Report on the 2005 Drought Exercise

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The Interstate Commission on the Potomac River Basin

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September 28-October 4, 2005

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

The ICPRB's CO-OP section annually coordinates a week-long drought management exercise that simulates water management operations and decision-making under drought conditions for the WMA water suppliers. The exercise ensures that operational procedures are well practiced and understood, despite many years between droughts. Annual simulation allows for the continual improvement of management tools and procedures, while training new personnel and refreshing procedures with veteran personnel.

The 2005 Drought Exercise took place September 28 through October 4, 2005. Using simulated drought data, CO-OP coordinated daily demands for water with available river flow, and determined virtual release rates from storage at Jennings Randolph Reservoir, Occoquan Reservoir, and the Patuxent reservoirs. In addition to the virtual releases, real releases were made from Little Seneca and Jennings Randolph reservoirs to test time of travel and to practice communications and operations.

Actual flow levels in the Potomac were low in September of 2005, so at the beginning of the exercise CO-OP was in an enhanced monitoring mode, in compliance with the terms of the Drought Operations Manual (of the Water Supply Coordination Agreement). In this mode, the water suppliers provide daily withdrawal data to CO-OP, and CO-OP calculates the flow at Little

Falls that would occur before water supply withdrawals. For the simulation portion of the exercise, flow levels in the Potomac were used from the drought of record (1930). Hourly data was developed based on the 1930 daily flow rates, and a simulated hourly stage level was developed at the upstream stream level monitor at Edwards Ferry.

This year marked the first time that simulated information from the newly activated (by CO-OP section) Edwards Ferry water level monitor on the Potomac River was used to assist in reservoir release decision-making.

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 both utility personnel and CO-OP staff for next year's exercise or in the event of a real drought.

The report is organized into three sections, addressing issues relating to communications, reservoir releases, and system management.

Background

The majority (approximately 90 percent) of the WMA's population relies on water furnished by the three water suppliers (collectively, 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 (FW) serving parts of northern Virginia.
- The Washington Suburban Sanitary Commission (WSSC) serving the Maryland suburbs

The Water Suppliers provide treated water either directly to customers or through wholesale suppliers to a total of approximately 4.1 million people (Kame'enui and Hagen, 2005). The 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). In addition, WSSC and FW own and operate the Patuxent and Occoquan reservoirs, respectively, and have agreed to operate these reservoirs to improve regional water supply reliability during droughts.

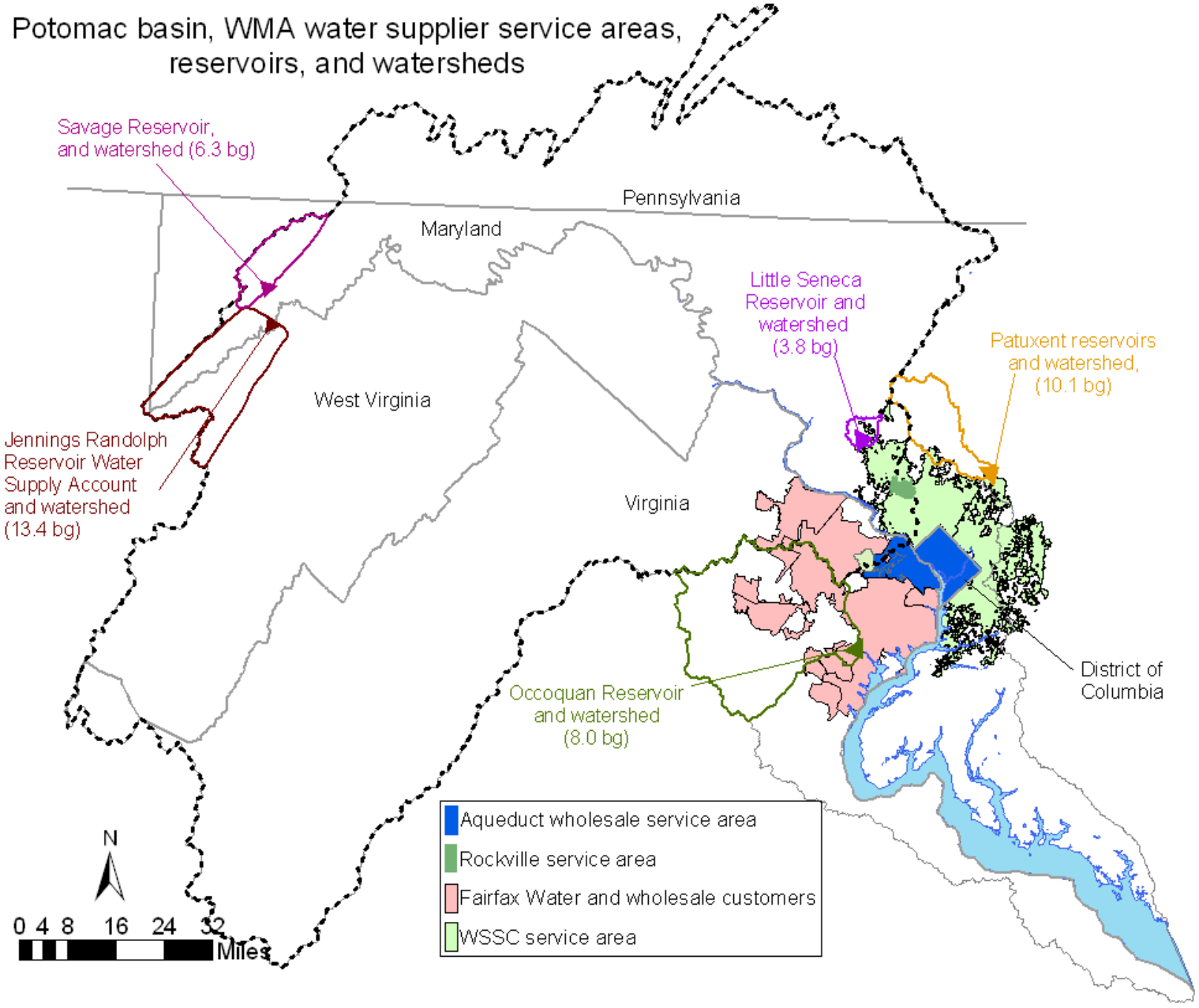

Figure 1: Potomac basin, Patuxent basin, basin states, water supply service area, and regional supply reservoirs

Communications

Communications are a critical part of drought operations. This section of the report details the drought exercise pre-meeting, authorization for reservoir releases, web links, and the daily drought updates. Unrelated to the Drought Exercise was a conference call of the Drought Coordinating Technical Committee to discuss actual drought conditions, which is also discussed in this section of the report.

Drought Exercise Pre-Meeting

A meeting of the CO-OP and the WMA Water Suppliers was held on September 22, 2005 in advance of the drought exercise. The purpose of the meeting was to:

- Share information about current maximum and minimum production capacity at each plant.
- Meet the other operational personnel from the other utilities.
- Discuss the drought exercise procedures.
- Update contact information.

Table 1 shows the production capacity information provided by the suppliers.

Table 1: WMA Water Suppliers Rated Production Capacities

Rated Production Capacity [MGD]	
WSSC	
Potomac	285[a]
Patuxent	60 for a day or two, 50 continuously [b]
FW	
Potomac	150 (future: 225 with expansion)
Occoquan	Planned expansion to 160
Aqueduct	
Dalecarlia	200
McMillan	65-70 constrained by turbidity – short term can increase.
TOTALS	
Total Potomac	**700 with short term increases possible**
Total System	**870 with short term increases possible**

[a]WSSC's Potomac plant, while rated at 285 MGD, cannot always move that volume of water. According to Doug Grimes, Potomac Plant Superintendent, 240 MGD is closer to the plant's current actual capacity.
[b]The Patuxent plant will be rated at a 72 MGD treatment rate with an emergency maximum of 120 MGD when the new plant is complete.

Authorization for water supply releases

During droughts, CO-OP staff provide operational recommendations to its Operations Committee, which has oversight and authority to over-ride the CO-OP staff recommendations per the Water Supply Coordination Agreement (1982). The Operations Committee is currently comprised of the Chief of the Washington Aqueduct, the Chief of Production for WSSC, and the General Manager of the FW. Communications between the CO-OP Operations Committee and CO-OP staff take place during droughts when water supply releases are imminent. The Operations Committee was contacted via conference call to discuss and authorize releases from Little Seneca and Jennings Randolph Reservoirs in specified amounts to take place during the drought exercise. This part of the exercise was useful for practicing communication procedures and maintaining emergency contact information for the Operations Committee.

Web links

Operators and others may be interested in the web links that ICPRB uses to evaluate precipitation forecasts and other weather related information as shown in Table 2.

Table 2: Websites and links for weather information

Description/ agency	Website/directions
Map showing quantitative forecast of precipitation, 1- and 2- days ahead. Middle Atlantic River Forecast Center (MARFC).	http://www.erh.noaa.gov/er/marfc/ Look for "Precipitation" heading on left margin, and click on "Forecasts."
Aerial map showing precipitation that has fallen in the region for the prior 24, 48 or 72 hours. MARFC.	http://www.erh.noaa.gov/er/marfc/ Look for "Precipitation" heading on left margin, and click on "Multisensor Obs."
Aerial map showing quantitative forecast of precipitation, 1 through 5 days ahead. National Weather Service's Hydrometeorological Prediction Center.	http://www.hpc.ncep.noaa.gov/qpf/qpf2.shtml Click on appropriate day's map. Days 1 through 5 show the total forecast.
Table showing daily average precipitation at each of the three regional airports. National Weather Service Forecast Office Baltimore/Washington.	http://www.weather.gov/climate/index.php?wfo=lwx This is an experimental site and may change in the near future.

Daily updates

Daily updates were sent out to the following distribution:

- WSSC: Karen Wright, Todd Supple, Bill Staple, Roland Steiner, Tom Heikkinen.
- FW: Traci Kammer Goldberg, Greg Prelewicz, Chuck Murray, Charlie Crowder.
- Aqueduct: Woody Peterson, Jay Nolan, Tom Jacobus.
- COE: Stan Brua, Bill Haines.
- ICPRB: Joe Hoffman, Julie Kiang, Erik Hagen, Cherie Schultz.

Updates were written with a short summary at the top of the page, so readers could quickly identify new information. An example update is shown below:

Today's A.M. Summary (10/03/05)

A third Seneca release was initated this morning, as planned. The release rate will be 75 MGD and continue for about 24 hours. As a result of our three test releases from Little Seneca Reservoir, the lake level will be down by a total of approximately 2 feet. Flows continue to be steady at Little Falls. There is a chance (40% probability of precipitation) of significant rain in the basin on Thursday/Friday.

Gage Flow:
Little Falls flow 10/02: 650 MGD
Little Falls flow 10/03: 580 MGD (est.)
Point of Rocks flow 10/02: 870 MGD (est.)
Point of Rocks flow 10/03: 840 MGD (est.)

Net Production (10/02/05)
FW Corbalis raw water withdrawal (Potomac): 130 MGD
FW Occoquan raw water withdrawal: 78 MGD
WSSC Potomac Production: 155 MGD
WSSC Patuxent Production: 48 MGD
Aqueduct Great Falls withdrawal: 166 MGD
Aqueduct Little Falls withdrawal: 0 MGD
Total demand: 576 MGD
Potomac demand: 451 MGD

Monday, October 03, 2005
A.M. Operations (The following is part of the 2005 Drought Exercise. Operational recommendations should not actually be implemented.)

Fairfax Water:
Simulated Occoquan withdrawal: 75 MGD (flexible)
Simulated Potomac withdrawal: 130 MGD (firm) Please keep Potomac withdrawals as steady as possible.

WSSC:
Simulated Patuxent withdrawal: 40 MGD (flexible).
Simulated Potomac withdrawal: 160 MGD (firm) Please keep Potomac withdrawals as steady as possible.

Simulated Seneca: (release date, time, amount in MGD):

10/3/2005 9:00	120
10/3/2005 10:00	120
10/3/2005 11:00	120
10/3/2005 12:00	130
10/3/2005 13:00	130
10/3/2005 14:00	130
10/3/2005 15:00	130

Conference call, Drought Coordinating Technical Committee

A conference call of the regional Drought Coordinating Technical Committee (DCTC) coordinated by the Metropolitan Washington Council of Governments (MWCOG) took place on October 6, 2005. The conference call was not a part of the drought exercise; rather, it was conducted in response to actual drought conditions. The situation at the time was one in which a very late season drought developed, with unlikely implications for affecting the water supply situation. Most of the Potomac River basin was just placed in NOAA's "D1" drought status, thereby triggering the "Drought Watch" stage of the Metropolitan Washington Waster Supply and Drought Awareness Response Plan: Potomac River System (MWCOG Board Task Force on Regional Water Supply Issues, 2000).

The DCTC unanimously recommended to the MWCOG Chief Administrative Officers that no action be taken to move the region into a "Drought Watch" status. This conclusion was based on a forecast for significant basin-wide precipitation and was coupled with the time of the year (fall) with attendant cooling ambient temperatures, less evaporation and transpiration, and decreased consumer demand. CO-OP recommends including a similar conference call in coordination with MWCOG as part of a future drought exercises.

Reservoir Releases

Reservoir releases represent the mainstay of drought operations. This section of the report details the Jennings Randolph and Savage reservoir release procedures and storage accounting, and documents the travel time of the releases made from Jennings Randolph and Little Seneca reservoirs as part of the drought exercise.

Jennings Randolph and Savage release procedure and storage accounting

The Water Control Section of the Baltimore office of the U.S. Army Corps of Engineers (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. 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 estimate of a 9-day travel time to Little Falls, more frequent updates would most likely be unnecessary in most situations. For after-hours or weekend communications, CO-OP staff referred to the after hours call router and the "Priority Call List" (respectively) maintained internally by Baltimore COE staff. The list provides home contact information for Baltimore Staff and prioritizes the call order. Both the call router and priority call list were tested during the exercise.

When releases are needed from the North Branch system for water supply, ICPRB determines a flow target just downstream of Jennings Randolph and Savage Reservoirs at Luke, Maryland and conveys this information to the Baltimore COE. This flow target is

known as the "Luke target." (This target should be given to the Baltimore COE in cubic feet per second.)

Next, the COE determines how much water quality release they will make. The relevant agreement specifying COE operations is the *Agreement for Future Water Supply Storage Space in the Bloomington Reservoir, Maryland and West Virginia*. Reservoir releases are made given the following criteria:

"The Government will make releases from Bloomington Lake to enhance water quality based upon the following considerations:

1. *Satisfaction of the requirements in the authorizing legislation (the Flood Control Act of 1962, Public Law 89-874.*
2. *The need for flow-by in the Potomac River,*
3. *The optimum overall quality of the Potomac River for all project purposes and for the benefit of all users downstream from Bloomington lake.*

The Government may adjust any water quality releases upon a determination that such adjustment is in the public interest."

In 1999, the COE released 77 MGD (not the 100 MGD flowby) citing the availability of water quality storage. For this year's water supply release, the COE supported the 100 MGD target. Typically, water quality releases are bigger than either target, but during water supply releases the water quality release is reduced.

Table 3 provides an accounting of the virtual water supply releases called for by CO-OP during the drought exercise. The accounting was calculated by the COE and provided to CO-OP after the conclusion of the drought exercise. The water supply accounting can be understood through the following example. Numbers may not match the table exactly due to rounding error.

- On October 1, a Luke flow target of 370 cfs is provided to the COE by ICPRB.
- The COE subtracts local inflow, in this example 10 cfs, to account for inflow between the reservoirs and the gage at Luke (370 cfs – 10 cfs = 360 cfs).
- The remaining flow (360 cfs) must be allocated between Jennings Randolph and Savage Reservoir. Eighty percent (288 cfs) is released from Jennings Randolph and twenty percent is released from Savage Reservoir (72 cfs). This policy, which initially was codified in the *1985 Master Manual for Reservoir Regulation, North Branch Potomac River Basin* (COE, 1986), was effected during drought operations in the summer of 2002 and was supported in a letter dated May 2, 2003 written by James Taylor of the Upper Potomac River Basin Commission to Richard Olin of the Baltimore COE. This policy effectively provides a 20% credit to the water supply account at Jennings Randolph. The exact percentage used for the allocation is a function of the release rate from Jennings Randolph and is given on page L-6 (COE, 1986).
- The water released from Jennings Randolph must be allocated between the water supply and water quality accounts, in this example, 288 cfs. The net water quality release from Jennings Randolph is 80 percent of the flowby value of 100 MGD, or 80 MGD (125 cfs).
- The net water supply release from Jennings Randolph is the difference between the total Jennings Randolph release of 288 cfs and the water quality release of 125 cfs (288 cfs – 125 cfs = 163 cfs).
- Inflow greater than 50 cfs is distributed between water supply and water quality accounts. The first 50 cfs of inflow is passed through the reservoir as part of a water quality release. Inflow to the water supply account is allocated as a ratio of water supply storage to the total allocated capacity, 46.5% (per *Agreement for Future Water Supply Storage Space in the Bloomington Reservoir, Maryland and West Virginia*, 1982).

Table 3: Excerpt of Jennings Randolph storage accounting spreadsheet provided by COE

DATE	STATUS - J.RANDOLPH LAKE					LUKE			AVERAGE DAILY RELEASES				J.RANDOLPH INFLOW DISTRIBUTION				
	ELEV @ 0800 HRS	WATER SUPPLY STORAGE REMAINING @ 0800		WATER QUALITY STORAGE REMAINING @ 0800		TARGET	EST. OBS.	EST. LOCAL	TOTAL SAVAGE	TOTAL J.RAND	J.RAND WQ	J.RAND WS	AVG DAILY INFLOW	BASE INFLOW TO WQ	EXCESS INFLOW	TOTAL INFLOW TO WS	TOTAL INFLOW TO WQ
mm/dd/yy	(FT NGVD)	(AC-FT)	(%)	(AC-FT)	(%)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)
28-Sep-05	1438.3	40,995	100.0%	24,595	52.1%												
						350		10	67	273	125	148	53	50	3	0	53
29-Sep-05		40,702	99.3%	24,452	51.8%												
						430		10	83	337	125	212	39	39	0	0	39
30-Sep-05		40,282	98.3%	24,282	51.5%												
						430		10	83	337	125	212	55	50	5	2	53
1-Oct-05		39,867	97.2%	24,139	51.2%												
						370		10	71	289	125	164	71	50	21	10	61
2-Oct-05		39,562	96.5%	24,013	50.9%												
						370		10	71	289	125	164	43	43	0	0	43
3-Oct-05		39,237	95.7%	23,850	50.6%												
						370		10	71	289	125	164	24	24	0	0	24
4-Oct-05		38,912	94.9%	23,650	50.1%												
						500		10	97	393	125	268	31	31	0	0	31
5-Oct-05		38,382	93.6%	23,464	49.7%												
						No WS		10	50	225	225	0	36	36	0	0	36
6-Oct-05		38,382	93.6%	23,090	48.9%												
						No WS		10	50	225	225	0	40	40	0	0	40
7-Oct-05		38,382	93.6%	22,724	48.2%												
						No WS		10	50	225	225	0	119	50	69	32	87
8-Oct-05		38,445	93.8%	22,450	47.6%												
						No WS		10	50	225	225	0	116	50	66	31	85

Jennings Randolph release and time of travel

A Jennings Randolph release from water supply storage was initiated on 9/27, at approximately 10:00 AM. The release took about 2.5 hours to arrive at Luke. When the release passed Luke, it was approximately 300 cfs greater than the background flow. Flow at Point of Rocks was approximately 1,400 cfs during the release (not including the release flow rate). A second and larger whitewater release was initiated with water released from water quality storage on 10/1 at approximately 6:30 AM. When this second release passed Luke, it was approximately 700 cfs greater than the background flow. Flow at Point of Rocks was approximately the same during this release as it was during the first release (1,400 cfs, not including the release flow rate). Travel times of the releases are shown in Table 4, Table 5, and in Figure 2.

Table 4: Travel time of first release (from water supply storage), 300cfs

	First release arrival time	Travel time from Luke, days
Luke	9/27/2005 12:30	Not applicable
Pinto	9/28/2005 0:30	0.50
Cumberland	9/28/2005 4:30	0.67
Paw Paw	9/28/2005 22:00	1.40
Hancock	9/30/2005 2:00	2.56
Point of Rocks	10/2/2005 4:15	4.66
Little Falls	10/3/2005 16:45	6.18

Table 5: Travel time of second release (from water quality storage for whitewater), 700 cfs

	First release arrives	Travel time from Luke, days
Luke	10/1/2005 9:00	Not applicable
Pinto	10/1/2005 18:00	0.37
Cumberland	10/1/2005 23:00	0.58
Paw Paw	10/2/2005 15:30	1.27
Hancock	10/3/2005 15:30	2.27
Point of Rocks	10/5/2005 18:00	4.37
Little Falls	Obscured by rain	Not available

A factor which affects the travel time is the magnitude of the release. The larger, second release traveled faster than the first release. This is consistent with what would be expected from solitary wave travel theory which suggests that the travel time of the wave is a function of its magnitude (Dodd et al., 1984).

The magnitude of river flow also affects the travel time of the release, with quicker travel times associated with higher flows. During the lower flows experienced in the drought years of 1999 and 2002, when Point of Rocks flow was approximately 700 to 800 cfs, releases from Jennings Randolph took about 9 days to reach Little Falls.

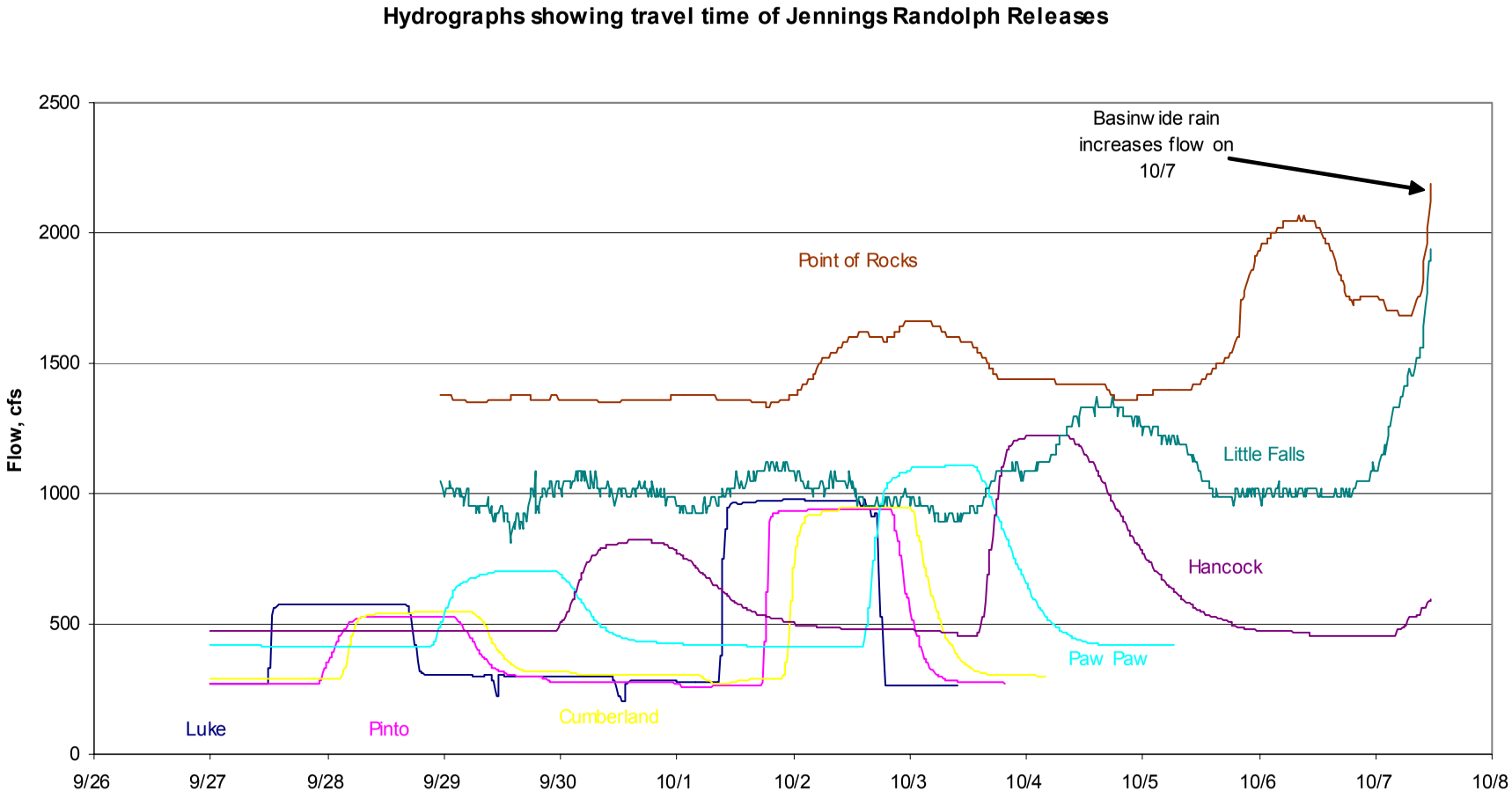

Figure 2: Hydrograph showing travel time of Jennings Randolph releases from Luke to Little Falls, data source: USGS stream flow gages

Little Seneca release and time of travel

As part of the drought exercise, several releases were made from Little Seneca reservoir for the purpose of observing travel time and to exercise coordination with other agencies (Black Hills Regional Park via Maryland National Capital Park and Planning Commission) as well as the public through local elected officials. The Montgomery County Council and County Executive were given notification of the release (Appendix B). In addition, a press release was issued by ICPRB with the opportunity for input from MNCPPC (Appendix A). No newspapers picked up the story this year. Figure 3, Figure 4 and Figure 5 show the hydrograph of the Little Seneca release as seen at the USGS gage at Dawsonville, at the ICPRB Potomac level monitor at the mouth of Seneca Creek, and at the USGS gage at Little Falls.

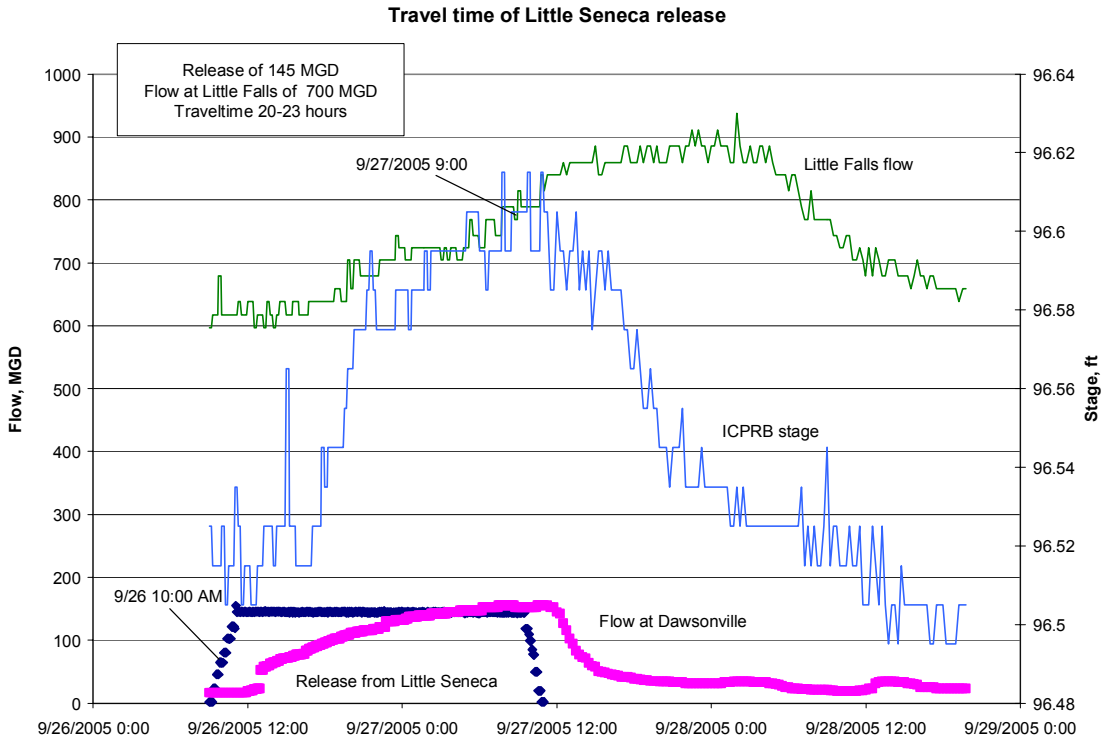

Figure 3: Travel time, first Seneca release of 145 MGD

All of the Seneca Reservoir releases took between 20 to 24 hours to arrive at Little Falls. Figure 6 shows a hydrograph of all of the Seneca releases and the Jennings Randolph water supply release as seen on the Potomac at the mouth of Seneca Creek on the Potomac River and at Little Falls. The water quality release is not shown as it was obscured by a rising hydrograph due to rain.

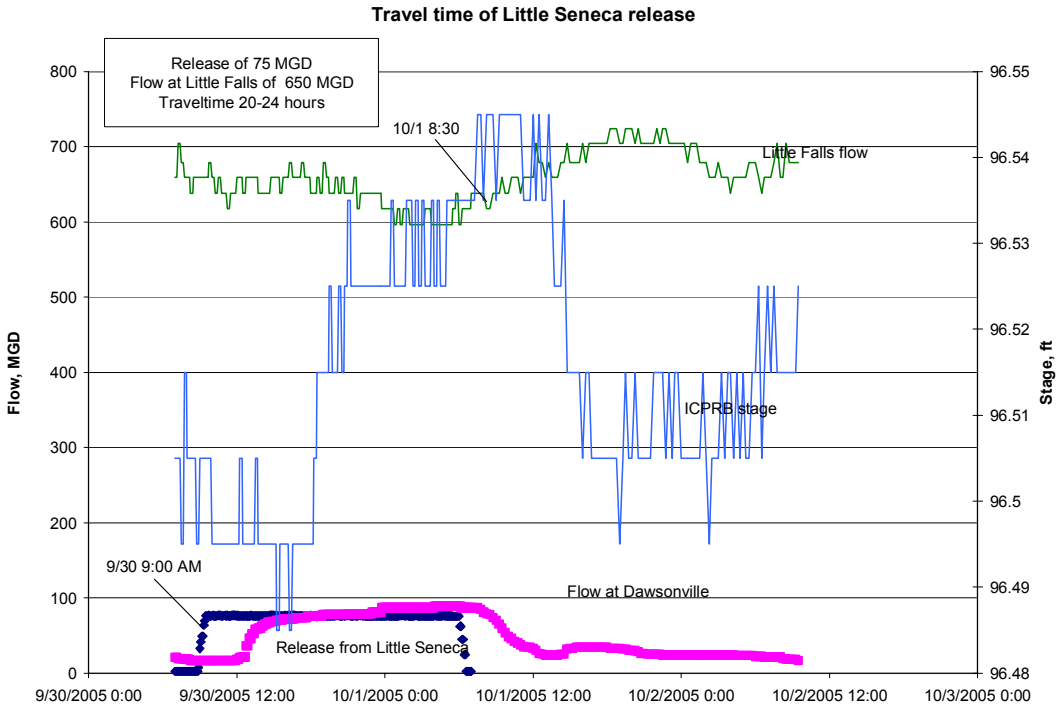

Figure 4: Travel time, second Seneca release (75 MGD)

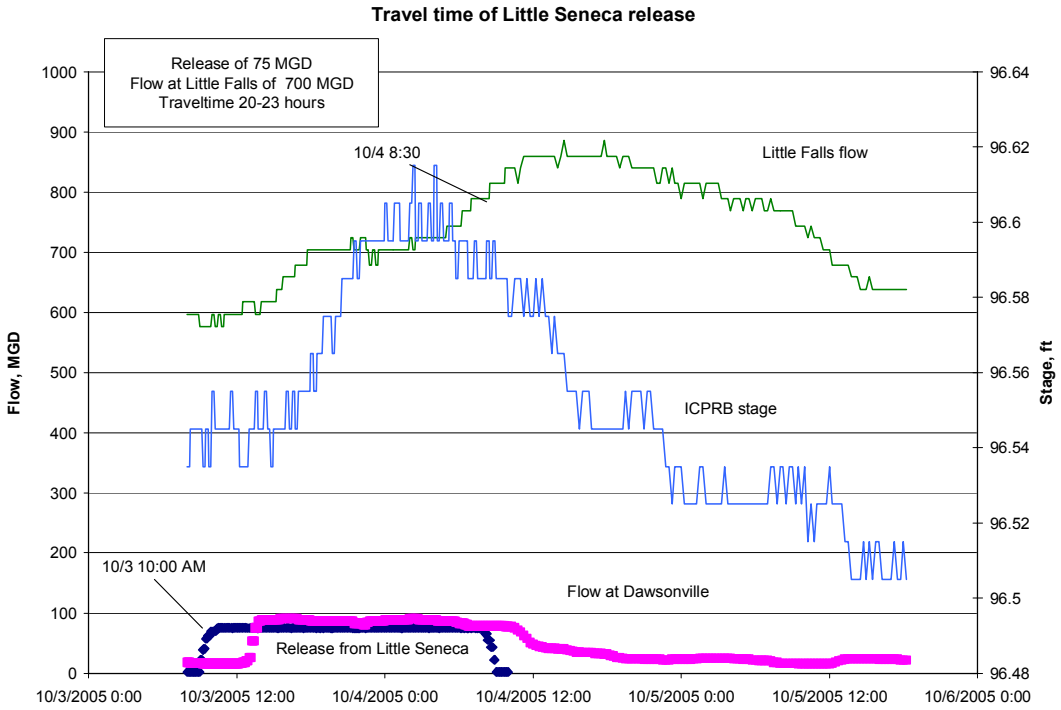

Figure 5: Travel time, third Seneca release (75 MGD)

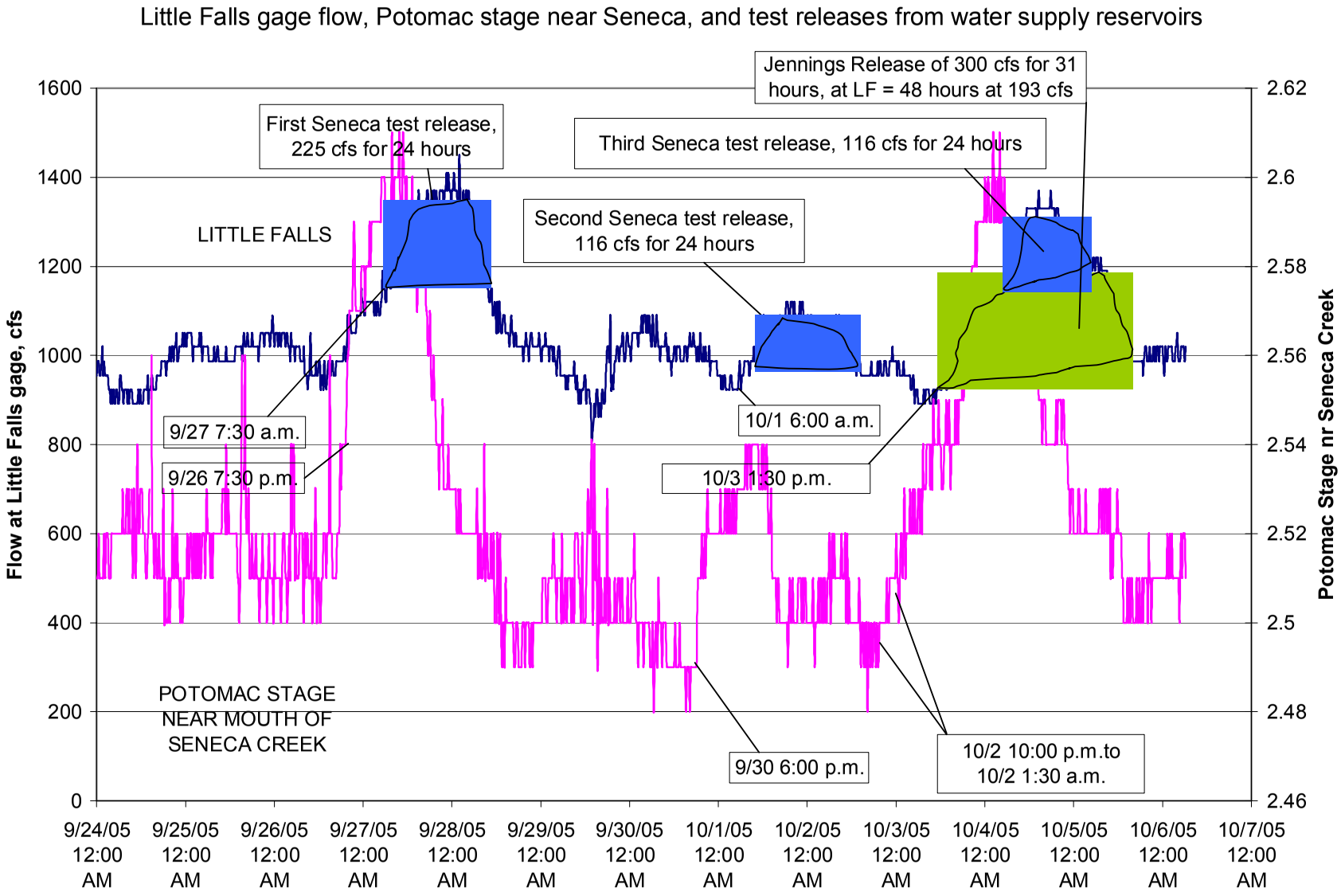

Figure 6: Water supply releases on the Potomac as observed by the stream level monitor near the mouth of Seneca Creek and at Little Falls streamflow gage

System Management

The technical tools and practices that are a part of daily drought operations and coordination are detailed here, including daily operational procedures, a demand forecasting tool, load shifting at Little Falls and Great Falls, Potomac withdrawals and pumping, river level monitors, and operations at Patuxent and Occoquan reservoirs.

Daily Operational procedures for 2005 operations

Daily operations are summarized below:

7:30 am CO-OP:

1. Obtain latest USGS gage flows for Potomac River at Point of Rocks and Little Falls, and ICPRB gage levels. Estimate flow at Little Falls in 24 hours.

7:30 am Aqueduct, FW and WSSC:

1. Provide operator forms to CO-OP by email or by phone if arranged ahead of time. Please mail to coop@icprb.org or call 301 984 1908 x133 and leave a message.

7:45 am CO-OP:

1. Check to see if all water use, forecast, and storage data has been received by email or phone at CO-OP. If not, call the designated staff contact at their office phone number or alternate contact number if it is the weekend. 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.

10:00 am CO-OP:

1. Provide email Potomac withdrawal rates to FW and WSSC (remainder of demand to be met from Occoquan and Patuxent). Follow up with verbal contact. (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).
4. Provide upstream release target for Jennings Randolph to the Baltimore District of the Corps of Engineers (cfs and MGD).

1:00 pm Aqueduct, FW and WSSC:

1. Update operator forms. Provide operator forms to CO-OP by email or by phone if arranged ahead of time. Please mail to coop@icprb.org or call 301 984 1908 x133 and leave a message.

1:15 pm CO-OP:

1. Check to see if all operator forms have been received by email or phone at CO-OP. If not, call the designated staff contact at their office phone number or alternate contact number if it is the weekend. If contact cannot be made, call the appropriate operations control center.
2. Update flows. Advise WSSC of any needed change in the release rate for Little Seneca Reservoir.
3. Advise FW 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.

Anytime: Update Little Seneca release rate as necessary. Contact WSSC control center directly.

Demand forecasting tool

CO-OP refined a demand forecasting tool that can predict daily demand at each utility, based on stepwise multivariate linear regression (backwards stepping) combined with an autoregressive moving average model (ARMA). The ARMA model represents an improvement over the model that was used for last year's drought exercise. The independent variables as inputs for estimating the current day's and next 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
- prior days' maximum temperature (up to 2 days)
- prior days' rainfall (up to 5 days)

Demand forecasting contest - Results

Operators competed with each other in the second so-called "*ICPRB CO-OP Annual Demand Forecast Competition,"* the first in which a prize was awarded. The winner of this year's contest was the Washington Aqueduct.

Operator estimates were consistently better than the CO-OP model for the current day's demand for all three suppliers (Table 6), and the CO-OP model consistently outperformed operator estimates for the next day's demand.

Early in the exercise there was confusion with a new computer system and whether production or raw water withdrawals were reported at FW. This issue was resolved within a few days but the error effectively kicked FW out of the running for the contest. The error emphasizes the value of conducting the drought exercise so that these sorts of errors can be resolved before conducting actual operations.

Drought Exercise, 2005. Estimates of today's a.m. and p.m. water use, tomorrow's water use, and average of absolute value of error.	28-Sep	29-Sep	30-Sep	1-Oct	2-Oct	3-Oct	4-Oct	Average of absolute value of error, operators	Average of absolute value of error, ICPRB model
	Fairfax Water - Operator estimate								
A.M. estimate of today's raw water use, MGD	180	160	175	202	202	205	195		
P.M. estimate of today's raw water use, MGD	190	180	180	202	202	200	195		
Tomorrow's estimated Raw water use, MGD	160	180	195	202	185	195	190		
Actual raw water use, MGD	197	179	202	202	208	207	197		
Error, A.M. estimate	17	19	27	0	6	2	2	**10**	**12**
Error, P.M. estimate	7	-1	22	0	6	7	2	**6**	**12**
Error, Tomorrow's estimate	19	22	7	6	22	2	7	**12**	**10**

Note: estimates on 9/28 and 9/29 are for finished water

	Aqueduct - Operator estimate								
A.M. estimate of today's withdrawal, MGD	170	177	177	175	175	175	180		
P.M. estimate of today's withdrawal, MGD	176	180	174	175	176	179	185		
Tomorrow's estimated withdrawal, MGD	170	180	170	171	180	175	185		
Actual withdrawal, MGD	173	179	177	179	184	166	182		
Error, A.M. estimate	3	2	0	4	9	-9	2	**4**	**8**
Error, P.M. estimate	-3	-1	3	4	8	-13	-3	**5**	**8**
Error, Tomorrow's estimate	9	-3	9	13	-14	7	-13	**10**	**9**

	WSSC - Operator estimate								
A.M. estimate of today's production, MGD	180	170	180	190	200	200	185		
P.M. estimate of today's production, MGD	185	170	180	190	200	200	180		
Tomorrow's estimated production, MGD	170	170	180	190	190	190	180		
Actual production, MGD	181	193	177	187	203	205	171		
Error, A.M. estimate	1	23	-3	-3	3	5	-14	**7**	**8**
Error, P.M. estimate	-4	23	-3	-3	3	5	-9	**7**	**8**
Error, Tomorrow's estimate	23	7	7	13	15	-19	17	**14**	**11**

Table 6: Demand forecasts and results for 2005 drought exercise.

Shifting demand from Great Falls to Little Falls

Load shifting from Great Falls to Little Falls can cause significant dips in flow at Little Falls, lowering flows by a margin greater than the value of the quantity of water shifted. This consequence is very important for drought managers to understand, otherwise their actions could cause the instantaneous flow to drop below desired levels. This phenomenon is documented at great length in ICPRB report 05-01.

Potomac withdrawals and pumping operations

Variations in Potomac withdrawals affect flow downstream at Little Falls. Without careful management, 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.

CO-OP staff tracked the hourly operations for:

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

CO-OP staff developed operator forms which show exactly what information is needed. The information was updated during the drought exercise at 7:30 AM and at 1:00 PM. The tracking went very smoothly. CO-OP staff recommend that the same operator forms and procedures are used for the next exercise or operations, with minor modifications to the FW form to account for reporting of raw water withdrawals.

During droughts, WSSC maintains fairly steady Potomac demand. They have a large storage relative to their withdrawal, therefore their storage tanks act as a buffer. FW currently has less storage relative to their Potomac withdrawal, therefore they have a more limited ability to keep their Potomac demand steady. FW does have plans to increase its storage capacity in their distribution system. WSSC and FW hourly withdrawals are shown in Figure 7.

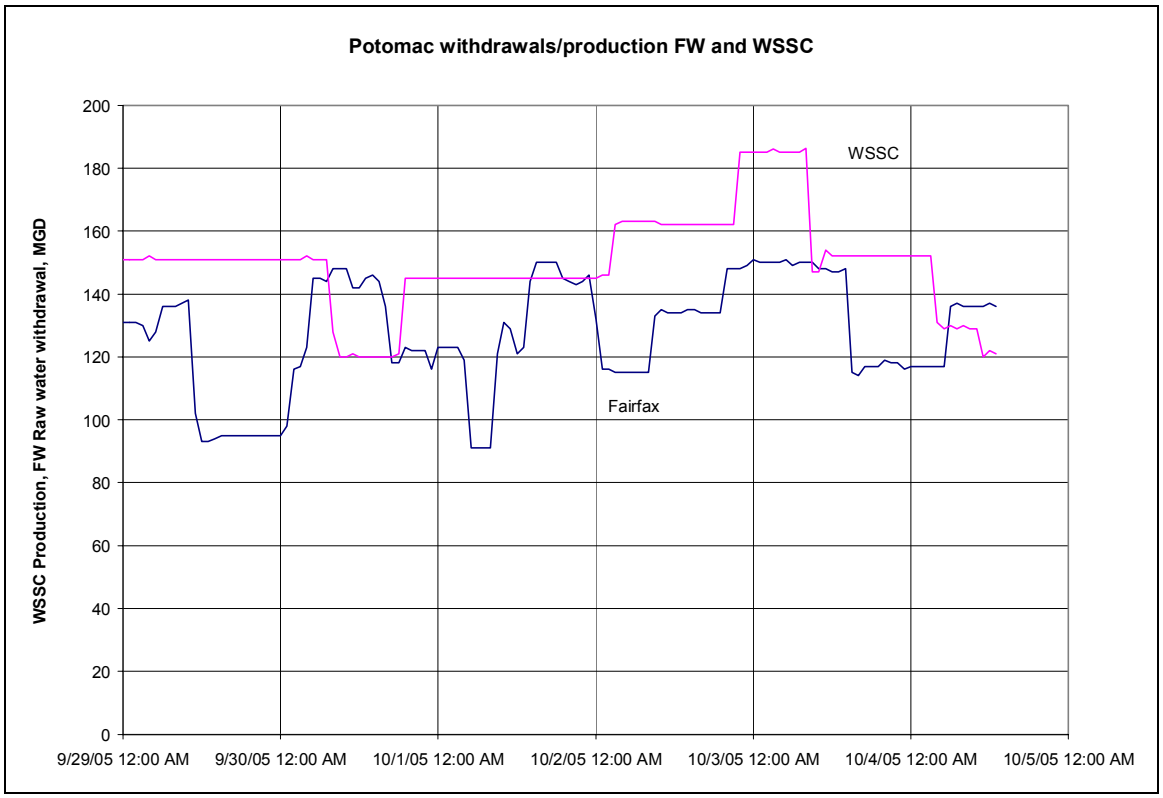

Figure 7: FW and WSSC raw water withdrawals/production during drought exercise

The ability to fine tune withdrawals from the Potomac is limited by the size of the WSSC raw water pumps. The approximate capacities of WSSC's raw pumps on the Potomac are as follows:

Pumps:	Capacity:
R1, R2, R5, R6	50 MGD
R7, R8, R9, R10, R11, R13	55 MGD
R3, R4	25 MGD

There are ranges, such as below 100 mgd, where rate changes would have to be as much as 25 mgd. Above 100 mgd WSSC can change the withdrawal rate by as little as 5 mgd with various combinations of pumps, but there are some gaps where the jumps would be higher.

Great Falls gate settings were tracked to see if a withdrawal rate could be determined as a function of Great Falls gate settings and Potomac flow rate. Unfortunately, it is very difficult to keep the gates at one setting for a 24-hour period and no clear relationship could be determined.

ICPRB Potomac River level monitors

Several Potomac River level monitors were deployed this summer. These monitors were located at Edwards Ferry, the mouth of Seneca Creek, and at Great Falls. The monitors are used to provide an advance prediction of river flows in order to monitor and improve the efficiency of water supply releases.

The simulated data for the Edwards Ferry monitor was extremely useful for determining how much water to release from Little Seneca Reservoir during the drought exercise, as the travel time from Little Seneca Reservoir to Little Falls is approximately the same as it is from Edwards Ferry to Little Falls during low-flow periods. The monitor at the mouth of Seneca Creek was also valuable for drought operations, both as a backup for predicting Little Falls flow and for monitoring the arrival of the Jennings Randolph and Little Seneca Reservoir releases. The Great Falls gage had the least utility of the three gages in terms of drought operations. ICPRB report 06-02 provides a summary of the pilot 2005 Potomac water level monitoring program, including data analysis, a plot of the stage-discharge relationship between Edwards Ferry stage and adjusted Little Falls flow, and recommendations and conclusions.

A significant recommendation of the report is that the Seneca and Edwards Ferry monitors be maintained year round to avoid time-consuming set-up and associated costs. The most useful monitor for drought operations was Edwards Ferry. Because of the primary importance of this gage to drought operations, it was redeployed after the conclusion of the drought exercise in October of 2005, and stage information from this monitor was updated to the Internet in real-time starting in mid-December of 2005. A link to the website is available at www.potomacriver.org.

FW has a Potomac stage monitor near the mouth of Seneca Creek. FW provided this data to CO-OP staff at the conclusion of the drought exercise. This data was compared to the information gathered by the ICPRB Potomac level monitor to assess the utility of the FW information for CO-OP purposes (Figure 8). Flow was much more variable at the FW gage, and of limited utility for predicting Potomac flow, especially as compared to the ICPRB Potomac level monitor. CO-OP staff recommends that the data from the FW stage monitor no longer be obtained during drought exercises and operations.

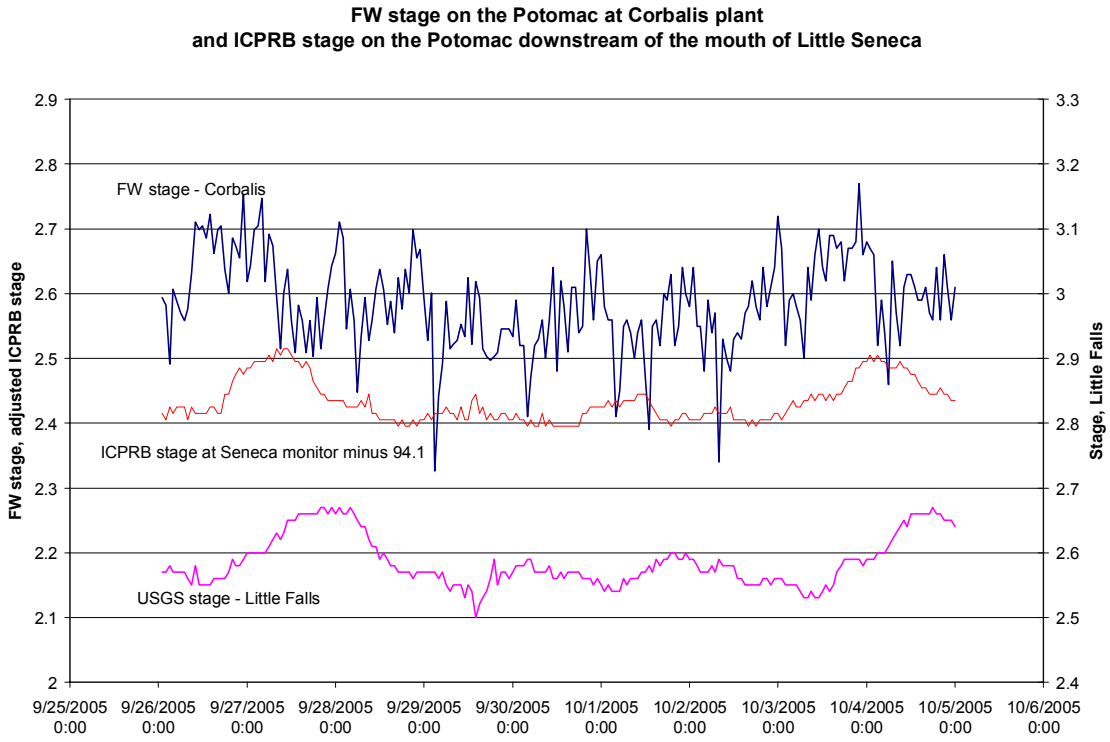

Figure 8: FW stage on the Potomac at Corbalis plant, ICPRB stage on the Potomac downstream of the mouth of Seneca Creek, and Little Falls flow

Determining withdrawals from Patuxent and Occoquan reservoirs

Spreadsheets were developed to determine sustainable withdrawal rates from the Patuxent and Occoquan reservoirs. These tools are user friendly and can show how different withdrawal rates will affect reservoir storage and refill given different percentiles of historical inflows. They are meant to replace the rule curve work developed in prior years (Hagen and Steiner, 2000) as these tools are somewhat easier to use and understand and allow selection of different withdrawal rates in different months.

Recommendations

CO-OP staff recommendations are very practical and operational in nature, and reinforce the lessons learned of both prior drought exercises and drought operations. These recommendations include the following:

- Continue to conduct Little Seneca and Jennings Randolph travel time releases during drought exercises or during periods of low flow. These releases are important for determining travel time and for exercising public communication and coordination with other agencies.
- This year's coordination with a designated point of contact at FW (as is done at WSSC and the Aqueduct) resulted in better operational management. Continue to implement this strategy.

- Improve the hourly operational spreadsheet for drought exercises and real operations to better incorporate the information available from the Edwards Ferry flow prediction. Consider adding an estimate of the uncertainty of the flow prediction. Improve this tool to better model the effects of shifting withdrawals from Great Falls to Little Falls.
- Data from the FW stage monitor on the Potomac at Corbalis is of limited utility and will not be obtained or monitored by CO-OP staff during future drought exercises and operations.
- Designate a staff person to 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.
- Distribute operator forms prior to the exercise or prior to drought operations.
- Ask utility operations personnel to include all CO-OP staff on email distribution.
- Continue to hold a pre-exercise meeting to establish minimum and maximum treatment capacity information and to update communication procedures.
- Given the increased demands on time and effort during droughts, continue to schedule at least three CO-OP staff persons during both drought exercises and for actual drought operations.
- Start on Wednesday, to allow 3 full days of operations before the weekend. Also, conduct a "dry-run" of the exercise the day before.
- Contact MWCOG in advance of the drought exercise to allow them the opportunity to exercise their role in regional coordination of drought response plans. Consider holding a Drought Technical Coordinating Committee meeting, in which the participants provide a recommendation to the broader Drought Coordinating Committee.
- Continue to copy all utility staff on all correspondence so that everyone is aware of changes in operations at other facilities. This provides more transparency in operations, as well as more redundancy.
- Review the 2005 drought operations report and the operations manual prior to the beginning of the 2006 exercise.
- Continue to use the newly developed spreadsheet tools for determining sustainable withdrawal rates from Patuxent and Occoquan reservoirs.
- Maintain steady withdrawals at FW and WSSC as much as possible
- Design the next drought exercise so that Aqueduct load shifting from Great Falls to Little Falls is practiced (virtual).
- Consider holding a meeting similar to the proposed pre-exercise meeting if reservoir releases and active drought management appears likely.
- Develop an improved forecast for Little Falls flow for 9-days into the future. Consider involving NWS Middle Atlantic River Forecast Center in 9-day forecasts of Little Falls flow using their soil moisture accounting model.
- Ask for suppliers to provide minimum system constraints in the pre-exercise meeting, in addition to the maximum capacities.

Results

This year's drought exercise accomplished the following results:

- Improvements in the hourly operational tools and procedures to include forecasts of flow from the Edwards Ferry Gage.
- A test of a revised demand forecasting tool and the operator forms.
- An opportunity to train new personnel.
- Improved communications between ICPRB staff and utility operators through both the use of operator forms and by designating specific staff at FW.
- Travel times from Jennings Randolph Reservoir to Little Falls were clearly measured at approximately 6 days, during this year's drought exercise. This appears to be inconsistent with the 9-days travel time observed during the drought of 1999. This is likely due to the lower flow levels associated with the release in 1999, resulting in slower travel times.

Conclusions

Practicing communications, conducting reservoir releases, and testing operating tools are a part of each year's drought exercise and generally are a valuable contribution to drought preparation and readiness. This year was no exception. In addition, annual exercises allow for ongoing improvements to drought operations and management.

All droughts are different and responses must be tailored to the specific impacts. It was noted in the Drought Coordinating Technical Committee conference call coordinated by MWCOG that the drought plan needed to be modified so that the "Drought Watch" mode was not automatically triggered by the NOAA Drought Monitor status, as is currently the case. It is also the case that this trigger is noted as provisional and subject to re-assessment within 2 years of publication of the drought plan (MWCOG Board Task Force on Regional Water Supply Issues, 2000). Rather, the consensus of the group was that the plan should be modified to represent what actually occurred during the conference call, namely that the NOAA Drought Monitor triggers a meeting of the DCTC, which in turn provides a recommendation to the Drought Coordinating Committee (DCC). The DCC is responsible for declaring drought warnings and watches. The increased flexibility in such a strategy avoids the pitfalls of automatic triggers.

Outreach to agencies, elected officials, and the press in coordination with the Little Seneca and Jennings Randolph reservoir releases reinforced the message of water supply reliability and normal drought operations. Annual releases allow for continuing reinforcement of this message.

References:

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Hagen, E.R., R.C. Steiner, 2000. Occoquan Reservoir Storage Response Curves. Interstate Commission on the Potomac River Basin, ICPRB 00-1, Rockville, Maryland.

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MWCOG Board Task Force on Regional Water Supply Issues, 2000. Metropolitan Washington Water Supply and Drought Awareness Response Plan: Potomac River System. Metropolitan Washington Council of Governments, Publication number 20703. Washington, D.C.

Water Supply Coordination Agreement, 1982. Signatories include: The District Engineer Baltimore District COE for the United States of America, the Chairman of the Fairfax County Water Authority, the General Manager of the Washington Suburban Sanitary Commission, The Mayor of the District of Columbia, Chairman of the Interstate Commission on the Potomac River Basin.

Appendices

A. Little Seneca Press Release
B. Letter to Montgomery County Council and Executive
C. Operator form for Washington Aqueduct
D. Operator form for WSSC
E. Operator form for FW

Appendix A. Little Seneca Press Release

Upstream Reservoir Release Bolsters Potomac Flow
Interstate Commission on the Potomac River Basin
For release September 26, 2005

Water stored by Washington-area water suppliers will be released from Little Seneca Reservoir near Germantown, Maryland, and from Jennings Randolph Reservoir located in the headwaters of the Potomac River basin during this year's annual drought management exercise conducted by the Interstate Commission on the Potomac River Basin (ICPRB). ICPRB coordinates the drought exercise on behalf of the Washington metropolitan area water suppliers, including the Washington Suburban Sanitary Commission serving Montgomery and Prince George's counties, Fairfax Water serving Northern Virginia, and the Washington Aqueduct serving suppliers in the District of Columbia, Arlington County, and Falls Church. Cooperative use of Little Seneca and Jennings Randolph reservoirs by the independent water suppliers allows for the demands of each to be met during droughts.

The drought exercise releases will occur between September 26 and October 4, 2005. The first release from Little Seneca was started September 26 at approximately 9:30 a.m. The release will ramp up to 145 million gallons per day (MGD) and last for 24 hours. The Little Seneca releases are expected to lower the level of Seneca Reservoir by up to 24 inches. The releases will be coordinated with staff from The Maryland-National Capital Park and Planning Commission, which manages recreational facilities and conservation areas in Black Hill Regional Park at Little Seneca Reservoir. The releases from Jennings Randolph and Little Seneca will test operating procedures and document travel times to Little Falls, the site of the most downstream water supply intake.

Little Seneca Reservoir was constructed with funds provided by the Washington metropolitan area water suppliers. The reservoir was completed in 1981 and is used to augment Potomac River flow during droughts and along with Jennings Randolph Reservoir to ensure a safe and reliable supply of water for 4.1 million residents of the Washington metropolitan area. Releases are a part of normal drought operations, and drought-related releases were made in 1999 and in 2002. A release from Little Seneca was made in 2004 to test operating procedures during last year's drought exercise.

The ICPRB 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.

"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 currently is full. It is late in the reservoir release season. In the unlikely event that water supply releases are necessary this fall, the releases will have no detrimental impact on our ability to respond to actual drought operations.

Hoffman noted that CO-OP, the utilities, and governments continue to assess water supply needs to ensure that the metropolitan area, as well as the entire Potomac basin, will meet future challenges to a safe and adequate water supply.

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. (Follow the appropriate links under "water supply.")

For more information contact Curtis Dalpra, Interstate Commission on the Potomac River Basin, 301 984 1908 x107

Appendix B. Letter to Montgomery County Council and County Executive

September 23, 2005

Dear members of the Montgomery County Council,

The Interstate Commission on the Potomac River Basin (ICPRB) coordinates an annual drought exercise on behalf of the Washington metropolitan area water suppliers including the Washington Suburban Sanitary Commission serving Montgomery and Prince George's counties, Fairfax Water serving Northern Virginia, and the Washington Aqueduct serving suppliers in the District of Columbia, Arlington County, and Falls Church. I am writing to give you background information about an upcoming water supply release planned for Little Seneca Reservoir. Water stored by the Washington-area water suppliers will be released from Little Seneca Reservoir near Germantown, Maryland, during this year's annual drought management exercise conducted by ICPRB.

Little Seneca Reservoir was constructed with funds provided by the Washington metropolitan area water suppliers. The reservoir was completed in 1981 and is used to augment Potomac River flow during droughts to ensure a safe and reliable supply of water for 4.1 million residents of the Washington metropolitan area including the citizens of Montgomery County. Releases are a part of normal drought operations, and drought-related releases were made in 1999 and in 2002. A release was made during the drought exercise of 2004.

Little Seneca releases for this year's drought exercise will occur between September 26 and October 4, 2005. It is anticipated that the first release will occur on the morning of September 26 unless weather conditions cause us to delay the release. These releases are expected to lower the level of the reservoir by up to 24 inches. The releases are being made while flows are low on the Potomac River in order to test the time of travel of releases, which are affected by flow levels. An additional benefit is to practice drought operations as they would occur. In the unlikely event that water supply releases are necessary this fall, the releases will have no detrimental impact on our ability to respond to actual drought operations.

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

Sincerely,

Erik Hagen
Director CO-OP Operations

Interstate Commission on the Potomac River Basin
Section for Cooperative Water Supply Operations on the Potomac
51 Monroe St., Suite PE-08
Rockville MD, 20850
301 984 1908 x116

Appendix C: Operator form for Washington Aqueduct

Drought Operations/ Drought Exercise
ICPRB Operator Form for the Aqueduct
Please email to coop@icprb.org at 7:30 a.m. and at 1:00 p.m.

Date	
Time sent (7:30 or 1300)	
A.M. estimate of today's demand, MGD	
P.M. estimate of today's demand, MGD	
Tomorrow's estimated demand, MGD	
Yesterday's withdrawal from Great Falls (MGD)	
Yesterday's pumpage from Little Falls (MGD)	

Yesterday's pumping rates from Little Falls Pumping Station

NO. 1			NO. 2		
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

NO. 3			NO. 4		
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

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

Today's pumping rates from Little Falls Pumping Station

NO. 1			NO. 2		
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

NO. 3			NO. 4		
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

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

Yesterday's Great Falls gate settings

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

Today's Great Falls gate settings

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

Appendix D: Operator form for WSSC

Drought Operations/ Drought Exercise
ICPRB Operator Form for WSSC
Please email to coop@icprb.org at 7:30 a.m. and at 1:00 p.m.

Date	
Time sent (7:30 or 1300)	
A.M. estimate of today's demand, MGD	
P.M. estimate of today's demand, MGD	
Tomorrow's estimated demand, MGD	
Storage in Triadelphia (bg)	
Storage in Duckett (bg)	
Storage in Little Seneca (bg)	
Yesterday's production from Potomac plant (MGD)	
Yesterday's production from Patuxent (MGD)	

Yesterday's production at Potomac Plant, MGD

	Production
12:00 AM	
1:00 AM	
2:00 AM	
3:00 AM	
4:00 AM	
5:00 AM	
6:00 AM	
7:00 AM	
8:00 AM	
9:00 AM	
10:00 AM	
11:00 AM	
12:00 PM	
1:00 PM	
2:00 PM	
3:00 PM	
4:00 PM	
5:00 PM	
6:00 PM	
7:00 PM	
8:00 PM	
9:00 PM	
10:00 PM	
11:00 PM	

Today's production at Potomac Plant, MGD

	Production
12:00 AM	
1:00 AM	
2:00 AM	
3:00 AM	
4:00 AM	
5:00 AM	
6:00 AM	
7:00 AM	
8:00 AM	
9:00 AM	
10:00 AM	
11:00 AM	
12:00 PM	
1:00 PM	
2:00 PM	
3:00 PM	
4:00 PM	
5:00 PM	
6:00 PM	
7:00 PM	
8:00 PM	
9:00 PM	
10:00 PM	
11:00 PM	

Appendix E: Operator form for FW

Drought Operations/ Drought Exercise
ICPRB Operator Form for Fairfax Water
Please email to coop@icprb.org at 7:30 a.m. and at 1:00 p.m.

Date	
Time sent (7:30 or 1300)	
A.M. estimate of today's RAW WATER USE, MGD	
P.M. estimate of today's RAW WATER USE, MGD	
Tomorrow's estimated RAW WATER USE, MGD	
Storage in Occoquan (bg)	
Yesterday's Raw Water w/d from Corbalis (MGD)	
Yesterday's Raw Water w/d from Occoquan (MGD)	
Yesterday's TOTAL Withdrawal (MGD)	

Yesterday's RAW WATER PUMP RATE at Corbalis, MGD

	Withdrawal
12:00 AM	
1:00 AM	
2:00 AM	
3:00 AM	
4:00 AM	
5:00 AM	
6:00 AM	
7:00 AM	
8:00 AM	
9:00 AM	
10:00 AM	
11:00 AM	
12:00 PM	
1:00 PM	
2:00 PM	
3:00 PM	
4:00 PM	
5:00 PM	
6:00 PM	
7:00 PM	
8:00 PM	
9:00 PM	
10:00 PM	
11:00 PM	

Today's RAW WATER PUMP RATE at Corbalis, MGD

	Withdrawal
12:00 AM	
1:00 AM	
2:00 AM	
3:00 AM	
4:00 AM	
5:00 AM	
6:00 AM	
7:00 AM	
8:00 AM	
9:00 AM	
10:00 AM	
11:00 AM	
12:00 PM	
1:00 PM	
2:00 PM	
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6:00 PM	
7:00 PM	
8:00 PM	
9:00 PM	
10:00 PM	
11:00 PM	