m. during drought exercises
Operator inputs in yellow.

Date	9/11/04
Time sent	1300

A.M. estimate of today's demand, MGD	170
P.M. estimate of today's demand, MGD	172
(Note: P.M. estimate provided at 1 p.m. only)	
Tomorrow's estimated demand, MGD	175

Storage in Occoquan (bg)	7.2
Yesterday's net withdrawal from Potomac (MGD)	104.5
Yesterday's pumpage from Occoquan (MGD)	78.2
Total	182.7

Net Potomac River Withdrawal at Corbalis Plant, MGD			
Midnight	withdrawal		withdrawal
12:00 AM	**100**	12:00 PM	**50**
12:30 AM	**100**	12:30 PM	**100**
1:00 AM	**100**	1:00 PM	**100**
1:30 AM	**50**	1:30 PM	
2:00 AM	**50**	2:00 PM	
2:30 AM	**50**	2:30 PM	
3:00 AM	**75**	3:00 PM	
3:30 AM	**75**	3:30 PM	
4:00 AM	**75**	4:00 PM	
4:30 AM	**75**	4:30 PM	
5:00 AM	**75**	5:00 PM	
5:30 AM	**75**	5:30 PM	
6:00 AM	**75**	6:00 PM	
6:30 AM	**50**	6:30 PM	
7:00 AM	**50**	7:00 PM	
7:30 AM	**50**	7:30 PM	
8:00 AM	**50**	8:00 PM	
8:30 AM	**50**	8:30 PM	
9:00 AM	**100**	9:00 PM	
9:30 AM	**100**	9:30 PM	
10:00 AM	**100**	10:00 PM	
10:30 AM	**100**	10:30 PM	
11:00 AM	**100**	11:00 PM	
11:30 AM	**100**	11:30 PM	

Potomac River Level, outside (ft)	
Date and Time	Level
9/11/2004 0:00	3.4198
9/11/2004 1:00	3.41111
9/11/2004 2:00	3.40727
9/11/2004 3:00	3.40007
9/11/2004 4:00	3.39778
9/11/2004 5:00	3.38924
9/11/2004 6:00	3.38568
9/11/2004 7:00	3.38004
9/11/2004 8:00	3.37189
9/11/2004 9:00	3.36631
9/11/2004 10:00	3.3633
9/11/2004 11:00	3.35885
9/11/2004 12:00	3.35567
9/11/2004 13:00	3.34541
9/11/2004 14:00	
9/11/2004 15:00	
9/11/2004 16:00	
9/11/2004 17:00	
9/11/2004 18:00	
9/11/2004 19:00	
9/11/2004 20:00	
9/11/2004 21:00	
9/11/2004 22:00	
9/11/2004 23:00	

Appendix I: Demand forecasting results

WSSC		Actual production	Model forecast current forecast	Model forecast next day forecast	Operator forecast current forecast	Operator forecast next day forecast	Difference between model forecast and actual demands current forecast	Difference between model forecast and actual demands next day forecast	Difference between operator forecast and actual demands current forecast	Difference between operator forecast and actual demands next day forecast
9/7/2004	Tuesday	169.8								
9/8/2004	Wednesday	166.1	167	169	163	163	0.9	4.4	-3.1	-1.6
9/9/2004	Thursday	164.6	169	177	166	168	4.4	10.9	1.4	1.9
9/10/2004	Friday	166.1	175	180	168	170	8.9	7	1.9	-3
9/11/2004	Saturday	173	176	180	175	180	3	-0.3	2	-0.3
9/12/2004	Sunday	180.3	180	185	180	175	-0.3	1.5	-0.3	-8.5
9/13/2004	Monday	183.5	185	182	175	175	1.5	19.6	-8.5	12.6
9/14/2004	Tuesday	162.4	181	177	170	170	18.6		7.6	
						bias in estimate (average of errors)	**5.3**	**7.2**	**0.1**	**0.2**
						Average of absolute value of errors	**5.4**	**7.3**	**3.5**	**4.7**

Aqueduct		Actual production	Model forecast today	Model forecast tomorrow	Operator forecast today	Operator forecast tomorrow	Difference between model forecast and actual demands today	Difference between model forecast and actual demands tomorrow	Difference between operator forecast and actual demands today	Difference between operator forecast and actual demands tomorrow
9/7/2004	Tuesday	183								
9/8/2004	Wednesday	188	190	195	170	170	2	15.1	-18	-9.9
9/9/2004	Thursday	179.9	195	199	180	180	15.1	13.4	0.1	-5.6
9/10/2004	Friday	185.6	191	192	185	180	5.4	15	-0.6	3
9/11/2004	Saturday	177	191	192	180	180	14	19.6	3	7.6
9/12/2004	Sunday	172.4	187	194	180	185	14.6	8	7.6	-1
9/13/2004	Monday	186	187	193	180	180	1	8.6	-6	-4.4
9/14/2004	Tuesday	184.4	194	196	183	180	9.6		-1.4	
						bias in estimate (average of errors)	**8.8**	**13.3**	**-2.2**	**-1.7**
						Average of absolute value of errors	**8.8**	**13.3**	**5.2**	**5.3**

FCWA		Actual Withdrawal	Model forecast today	Model forecast tomorrow	Operator forecast today	Operator forecast tomorrow	Difference between model forecast and actual withdrawals today	Difference between model forecast and actual withdrawals tomorrow	Difference between operator forecast and actual withdrawals today	Difference between operator forecast and actual withdrawals tomorrow
9/7/2004	Tuesday	158.5								
9/8/2004	Wednesday	164.4	152	157	159	159	-12.4	-3.2	-5.4	-1.2
9/9/2004	Thursday	160.2	164	173	159	169	3.8	20.6	-1.2	16.6
9/10/2004	Friday	152.4	171	177	160	165	18.6	14.1	7.6	2.1
9/11/2004	Saturday	162.9	173	181	157	162	10.1	12	-5.9	-7
9/12/2004	Sunday	169	175	179	**157**	**162**	6	9.1	-12	-7.9
9/13/2004	Monday	169.9	175	167	156	156	5.1	-3.6	-13.9	-14.6
9/14/2004	Tuesday	170.6	165	165	**156**	**156**	-5.6		-14.6	
						bias in estimate (average of errors)	**3.7**	**8.2**	**-6.5**	**-2.0**
						Average of absolute value of errors	**8.8**	**10.4**	**8.7**	**8.2**

Note: Bold values in operator forecast column estimated by ICPRB (repeat of prior day's forecast)

CO-OP totals (summed from)		Actual demand	Model forecast current forecast	Model forecast next day forecast	Operator forecast current forecast	Operator forecast next day forecast	Difference between model forecast and actual demands current forecast	Difference between model forecast and actual demands next day forecast	Difference between operator forecast and actual demands current forecast	Difference between operator forecast and actual demands next day forecast
9/7/2004	Tuesday	511.3								
9/8/2004	Wednesday	518.5	509	521	492	492	-9.5	16.3	-26.5	-12.7
9/9/2004	Thursday	504.7	528	549	505	517	23.3	44.9	0.3	12.9
9/10/2004	Friday	504.1	537	549	513	515	32.9	36.1	8.9	2.1
9/11/2004	Saturday	512.9	540	553	512	522	27.1	31.3	-0.9	0.3
9/12/2004	Sunday	521.7	542	558	517	522	20.3	18.6	-4.7	-17.4
9/13/2004	Monday	539.4	547	542	511	511	7.6	24.6	-28.4	-6.4
9/14/2004	Tuesday	517.4	540	538	509	506	22.6		-8.4	
						bias in estimate (average of errors)	**17.8**	**28.6**	**-8.5**	**-3.5**
						Average of absolute value of errors	**20.5**	**28.6**	**11.2**	**8.6**