2016 Washington Metropolitan Area Drought Exercise

March 2017

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ICPRB Report No. ICP17-4

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This report was prepared by the Interstate Commission on the Potomac River Basin, Section for Cooperative Water Supply Operations on the Potomac. Funds were provided for this report by the Washington Suburban Sanitary Commission, the Washington Aqueduct (a Division of the U.S. Army Corps of Engineers), and Fairfax Water. The opinions expressed in this report are those of the authors and should not be construed as representing the opinions or policies of the U. S. Government, or the signatory jurisdictions or Commissioners of the Interstate Commission on the River Basin, or the water suppliers. No official endorsements should be inferred.

The report is available online at www.PotomacRiver.org as ICP17-4_Schultz.pdf.

1 Introduction

The Washington, D.C., metropolitan area (WMA) relies on the Potomac River to supply approximately three-quarters of the water it uses. The area's three major water suppliers ("CO-OP suppliers"), Fairfax County Water Authority (Fairfax Water), the Washington Suburban Sanitary Commission (WSSC), and the Washington Aqueduct Division of the U.S. Army Corps of Engineers (Aqueduct) participate in a cooperative system of water supply planning and management. This includes joint funding of water supply storage in reservoirs located upstream of the suppliers' Potomac River intakes and coordinated operations when flows in the river fall below specified thresholds. This cooperative system is based on a set of agreements entered into more than 30 years ago. The Low Flow Allocation Agreement (LFAA) of 1978 specifies a formula for the allocation of water during shortages. The Water Supply Coordination Agreement (WSCA) of 1982 commits the three suppliers to operate "in a coordinated manner" to optimize the use of available resources and requires that long-term water demand and availability forecasts be conducted every five years.

During periods of drought, the Interstate Commission on the Potomac River Basin (ICPRB) Section for Cooperative Water Supply Operations on the Potomac (CO-OP) helps manage this system by coordinating CO-OP supplier water withdrawals from the Potomac River and off-river reservoirs. CO-OP also recommends releases from upstream reservoirs when forecasted flow in the river is not sufficient to meet expected needs. These needs include WMA demands and an environmental flow-by of 100 million gallons per day (MGD) on the Potomac River at the Little Falls dam near Washington, D.C.[1]

Each year in which actual drought conditions do not occur, CO-OP conducts a drought exercise. These exercises allow participants to practice and improve communication procedures among organizations and also provide ICPRB's CO-OP staff with an opportunity to practice using operational tools and making management decisions. This ensures that during an actual drought all stakeholders are properly trained and key operational strategies have been discussed and tested beforehand.

This report describes activities and lessons learned from the 2016 drought exercise, which took place from October 5-11. Participants in this year's exercise included staff from:

- ICPRB CO-OP Section;
- Aqueduct, which supplies water to the District of Columbia via DC Water, and to parts of Virginia;
- WSSC, which supplies water to Montgomery and Prince George's counties in Maryland, and on a limited basis to other parts of Maryland;
- Fairfax Water, which supplies water to Fairfax County, Virginia, and provides wholesale water to other suppliers in northern Virginia;
- Loudoun County Water Authority (Loudoun Water), a wholesale customer of Fairfax Water which is currently constructing a Potomac River intake and the Trap Rock Water Treatment Facility, expected to begin service in 2017, to provide a portion of its future supply needs;
- U.S. Army Corps of Engineers (USACE), Baltimore District Office;

[1] A complete discussion of CO-OP drought operations can be found in the report, 2015 Washington Metropolitan Area Water Supply Study: Demand and Resource Availability Forecast for the Year 2040, by S.N. Ahmed, K.R. Bencala, and C.L. Schultz, ICPRB Report No. 15-4a, August 2015, available at www.potomacriver.org under "Publications."

- U.S. Geological Survey Water Science Center for Maryland, Delaware, and the District of Columbia (USGS);
- District of Columbia Water and Sewer Authority (DC Water); and
- Middle Atlantic River Forecast Center (MARFC).

2 Overview of CO-OP Drought Operations

The Potomac River is the primary source of raw water for the CO-OP suppliers, which each have an intake on the river upstream of Little Falls dam near Washington, D.C. Fairfax Water also relies on stored water from the Occoquan Reservoir and WSSC relies on water from a pair of reservoirs in the Patuxent River watershed: T. Howard Duckett (Rocky Gorge) and Tridelphia (see map in Figure 1-1). The Aqueduct has intakes at two locations on the Potomac River at Little Falls and, several miles upstream, at Great Falls. In addition, these three suppliers jointly own storage in two reservoirs located upstream of their Potomac River intakes: Jennings Randolph Reservoir (JRR), located on the North Branch of the Potomac River adjacent to Garrett County, Maryland, and Mineral County, West Virginia, and Little Seneca Reservoir, located in Montgomery County, Maryland. Jennings Randolph Reservoir is operated by the U.S. Army Corps of Engineers and the dam at Little Seneca is operated by WSSC. The water suppliers pay a portion of the operations and maintenance costs of a third upstream reservoir, Savage, also located on the North Branch of the Potomac. These three reservoirs are available to augment Potomac River flow during low-flow periods.

Key operational goals for CO-OP staff during droughts are:

- Maintaining Potomac River flow at Little Falls dam, as measured by the USGS gage at that location (Station ID 01646500), at or above the environmental flow-by of 100 MGD, or equivalently, 155 cubic feet per second (cfs).
- Maintaining estimated flow below Great Falls, located approximately 9.3 river miles upstream of Little Falls, at or above the recommended minimum flow of 300 MGD (464 cfs). Estimated travel time between Great Falls and Little Falls during extremely low-flow conditions is nine hours.
- Balancing use of storage in system reservoirs to ensure that adequate volumes are maintained in each reservoir to sustain expected withdrawals throughout the remainder of a severe drought and to ensure a 95 percent probability of refill to 90 percent capacity by June 1 of the following year.

Given the travel times between upstream water storages and CO-OP utility intakes on the Potomac River, it is necessary to be able to predict future flows. To estimate future Potomac withdrawals for input into flow prediction tools, CO-OP staff develops withdrawal scenarios for both the Potomac River and off-Potomac reservoirs. Scenarios are based on estimates of near-term demands, estimates provided by the water suppliers, and historic data.

Withdrawal scenarios may require “load shifts” by the water suppliers between Potomac River intakes and off-Potomac reservoir intakes. Load shifting, that is, the shifting of some portion of a supplier’s withdrawal from one intake to another, may be requested by CO-OP during droughts to help meet operational goals. Each of the WMA suppliers has two intakes. Fairfax Water and WSSC both have one or more intakes on the Potomac River and one off-Potomac intake (at the Occoquan and the Patuxent reservoirs, respectively). Aqueduct has two intakes on the Potomac River: one at Great Falls and one at Little Falls. Load shifting requires close communication between ICPRB CO-OP and water supplier staff.

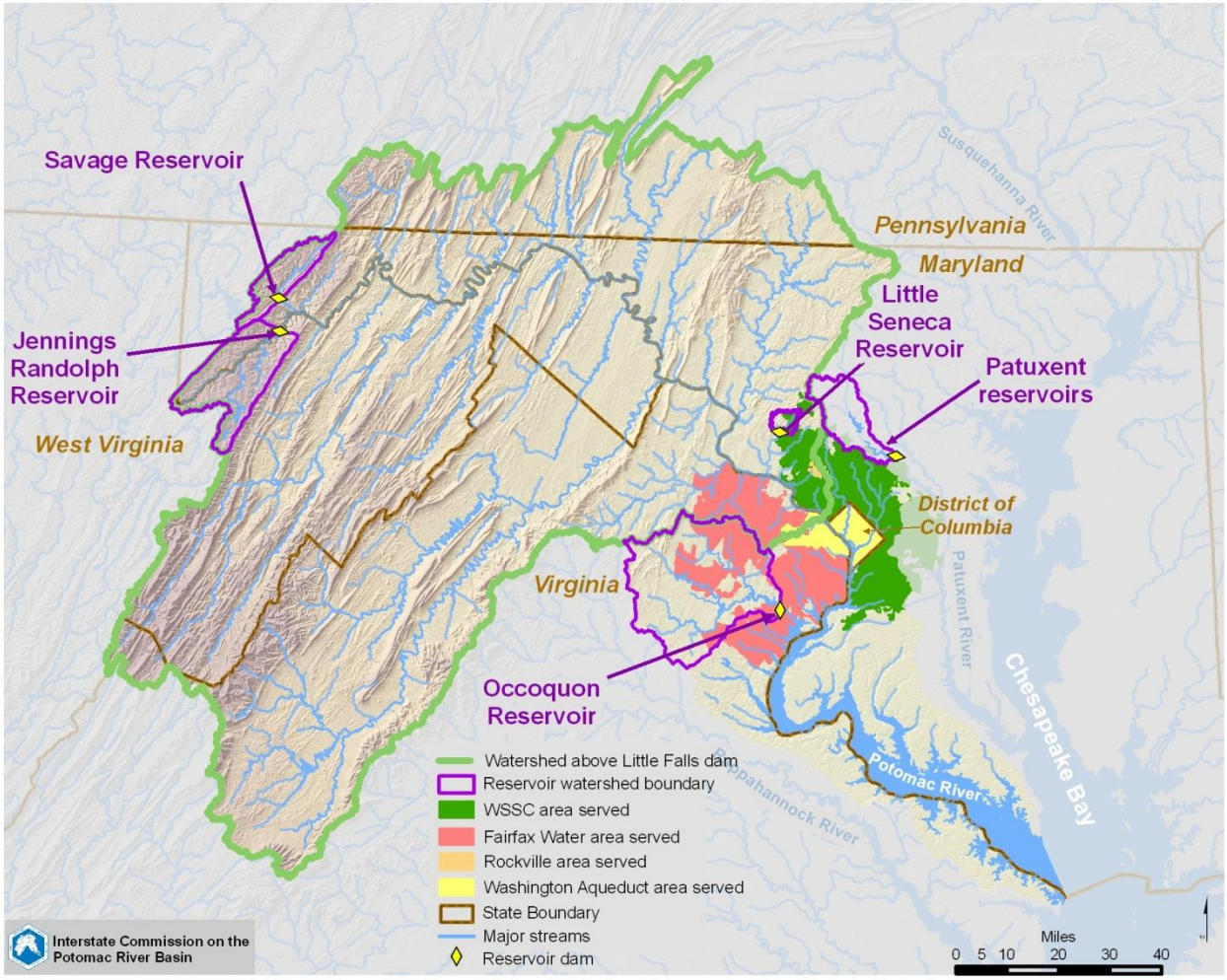


FIGURE 2-1: WMA WATER SOURCES

3 Summary of Exercise Activities

The 2016 WMA Drought Exercise was conducted during the seven-day period from October 5 through October 11. As has been the case for the past several years, actual flow conditions were low during the exercise. Daily drought monitoring had been conducted from September 1 through September 30, and resumed on October 24.

A pre-exercise meeting took place on October 3 at ICPRB's office in Rockville, Md. (see Appendix A for agenda). Pre-exercise meetings give the WMA drought operations team an opportunity to get acquainted or reacquainted. This meeting also gives CO-OP staff a chance to review and update information on system constraints, to obtain information on the expected status of reservoirs and other system components during the following year's low-flow season, and to update pertinent organizational drought-related contact information. Updated information on the WMA system appears in Table 3-3 through Table 3-6.

The hypothetical scenario for the exercise was unusually low autumn flows. The scenario description sent out in the first day's email report was as follows:

> *The date is October 5, 2020. The region has had a hot, dry summer and fall. CO-OP began daily drought monitoring in mid-July and enhanced monitoring in mid-September. No water supply releases have yet occurred but no rain is in the National Weather Service's 7-day quantitative precipitation forecast and river flows continue to decline. On the first day of the exercise, SIMULATED flows are 950 cfs (614 MGD) at Point of Rocks and 680 cfs (440 MGD) at Little Falls.*

In addition to practicing standard communications and operational procedures, this year's exercise included the following:

1. Use of updated version of the website for online data submission,
2. Use of output from CO-OP's real-time Low Flow Forecast System to inform simulated reservoir release decisions,
3. Use of stand-alone exercises for CO-OP staff training, and a
4. Water demand predictions contest.

These activities are described in detail in the sections below.

3.1 Exercise of Communications and Operations Procedures

During annual drought exercises, participants practice communication procedures that would be used in an actual drought and also practice working with flow forecast spreadsheets and other operational tools. The Potomac basin was experiencing actual dry conditions during the fall of 2016. To reduce confusion and keep staff cognizant of potential worsening of conditions, training on use of flow forecast tools that occurred during the exercise was based on actual flow data. However, in order to simulate drought conditions, a "flow reduction factor" was applied to actual flows before input into the flow forecast spreadsheets used in the exercise.

Most drought operations communications take place via email, but operational changes are discussed and/or confirmed via telephone. The following types of communications were practiced during the 2016 exercise:

- Fairfax Water, Aqueduct, and WSSC sent twice daily reports to ICPRB on yesterday's hourly demands, today's and tomorrow's forecasted daily demands, and reservoir storage volumes.
- Loudoun Water sent reports on yesterday's daily demand, tomorrow's forecasted demand and on yesterday's daily discharge from the Broad Run Water Reclamation Facility.
- CO-OP sent twice daily email reports to water suppliers, USACE, USGS, and other stakeholders on recent and forecasted demands, recent flows, and current system storage.
- CO-OP made telephone calls to the water suppliers to confirm the feasibility of requested (simulated) load shifts between intakes and (simulated) releases from Little Seneca Reservoir.
- CO-OP made telephone calls to the USACE's Baltimore District Office to request (simulated) changes in Jennings Randolph Reservoir water supply release rates.
- On the first day of the exercise, CO-OP supplier general managers were contacted to request concurrence on "SIMULATED water supply releases from Jennings Randolph and Little Seneca Reservoir over the course of the next week."

- CO-OP prepared a letter to the Montgomery County Executive and Council Members alerting them to possible simulated releases from Little Seneca Reservoir.

During the drought exercise, staff practiced using CO-OP spreadsheet tools to make Potomac River flow forecasts. They also reviewed on a daily basis the Middle Atlantic River Forecast Center (MARFC) 72-hour flow predictions for Little Falls and other basin streams.[2] Staff also practiced devising load-shifting and reservoir release scenarios that would maintain flow at Little Falls above the 100 MGD environmental flow-by.

One of the operational strategies used in the CO-OP system to optimize use of resources during droughts is "load-shifting," that is, the shifting of a portion of a supplier's withdrawal from one intake to another. Load shifts that reduce Potomac withdrawals when flows are falling can help preserve storage in a key system reservoir, Little Seneca. Load shifts that increase Potomac withdrawals when flows are more than adequate to meet downstream needs can help preserve storage in the Occoquan and Patuxent reservoirs. Load shifts to the Potomac also allow for more efficient use of water released from the North Branch reservoirs. Finally, load shifts by the Aqueduct from its Great Falls intake to its Little Falls intake help maintain flow above the recommended minimum of 300 MGD in the stretch of the river between Great Falls and Little Falls.

During the course of the 2016 drought exercise, requests for load shifts were made of all three CO-OP suppliers. Load shift requests are noted under the operations portion of CO-OP's twice daily emails to the water suppliers and stakeholders. The ability of a supplier to implement a load shift request is also verified by phone.

Information that clarified the timing of events and of constraints related to Aqueduct's load shifts came to light during the exercise. Aqueduct was requested to make a simulated load-shift from Great Falls to Little Falls, that is, to reduce its withdrawals at the Great Falls intake and increase its withdrawals at the Little Falls intake. CO-OP staff discussed load-shifts with Woody Peterson of Aqueduct (private communication, October 6, 2016), who explained that the required changes in withdrawal can be made remotely via Aqueduct's SCADA system. He also noted that since water would continue flowing in the conduits from Great Falls to Dalecarlia Reservoir for approximately four or five hours after the Great Falls withdrawals were reduced, operators would delay turning on pumps at Little Falls for this amount of time. On Thursday we called Woody directly to simulate this release. On Friday we called the Dalecarlia Control Room and were told by the operator that because of energy cost considerations he would need to get approval for an actual shift to Little Falls.

3.2 Updated Website for Data Entry

ICPRB CO-OP staff are developing a private website for exchanging withdrawal, demand, and storage data between CO-OP and supplier staff. The website replaces emails with a structured database and forms. It collects, archives, graphs, and tabulates the data. Drupal, an open source content-management framework supports the website with content authoring and user management functions. The website hosting service, AcuGIS, manages the Drupal services for performance and security. Table 3-1 compares website functionality between the 2015 and 2016 exercise.

[2] Available at http://water.weather.gov/ahps/region.php?rfc=marfc.

TABLE 3-1: COMPARISON OF WEBSITE CAPABILITIES IN 2015 AND 2016

2015 Exercise	2016 Exercise
• Accepts daily average withdrawal, demand, and reservoir storage values • Displays supplier data as a table and graph	• Accepts daily average withdrawal, demand, and reservoir storage values • Accepts hourly withdrawal data as a CSV file • Displays supplier data as a table (graph was temporarily disabled) • Creates a CSV file of supplier data • Generates email summary text • Shares data with MARFC

During the 2015 exercise, the website enabled suppliers to enter data for average daily withdrawals, demand, and reservoir storage. Once the data was entered, suppliers could review it, along with data entered within the last 10 days, in a table and a graph. Each of the four suppliers had their own account and successfully provided data at 8:00 am and 1:00 pm.

In 2016, ICPRB added features to the existing website in order to enable suppliers to submit hourly withdrawal data as a CSV file from the same form that accepted average daily withdrawals, demand, and reservoir storages. The suppliers returned to their submitted form to download, edit, and resubmit the CSV hourly withdrawal data to reflect changes as the day progressed. Functionality was also added to the website that allowed CO-OP staff to filter and displayed supplier data as CSV files to copy and paste into CO-OP models. Once analyses were conducted, CO-OP staff returned to the website to generate the email summary text and edit it to include any suggested operational changes provided by the CO-OP models. The website link that generated the email text performed a special screen scrape on the U.S. Geological Survey website to automate the look up of current and previous day's Little Falls and Point of Rocks flows. CO-OP staff also shared a website link with MARFC that reported yesterday's net Potomac production data divided between Fairfax Water, Washington Suburban Sanitary Commission, Washington Aqueduct at Great Falls, Washington Aqueduct at Little Falls. This shared data may be useful MARFC in their flow forecasts during low flow periods in the future (S. Reed, personal conversation, Oct 6, 2016).

After the 2016 exercise, Fairfax Water requested that the website accept their hourly data as an Excel file in order to minimize their need to copy and paste. This change has been added to the website. However, archiving and displaying the Excel files as CSV on the website is incomplete.

Some other noteworthy website changes since the 2016 exercise allow users to customize data manipulation. Both suppliers and CO-OP staff can customize views of supplier data based on user specified date ranges, time series combinations, and format (e.g., graph, table, or CSV). These users can save this views through unique website links that appear in the address bar. CO-OP staff can customize email text based on user specified section headers so that only pertinent contact appears on the page for copying into an email.

Future website changes would allow users to:

- Manage duplicate today and yesterday submissions with error messaging

- Store hourly data submissions as values in the database (currently being stored as CSV and .xlsx file paths)
- Upload a CSV or .xlsx file for daily average withdrawals, demands, and storage values in order to populate database for a multi-day period of record
- Read Potomac Basin average precipitation automatically from the ICPRB's real-time flow forecast model
- Import data into CO-OP models directly from website (CSV files can currently be generated from the CO-OP staff's Data View page, which are readable by a unique website link)
- Manage contacts in database including a shared contact page and contact manage page where suppliers can edit their participants,
- Inform participants of pertinent drought operation documents, possibly including a 101 presentation giving an introduction to drought operations

It is also recommended that CO-OP staff explore the possibility of more seamless data-interchange between ICPRB and suppliers using JSON (JavaScript Object Notation, a popular data format that is familiar to web programmers and very easy to understand) and REST (Representational State Transfer, a popular way to communicate data - used by almost all websites to communicate data to a server). Understanding these two tools, as well as understanding how to incorporate USGS's API (Application Program Interface) for downloading data as opposed to the current screen scrape code, could improve data reliability.

3.3 Use of Real-Time Low Flow Forecast System

CO-OP's Low Flow Forecast System (LFFS), which currently operates on a Linux server at ICPRB's office, provides real-time streamflow forecasts for the Potomac River at Little Falls and for many other locations in the basin. The LFFS relies on recent precipitation and other meteorological data from the National Weather Service (NWS), and on NWS meteorological forecasts going out 15 days in the future.

In preparation for the 2016 exercise, LFFS Little Falls flow forecasts were incorporated into CO-OP's daily and hourly flow prediction tools. The LFFS predictions provided additional input for both the nine-day Jennings Randolph release decision and the one-day Little Seneca release decision.

During the seven days of the exercise, CO-OP staff discussed and compared forecasts for flow at Little Falls from the LFFS, from CO-OP's prediction algorithm based on yesterday's flow at Little Falls and changes in upstream gage data (LF yesterday + POR delta), from CO-OP's nine-day recession prediction for Little Falls, and from the MARFC. The set of forecasts made on October 7, 2016 displayed by the daily tool are shown in Figure 3-1. During these discussions, staff concluded that in the case of the nine-day forecast, reservoir release decisions should usually continue to be based on the Little Falls recession equation, since this has been tested in CO-OP's planning model. However, in a situation where rainfall has occurred recently, decisions should take into account the LFFS prediction, especially if it predicts a higher flow than the recession equation. In the case of the one-day forecast, more evaluation of the LFFS predictions are warranted.

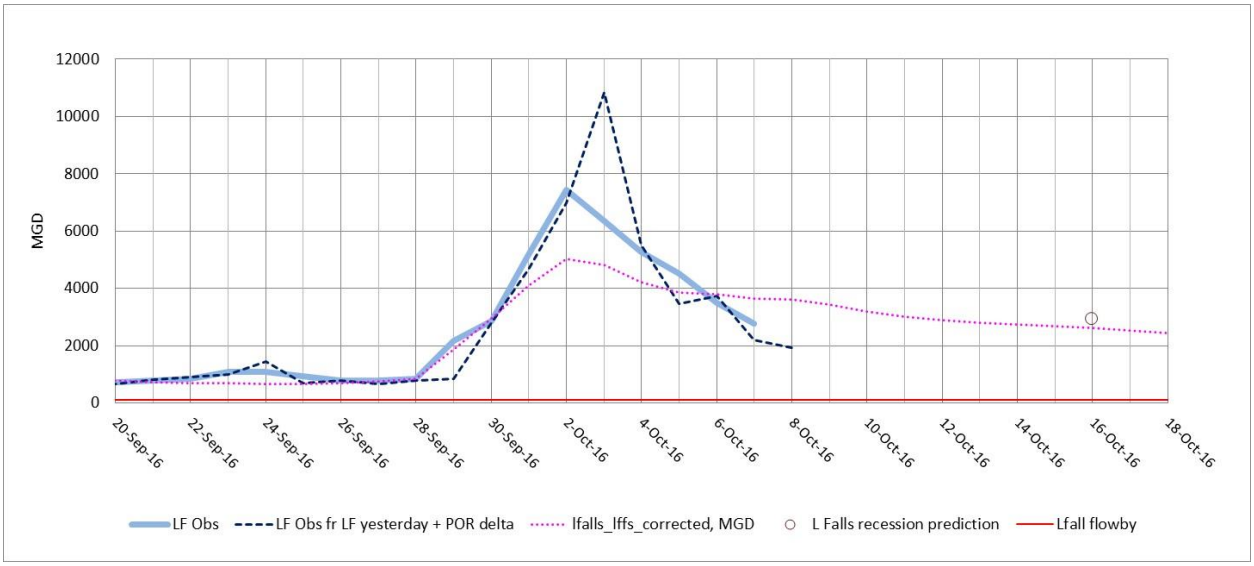


FIGURE 3-1: LITTLE FALLS FORECASTS DISPLAYED BY DAILY PREDICTION SPREADSHEET

3.4 Use of Stand-Alone Training Exercises

In response to past input from CO-OP operations staff, training material and a set of four training exercises were developed for the 2016 exercise. The training material, the "2016 CO-OP Drought Exercise Guide", contains a flow chart showing the inputs of the operational spreadsheets, a daily schedule, and information on making operational decisions, and is included as Appendix C of this report. The four training exercises each consists of a set of data and operational spreadsheets which were used during the exercise and which also can be reviewed after the exercise. These are:

Exercise 1: North Branch release (and potential use of the various flow forecasts)

Exercise 2: Great Falls to Little Falls load shift

Exercise 3: Little Seneca release + Occoquan load shift

Exercise 4: Patuxent load shift

These stand-alone exercises allow staff to discuss and practice the four primary operational decisions made by CO-OP. They also can be used by any new staff members that need to become familiar with drought operations.

3.5 Water Demand Prediction Contest

A water demand prediction contest was conducted as part of the 2016 exercise. Twice each day during actual drought operations and during CO-OP drought exercises, the water suppliers provide forecasts of today's and tomorrow's demand. After the 2016 exercise was completed, the AM forecasts of tomorrow's demand from each of the suppliers were compiled along with forecasts from CO-OP's daily demand model. CO-OP's demand model (see Ahmed et al., 2015 for the most recent model) was developed for use in CO-OP's long-term planning tool, the Potomac Reservoir and River Simulation Model (PRRISM). The demand contest provided an opportunity to compare the predictions of CO-OP's model with supplier predictions.

Actual demands, supplier predictions, and CO-OP model predictions for the individual systems are graphed in Figure 3-2, Figure 3-3, and Figure 3-4. Unfortunately, due to poor communication on the part of CO-OP, Loudoun Water provided estimates of simulated rather than actual demand, so their predictions could not be used in the contest. For the CO-OP model predictions, adjustments were made to account for the fact that Falls Church demand is included in Aqueduct's prediction rather than Fairfax Water's prediction, and Loudoun Water demand is included in Fairfax Water's predictions. CO-OP model predictions contain a random component that represents unexplained model error, so each of these graph shows several model predictions.

A summary of prediction errors is given in Table 3-2. This table includes both mean errors over the seven-day exercise and mean absolute errors. The winner of the contest was WSSC, which had the smallest mean error, -0.6 MGD, and the smallest mean absolute error, 3.2 MGD. The worst predictions were from CO-OP's model, which had a mean error and mean absolute error for the individual suppliers of 2.6 and 7.9 MGD, respectively. The suppliers also did a considerably better job in predicting total system demand, with mean error and mean absolute errors of -0.5 and 9.1 MGD, respectively, compared with the CO-OP model's mean and mean absolute errors of -6.5 and 19.2 MGD. A token prize was awarded to WSSC during a meeting of the CO-OP Operations Committee on November 21, 2016.

For planning purposes, the CO-OP model, which is used to simulate future demands in a future drought, does a good job, because it generates a demand time series which has been shown to have statistical characteristics that are close to those of actual demands. However, the results of the prediction contest emphasize the importance of collecting supplier demand predictions during drought operations.

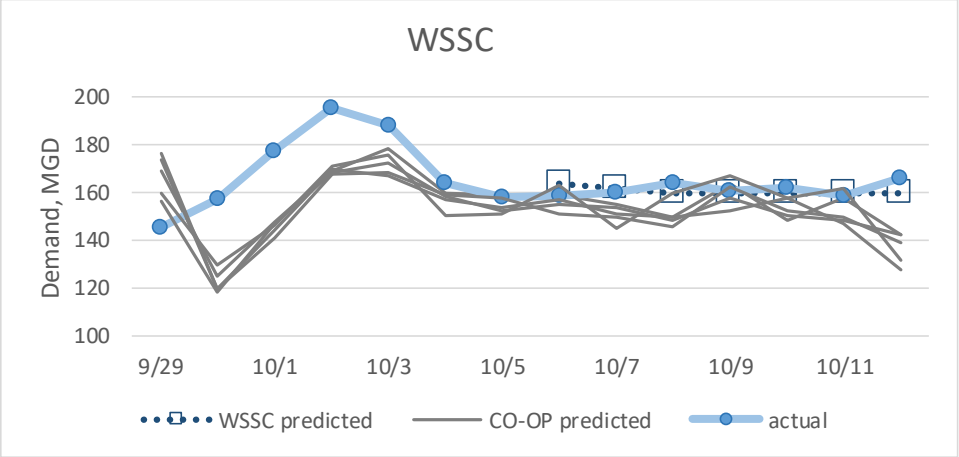


FIGURE 3-2: WSSC'S AM FORECASTS OF TOMORROW'S DEMAND

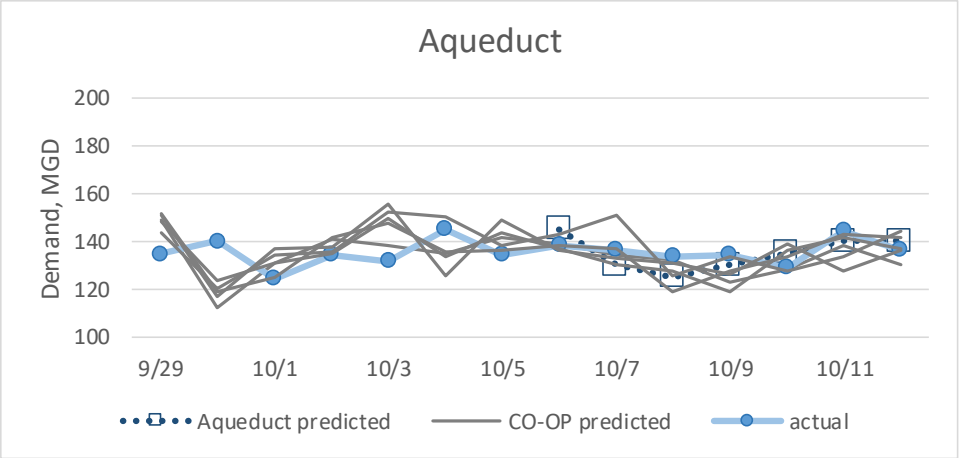


FIGURE 3-3: AQUEDUCT'S AM FORECASTS OF TOMORROW'S DEMAND

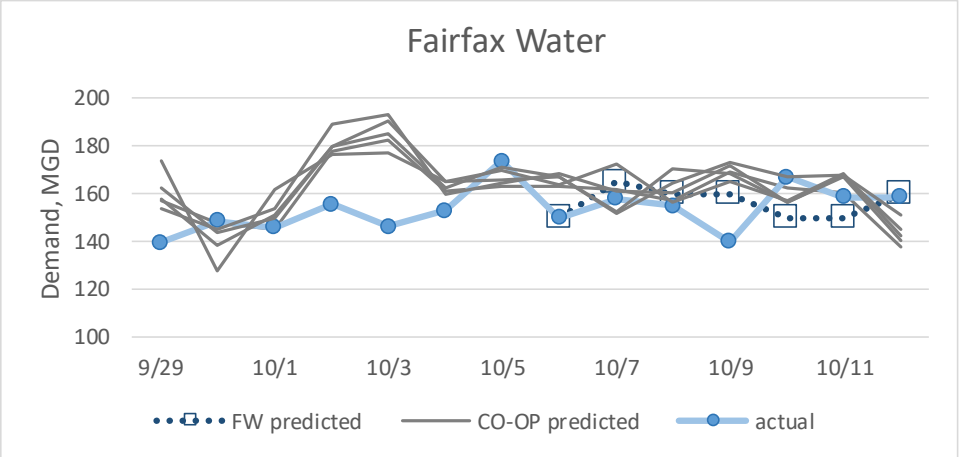


FIGURE 3-4: FAIRFAX WATER'S AM FORECASTS OF TOMORROW'S DEMAND

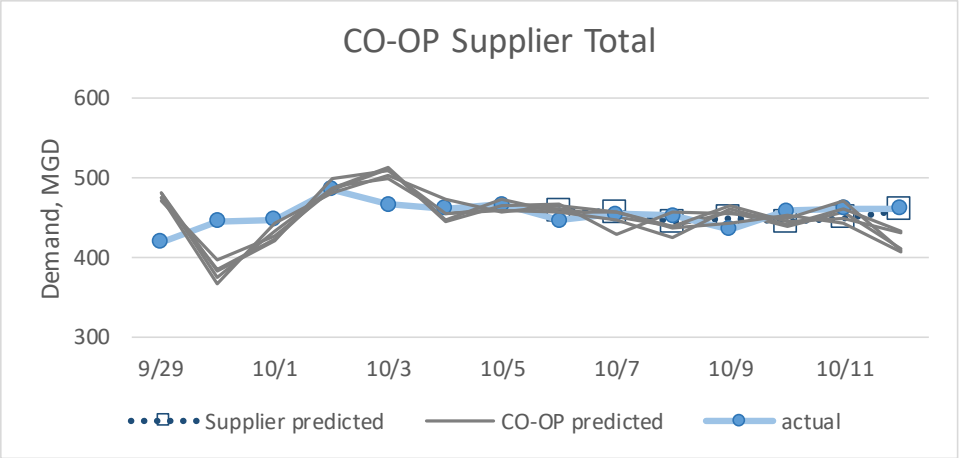


FIGURE 3-5: CO-OP MODEL'S FORECASTS FOR TOMORROW'S TOTAL DEMAND

TABLE 3-2: FORECAST ERRORS (MGD)

	Oct 6	Oct 7	Oct 8	Oct 9	Oct 10	Oct 11	Oct 12	Average
FW error	0.1	7.2	5.1	20.1	-17.0	-8.4	1.3	**1.2**
FW abs error	0.1	7.2	5.1	20.1	17.0	8.4	1.3	**8.5**
WA error	6.7	-6.6	-8.7	-4.3	5.9	-4.4	3.5	**-1.1**
WSSC abs error	6.7	6.6	8.7	4.3	5.9	4.4	3.5	**5.7**
WSSC error	5.5	2.2	-4.3	-0.8	-2.1	1.4	-6.2	**-0.6**
WSSC abs error	5.5	2.2	4.3	0.8	2.1	1.4	6.2	**3.2**
COOP individual supplier error								**2.6**
COOP individual supplier abs error								**7.9**
Supplier total system error	12.3	2.8	-7.9	15.0	-13.2	-11.4	-1.4	**-0.5**
Supplier total system abs err	12.3	2.8	7.9	15.0	13.2	11.4	1.4	**9.1**
COOP total system error	5.7	-24.9	-20.4	6.7	12.9	18.9	-44.6	**-6.5**
COOP total system abs error	5.7	24.9	20.4	6.7	12.9	18.9	44.6	**19.2**

TABLE 3-3: 2016 FAIRFAX WATER SYSTEM INFORMATION AND OPERATIONAL CONSTRAINTS

Facility	MGD	Notes
Griffith plant max. production	120	The maximum production from the Griffith plant (Occoquan Reservoir) will be increased to 160 MGD at some time in the future.
Griffith plant min. production	45	The minimum current production at Griffith is approximately 45 MGD (25 to Prince William County East + 20 to Main Service area). More accurately, the minimum production rate is a function of the maximum possible transfer rate from the Potomac plant (Corbalis) and total demand in the Occoquan service area. The maximum transfer rate from the Potomac plant to the Occoquan service area is 65 MGD. Minimal advance notice is required to implement this change. In addition to this constraint, there is also a hydraulic limitation requiring a minimum Occoquan withdrawal of 45 MGD. The minimum Occoquan demand is the greater of these two constraints. The fraction of total demand that comes from the Potomac service area is currently about 0.6, or 60 percent.
Corbalis plant max. production	225	Capacity of the Corbalis plant (Potomac River) will be expanded to 300 MGD at some point in the future.
Corbalis plant min. production	60	Lower in the winter and higher in the summer. The minimum current production at Corbalis is a function of demand in the Potomac service area as well as pump capacities and the need to furnish part of Loudoun Water demand directly from the Corbalis plant. Roughly, the minimum Potomac demand is the fraction of the total demand serviced by the Potomac minus 35 MGD. (30-35 MGD is the maximum that can be transferred from the Occoquan service area, but note that approximately a 24-hour notice is required to configure yard piping at Pohick Pump Station.)
Maximum WEST to EAST (Potomac TO Occoquan) transfer rate of finished water*	65	Potomac withdrawals can be increased to conserve Occoquan storage by transferring up to 65 MGD of treated water from Corbalis to the Occoquan service area. Minimal advance notice required.
Maximum EAST to WEST (Occoquan TO Potomac) transfer rate*	35	Potomac withdrawals can be decreased to conserve Little Seneca storage by transferring up to 35 MGD or treated water from the Griffith plant to the Potomac service area. 24-hour advance notice required to configure yard piping at Pohick Pump Station.
*These transfer amounts also depend on demands in the two service areas - in other words, check with Fairfax Water to confirm the feasibility of all load shift requests.		

TABLE 3-4: 2016 AQUEDUCT SYSTEM INFORMATION AND OPERATIONAL CONSTRAINTS

Facility	MGD	Notes
Dalecarlia max. production	200	
Dalecarlia min. production	60	
McMillan max. production	65-70	Flat rate constrained by turbidity, although in the short term an increase to 120 max. is possible.
McMillan min. production	63	
Great Falls min. withdrawal	(32)	The gates can go as low as needed (Woody Peterson, 9/16/14). Under normal circumstances, changes in gate height are made at 0.5 foot increments. One gate can be closed, and the other one be open. According to our current algorithm, both gates are at the lowest setting, 0.5 foot, the withdrawal is 32 MGD.
Woody Peterson says that Little Falls pump #6 is closest to the USGS gage and may locally depress the water level in the vicinity of the gage (see Figure 3-6).		

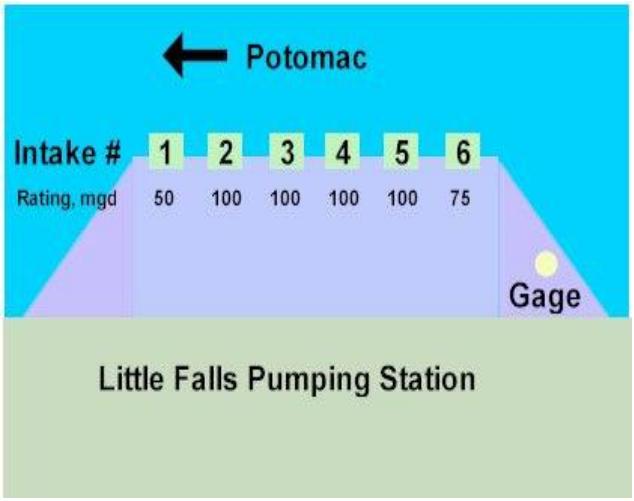


FIGURE 3-6: WASHINGTON AQUEDUCT'S LITTLE FALLS PUMP RATES

TABLE 3-5: 2016 WSSC SYSTEM INFORMATION AND OPERATIONAL CONSTRAINTS

Facility	MGD	Notes
Patuxent plant max. production	62 to 65	A max. of 70 MGD might be possible for a couple of days (Karen Wright, WSSC). The Patuxent plant max. depends on reservoir levels. When the new plant is completed, it will be rated at 72 MGD with an emergency maximum of 120 MGD.
Patuxent plant min. production	33	
Potomac plant max. production	283	
Potomac plant min. production	100	
Brighton Dam will be undergoing repairs beginning in 2017 that are expected to take two years to complete. This will reduce available storage in the Patuxent reservoirs by approximately 4 BG. The work will include gate and dam repair and sediment removal.		

TABLE 3-6: ADDITIONAL SYSTEM INFORMATION

Organization - Facility	MGD	Notes
Loudoun Water – BRWRF discharge	4.5	Loudoun Water's Broad Run Water Reclamation Facility (BRWRF) discharges treated wastewater into the Potomac River upstream of WMA system intakes.
USGS – Point of Rocks stream gage		During low flow conditions, the growth and/or die-off of aquatic grasses at the Point of Rocks gage may require more frequent updates of the rating curve. If grass effects are suspected, call Matt Baker of the USGS's Frostburg office.

4 Lessons Learned and Action Items

The lessons learned during the course of the exercise and corresponding action items are listed below.

1. **Drupal website**: During the exercise, the water suppliers used the second version of CO-OP's Drupal website to enter daily demand and reservoir storage data. In addition, the capability has been added to allow the suppliers to upload hourly data. CO-OP's goal is collection of hourly data from the suppliers throughout the year, to support development and verification of the LFFS. However, because of security concerns on the part of the suppliers, a method for daily automated uploads of hourly demands has not yet been identified.

   ACTION ITEM: CO-OP needs to continue discussions with the suppliers to evaluate automating the acquisition of hourly withdrawal data from the suppliers.

2. **Energy-related load shift constraints**: The CO-OP system relies on load shifts to increase system efficiency during droughts. Past exercises made CO-OP staff aware of the fact that energy concerns were limiting Fairfax Water's use of the Griffith treatment plant during normal operating conditions.

During the 2016 exercise it came to light that Aqueduct decision to use the Little Falls intake is also subject to energy-related constraints.

ACTION ITEM: CO-OP needs to discuss with the water suppliers how and when to put into place procedures to allow the over-riding of energy considerations during droughts.

3. **Provision of data to MARFC**: During some recent drought exercises, information on North Branch reservoir releases and WMA withdrawals has been provided each day to MARFC for use in its flow forecasts. As part of the 2016 exercise, the Drupal website was configured to automatically create a text file with this information which could be accessed by MARFC models. MARFC staff were contacted and provided information on this file.
   ACTION ITEM: Follow-up communications with MARFC needs to occur on whether the information content and format is appropriate, and if any changes in procedures are necessary in order for them to incorporate this information into their forecast models.

Appendix A – Agenda for the pre-exercise meeting

2016 Annual CO-OP Drought Exercise

Pre-Exercise Meeting

10 AM to 12:30 PM, Monday, October 3, 2016
Interstate Commission on the Potomac River Basin
30 West Gude Drive, Suite 450, Rockville, Maryland

2016 Drought Exercise Goals

1. Exercise CO-OP communications and operational procedures
    a. Communications with suppliers regarding "load-shifting"
    b. Communications with the Corps regarding North Branch releases
    c. Communications with WSSC and others regarding Little Seneca releases
    d. Communications with MARFC on metropolitan area withdrawals
    e. Use of CO-OP flow prediction tools and MARFC flow prediction resources
2. Test updated version of website for online data submission
3. Test use of CO-OP's real-time Low Flow Forecast System forecasts to inform reservoir release decisions

1. Welcome & introductions
2. Current drought status
3. Overview of CO-OP drought exercises (Cherie Schultz)
4. Reports on system updates and current operational considerations; contact information (see Tables, 1 to 5)
    - Fairfax Water
    - Loudoun Water
    - Washington Aqueduct
    - WSSC
    - MWCOG
    - USACE
    - USGS
    - MARFC
5. Updates to website for online data submission (Sarah Ahmed)
6. Lunch (bag lunch provided)

Appendix B – Communications related to Little Seneca release

INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN

30 W. Gude Drive, Suite 450
Rockville, MD 20850
(301) 984-1908
www.potomacriver.org

October 5, 2016

The Honorable Isiah Leggett
Montgomery County Executive
Executive Office Building
101 Monroe Street, 2nd Floor
Rockville, MD 20850

Dear Mr. Leggett:

The Interstate Commission on the Potomac River Basin (ICPRB) coordinates drought-related water supply operations on behalf of the Washington, D.C., metropolitan area water suppliers (Washington Suburban Sanitary Commission (WSSC), Fairfax Water, and the Washington Aqueduct Division of the Army Corps of Engineers).

ICPRB is conducting the annual Washington metropolitan area drought exercise from October 5 to October 11, 2016. These exercises are conducted each year when an actual drought does not occur. The main goal is to practice decision-making and communications within and between organizations. This year's exercise includes a simulation of water supply release(s) from Little Seneca Reservoir, to test coordination between ICPRB, WSSC staff operating the dam at Little Seneca, and staff at Black Hill Regional Park, where the reservoir is located.

Little Seneca Reservoir was constructed with funds provided by the Washington area water suppliers in 1981. The reservoir is used to augment Potomac River flow during droughts to ensure a safe and reliable water supply for the over 4.6 million customers in the Washington metropolitan area, including the citizens of Montgomery County. It is an integral component of the cooperative system devised for the region. Releases are part of normal drought operations; drought-related releases were made in 1999, 2002, and 2010. Releases were also made during the annual drought exercises of 2003, 2004, 2005, 2013 and 2015.

The Maryland-National Capital Park and Planning Commission (M-NCPPC) has also been contacted about the exercise and notification will be provided to M-NCPPC and Black Hill Regional Park staff prior to the simulated release.

The ICPRB is an interstate compact commission established by Congress in 1940. Its mission is to protect and enhance the waters and related resources of the Potomac River basin through science, regional cooperation, and education. Represented by appointed commissioners, the ICPRB includes the District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia, and the federal government.

If you have any questions contact me at cschultz@icprb.org or 301-274-8120.

Sincerely,

Cherie Schultz, Ph.D., Director of Cooperative Water Supply Operations on the Potomac
Interstate Commission on the Potomac River Basin

CC:
Council Member Roger Berliner
Council Member Marc Elrich
Council Member Nancy Floreen
Council Member Tom Hucker
Council Member Sidney Katz
Council Member George Leventhal
Council Member Nancy Navarro
Council Member Craig Rice
Council Member Hans Riemer

Appendix C – 2016 CO-OP Drought Exercise Guide

2016 CO-OP Drought Exercise Guide

October 5 – 11

ICPRB Section for Cooperative Water Supply Operations on the Potomac (CO-OP)

Daily scenarios/goals/events

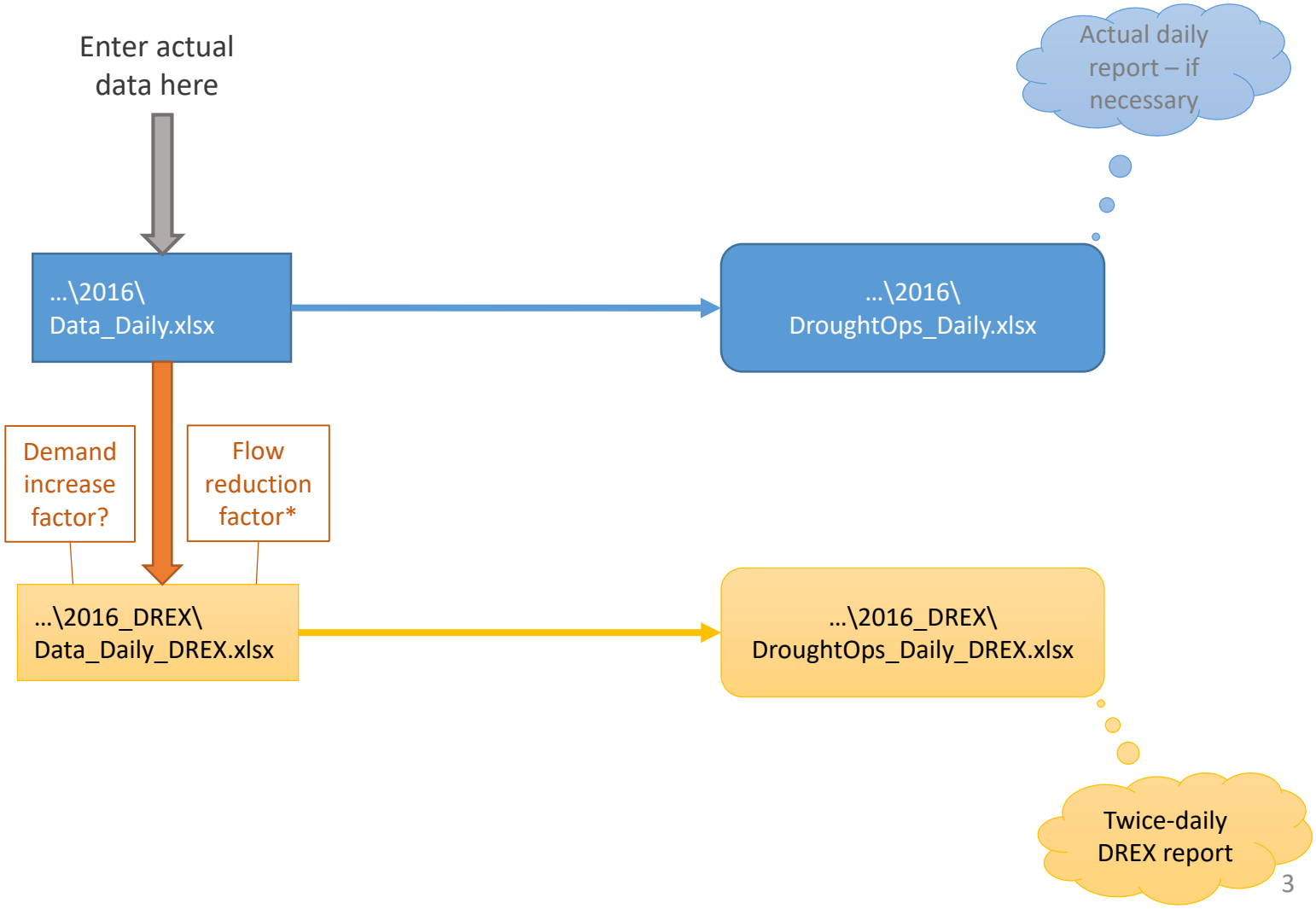
DREX Scenario

The year is 2020 and the basin has been unusually dry for the past several months. CO-OP initiated daily monitoring in mid-July and enhanced monitoring in mid-September. On the first day of the exercise, simulated flows are 950 cfs (614 MGD) at Point of Rocks and 680 cfs (440 MGD) at Little Falls. The utilities are doing the following (SIMULATED):

- WSSC: withdrawing the minimum from the Patuxent – 35 MGD – to conserve storage
- Fairfax Water: per operational preference
- Aqueduct: all withdrawals currently from Great Falls
- Loudoun Water: withdrawing an amount equal to Broad Run discharge, per permit (since Point of Rocks < 1400 cfs and no quarry yet)

Reporting - Structure of Daily Ops Files

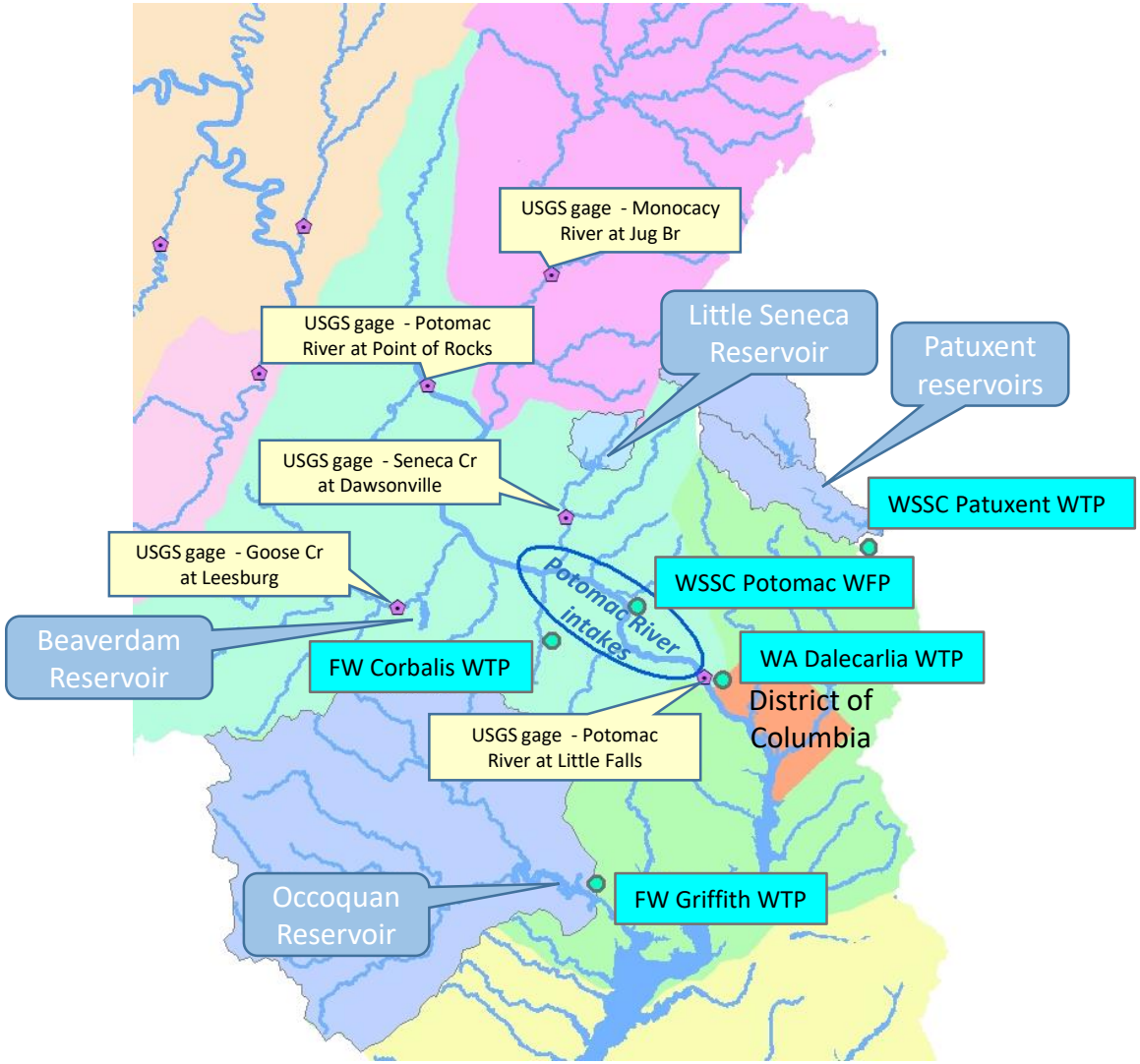
(Hourly files are linked in a similar fashion)



Drought Operations Schedule

7:30-8:00 AM	**CO-OP reviews and compiles flow and forecasts**
	Download recent USGS daily and hourly flow data, using Download Data.xlsm or another tool, and copy into Data_Daily.xlsx and Data_Hourly.xlsx.
	Download MARFC's 72-hour flow forecast using Download MARFC.xlsm
	Run any necessary scripts to compile and process LFFS streamflow forecasts and precipitation estimates
	CO-OP reviews meteorological data and forecasts
	Check the LFFS's 24-hour basin-wide precipitation average and MARFC's observed multisensory precipitation estimates (MPE) Check MARFC's 72-hour precipitation forecasts
	Check the NWS's 5-day and 7-day precipitation forecasts
	May want to check MARFC's POR and Little Falls ensemble flow predictions
8:00 AM	**Suppliers send previous day's demands, recent hourly withdrawals, today and tomorrow's forecasted demands, and reservoir storage by 8 AM**
8-9:00 AM	**CO-OP enters information from suppliers into Data_Daily.xlsx and Data_Hourly.xlsx.**
8-9:00 AM	**CO-OP determines Luke target (use DroughtOps_Daily.xlsx)**
	Review "default" demand values in row 12 of "Intro" pages of daily tool.
	Review graphs periodically in "Calibration" page of DroughtOps_Hourly.xlsx to see if travel times need adjustment
	Check with Corps periodically to find out plans for Luke water quality flow target - which can be entered into "Scenario" page
	Review graph and accompanying table in "Scenario" page of DroughtOps_Daily.xlsx to determine if Jennings water supply release is needed
9:00 AM	**If it's determined that a water supply release is needed, or needs to be continued (or discontinued) CO-OP calls the USACE Baltiimore District Office with requested change (water supply releases are requested by giving Luke target flow in cfs)**
9-10:00 AM	**CO-OP determines other operational requests for the morning (use both DroughtOps_Daily.xlsx and DroughtOps_Hourly.xlsx)**
10:00 AM	**CO-OP sends out morning email report**
1:00 PM	**Suppliers send any updates to today and tomorrow's forecasted demands**
2:00 PM	**CO-OP repeats steps above and sends out afternoon email report**

Map of Resources and Facilities Near the WMA

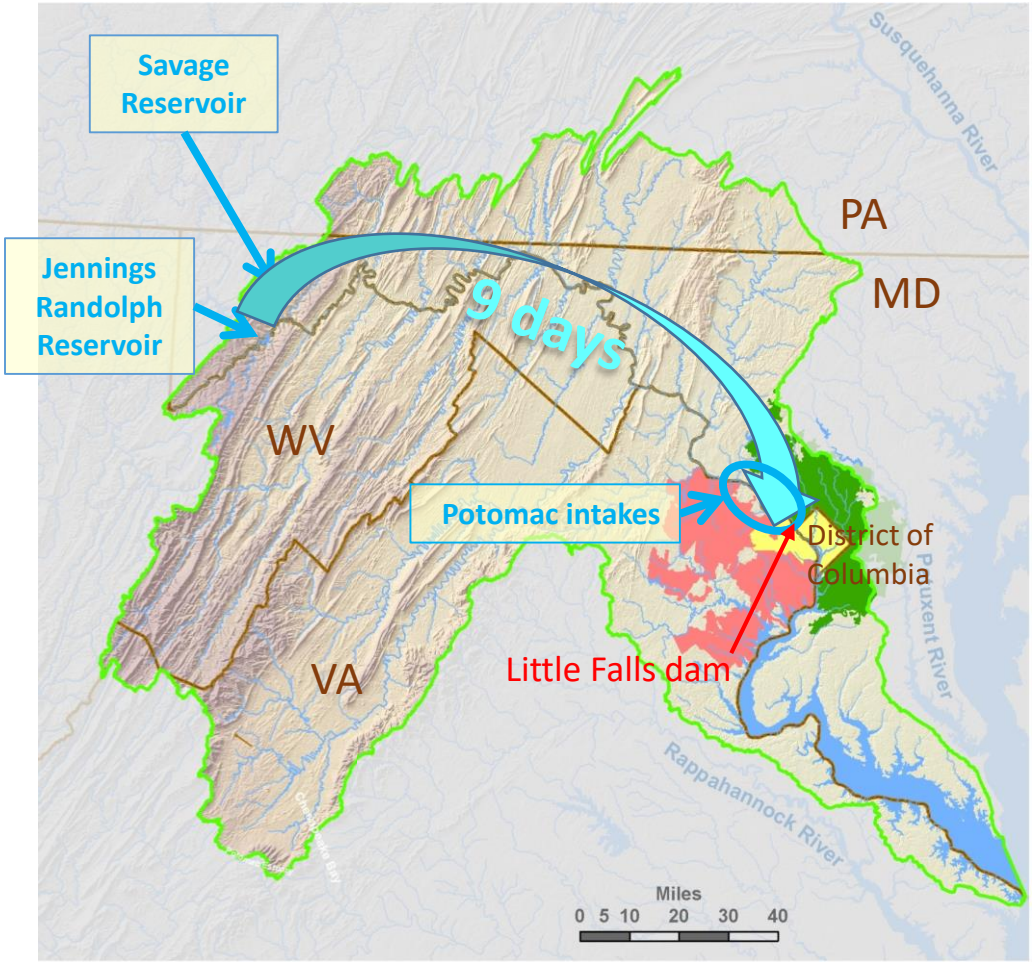


Daily scenarios/goals/events

Date	Scenario	Activities
Wed., Oct 5, 2020	POR: 1050 cfs (679 MGD) Lfalls: 850 cfs (549 MGD)	• Review daily schedule & data sources • Help utilities with data entry • Draft simulated letter to Montgomery Co. Council • Update contact table
Thurs., Oct 6, 2020		Exercise 1: North Branch release – discuss the various flow forecasts Exercise 2: Great Falls to Little Falls load shift
Fri., Oct 7, 2020		Exercise 3: Little Seneca release + Occoquan load shift
Sat., Oct 8, 2020		practice
Sun., Oct 9, 2020		practice
Mon., Oct 10, 2020		practice
Tues., Oct 11, 2020		Exercise 4: Patuxent load shift

North Branch Reservoir Release

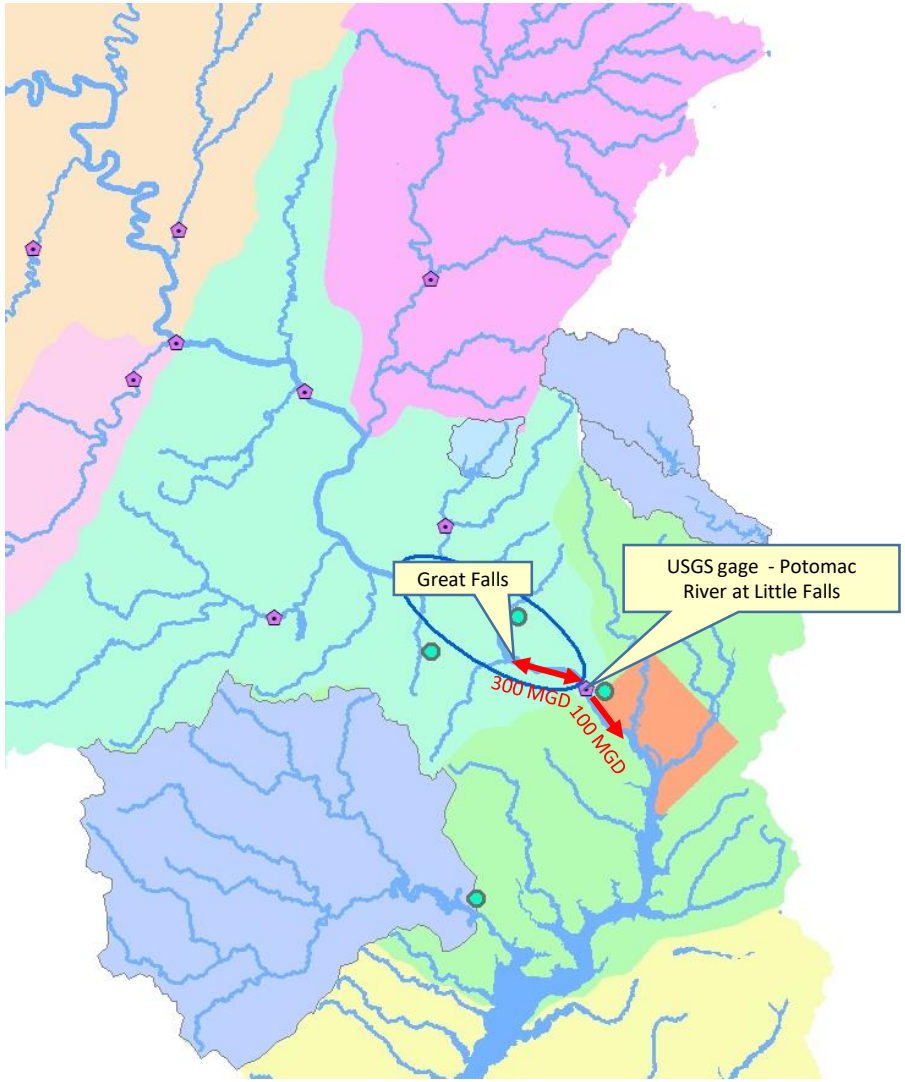
- The Corps operates Savage in coordination with Jennings Randolph (JR) (usually provides 20% Savage "match" to Jennings release)
- At full "conservation pool" (pool elevation = 1466") JR storage is:
  - 13.1 BG water supply (44.56%)
  - 16.3 BG water quality (55.44%)
- We request a "water supply" release by calling the Corps' Baltimore District Office by 9 AM
  - We calculate our estimated deficit, or "need", in 9 days time based on our assumed water quality release if there were no water supply release ("reference flow")
  - We add our estimated need to the reference flow to get our requested "Luke target" flow, in cfs
  - Call Baltimore Office Central Office (weekdays) or Duty Cell (weekends)
  - Note that the Corps' minimum Luke flow from a water quality point of view is 120 cfs
  - To meet the Luke target the Corps assumes it will be JR release + Savage release + local flow
  - The Corps has an "accounting" spreadsheet which calculates how much of the JR release came from water supply vs water quality storage
- Use DroughtOps_Daily to determine need for North Br release
  - Make sure that you agree with the default values for Patuxent and Occoquan withdrawals and current Luke flow – line 12 of "Intro" page
- Use graph and table on "Scenario" page to determine Luke target, considering
  - The 9-day flow forecast of "Little Falls recession" equation – best because used by PRRISM
  - The LFFS forecast – best if highest forecast?
  - In general, to be consistent with PRRISM, use NO MARGIN OF SAFETY, except for balancing:
  - Want to keep storage in JR and Seneca reservoirs reasonably "balanced" (this is a consideration in a prolonged drought) – see last page of this guide



Great Falls Load Shift

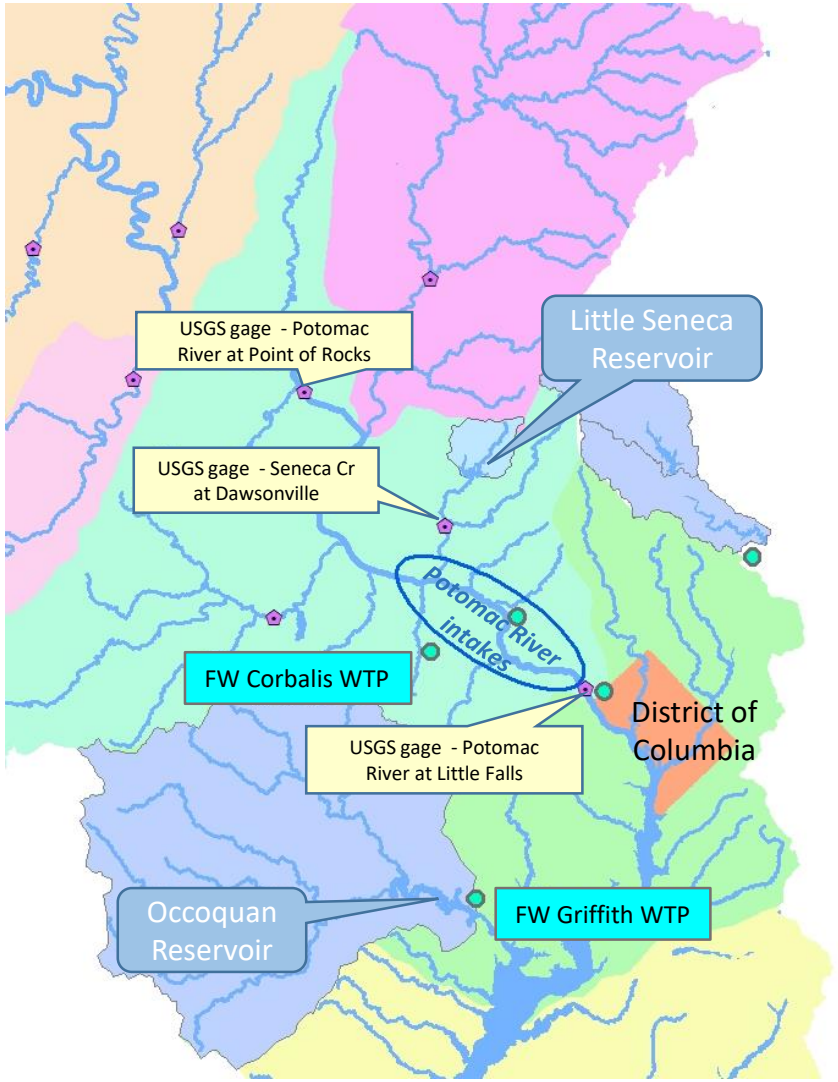
If flow at Little Falls reaches 400 MGD, START THINKING ABOUT a Great Falls – Little Falls load shift!

- There is a recommendation that the minimum flow in the stretch of the river between Great Falls and Little Falls be 300 MGD
- This can be achieved by shifting a portion of Aqueduct's withdrawal from Great Falls to Little Falls – use the DroughtOps_Hourly tool
- Aqueduct withdraws water from the Potomac at 2 locations
  - It prefers to withdraw from Great Falls, where gravity propels the water to the Dalecarlia Reservoir
  - It can withdraw downstream at Little Falls just above the USGS gage; this water must be pumped up hill to Dalecarlia at a considerable cost
- Example withdrawal scenarios
  - All withdrawals from G Falls (Q = flow; W = withdr):
    - Q LF = 150 MGD
    - W GF = 200 MGD
    - W LF = 0 MGD
    - Q GF to LF = 150 MGD
  - All withdrawals from L Falls:
    - Q LF = 150 MGD
    - W GF = 0 MGD
    - W LF = 200 MGD
    - Q GF to LF = 150 + 200 = 350 MGD
  - Mixed withdrawals:
    - Q LF = 150 MGD
    - W GF = 75 MGD
    - W LF = 125 MGD
    - Q GF to LF = 150 + 125 = 350 MGD
- The load shift from G Falls to L Falls should be done carefully and a good ½ day before flow at Little Falls drops below 300 MGD to avoid "double dipping"
  - It takes ~ 9 hours for a hydrograph at Great Falls to arrive at Little Falls
  - it seems some of the L Falls pumps may artificially depress stage readings at the L Falls gage



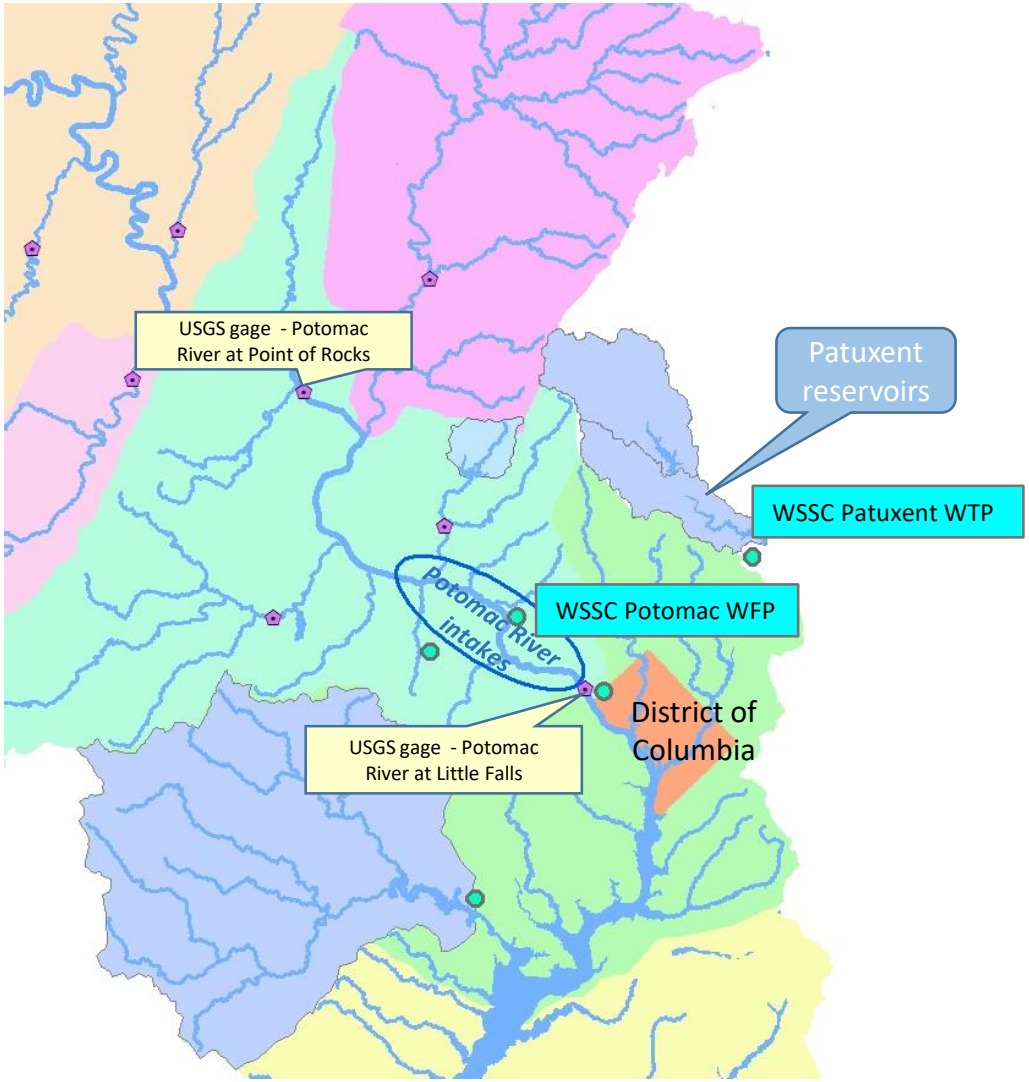
Little Seneca Release/Occoquan Load Shift

- Little Seneca and Occoquan should be operated in conjunction during droughts
  - Releases from Little Seneca take 1+ days to arrive at Lfalls during low flow conditions
  - A FW load shift may take 1+ days to impact LFalls
    - ~15 hours for a change in their Potomac withdrawal (Corbalis plant) to be seen at Lfalls
    - 4-24 hours (?) to implement a transfer of water from their Occoquan (Griffith plant) to their Potomac (Corbalis plant) "service area"
- Constraints on the FW load shift:
  - The Griffith WTP min/max production is 45/120 MGD
  - The Corbalis WTP min/max production is 60/225 MGD
  - Note that FW can only increase Griffith (Occoquan) production by ~15 MGD per day!
  - FW operators are constrained by energy costs, so pre-approval must be arranged during drought operations to operate Griffith at its maximum rate
- To request these releases
  - call the WSSC control room for a Little Seneca release
  - call the FW control room (and make sure Joel Thompson is kept informed) about FW load shifts
- Use a good margin of safety (MOS) for tomorrow's flow at Little Falls
  - PRRISM is using 130 MGD!
  - review of the recent performance of the forecast models may make you comfortable with a smaller MOS



Patuxent Load Shift

- If observed flow at Little Falls is nearing 140 MGD (217 cfs), WSSC's Patuxent withdrawals can be increased to take some burden off of the Potomac
- Such a load-shift can have a reasonably fast impact on flow at Little Falls because
  - WSSC is usually able to implement such shifts very quickly and
  - We estimate that under low-flow conditions, a change in WSSC's Potomac withdrawal take 10 hours to impact flow at Little Falls
- Constraints on the load shift include the following:
  - WSSC's Potomac WFP's min/max production are 100 MGD/283 MGD
  - WSSC's Patuxent plant's min/max production are 33 MGD/62 MGD
- To request the load shift call WSSC's Control Room (but Karen Wright should be kept informed).



Reservoir Releases – a System Perspective

- Don't be "conservative" in the operations of Jennings Randolph (JR)
  - Don't add an extra margin of safety to the calculated JR release rate (except for balancing purposes – see below) "just to be safe" – it is Seneca's role to take care of any deficit that later develops
  - Even if it doesn't seem so, it will probably rain sometime in the next 9 days
- Keep storage in JR and Seneca reservoirs reasonably "balanced"
  - Reduce JR release if JR is low relative to Seneca
  - Increase JR release if JR is high relative to Seneca
  - This is simulated in PRRISM by adding a "buffer" to the calculated release: buffer = (%JRWSStorage - %SenecaStorage)x10 MGD (where percentages are based on usable capacities); so e.g. if %JRWSStorage = 50% and %SenecaStorage = 55% , then buffer = -5x10 = -50 MGD. So -50 MGD would be <u>added to</u> the calculated North Branch release target (ie 50 MGD would be subtracted).
- Operate Occoquan Reservoir in conjunction with Seneca during droughts
  - It takes approximately <u>a day</u> for any change in Seneca & Occoquan operations to impact flow at Little Falls (during low flow conditions)
  - If forecasts indicate that there is sufficient flow in the river tomorrow, operate both of these reservoirs to conserve storage
  - If a flow deficit is predicted for tomorrow, schedule a Seneca release, but reduce the burden on Seneca by "load-shifting" to the Occoquan (ie reduce FW's Potomac withdrawal and increase their Occoquan withdrawal)
  - Consult with FW about how much of a load-shift is possible in a day – 10 MGD? 20 MGD?
  - Do be "conservative" in these operations, ie add a comfortable margin of safety. PRRISM runs indicate that a margin of safety of 120-130 MGD ensures that the probability of missing the 100 MGD Little Falls flowby is minimal, and in 2002 operations a margin of safety of 100 MGD was used.
- Operate the Patuxent reservoirs to address near-term flow shortages
  - Changes in WSSC's operations can have a relatively quick impact at Little Falls (~ 10+ hours)
  - If it looks like there is a shortage developing today, ask WSSC to load-shift to the Patuxent ASAP (ie reduce their Potomac withdrawal and increase their Patuxent withdrawal).