The importance of an ensemble forecast for NYC water supply

A shift in the operational decision making approach

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Presentation Outline

- New York City (NYC) water supply
- NYC Operations Support Tool (OST)
  - Introduction
  - Components
  - Application
- The importance of an ensemble forecast
  - OST application examples
- Our experiences and lessons learned
- NYC forecast support needs
New York City Water Supply

- Three Sub-systems
  - Catskill, Delaware, Croton
- 19 reservoirs & 3 lakes
- 570 BG storage capacity
- Delivers 1.1 BG per day
- Serves 9 million people
- Unfiltered Surface Water Supply
- Managed by NYC DEP
Multiple Objectives and Challenges

- Supply reliability
- Drinking water quality regulations
- EPA Filtration Avoidance Determination (FAD)
- Tail water fisheries
- Ecological flows
- Regulated releases and diversions
- Spill mitigation
- Long-term supply/demand
- Climate change impact
- Extreme events frequency
- Operating costs
- Hydropower
NYC’s Operations Support Tool (OST)

Developed as one of the FAD deliverables
OST Application Modes

POSITIONAL ANALYSIS (PA) MODE

- 1-Year Long Simulation
  - Multiples traces
  - Support water supply operations

- Regular Runs
  - Open (Open)
  - Current Operations (CO)

- Test Operational Alternatives (TOA)

- Development Runs
  - Test New Rules (TNR)
  - Test New Infrastructure (TNI)

SIMULATION (SIM) MODE

- Long-term simulation
  - 1 Trace
  - Multiple years
  - Support planning
  - Support policy development
  - Climate change impact assessment
OST Application – PA Mode

Ensemble of inflow forecasts

Probabilistic output metrics

OASIS – W2 Model

simulation scenario setup

Current system status
Importance of Ensemble Forecasts

Example 1:

Winter 2013-2014: Spill mitigation by modeling alternatives for implementing a CSSO
By February 2014, there was a large amount of water stored as snowpack in the Ashokan Reservoir watershed.

OST was used to determine the most efficient way to minimize uncontrolled releases while maximizing reservoirs refill.
Water is released using the Ashokan Release Channel (ARC)
600 mgd release simulation scenario
Impact on Jun 1st refill by Scenario

OST simulated alternative release impacted reservoir probability of refill by June 1st, differently.
Repeated OST simulations provided valuable information to guide releases from Ashokan Reservoir.
OST simulations helped operators meet spill mitigation objectives while ensuring reservoir refill.
Example 2:
Winter/Spring 2015: Modeling support to prevent NYC’s Delaware River basin reservoirs (Pepacton, Cannonsville and Neversink) from entering drought watch. Very cold temperatures, large snow accumulation.
Series of OST Simulations

Each line represents a model simulation with a different starting date and ensemble forecast
Actual Storage

Actual daily data
Reservoir inflow accumulated through Jun 1 is used to calculate NYC Delaware basin reservoirs mass balance.
Flexible Flow Management Program (cont.)

Mass balance is used to determine the release quantity from three NYC reservoirs to the Delaware River Basin.

### Current Storage Zone for Schedule Selection

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Usable Storage</th>
<th>Usable Storage + Snow Storage</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCN</td>
<td>83.7%</td>
<td>*</td>
<td>L2</td>
</tr>
<tr>
<td>Pepacton</td>
<td>86.7%</td>
<td>*</td>
<td>L2</td>
</tr>
<tr>
<td>Cannonsville</td>
<td>77.4%</td>
<td>*</td>
<td>L2</td>
</tr>
<tr>
<td>Neversink</td>
<td>88.3%</td>
<td>*</td>
<td>L2</td>
</tr>
</tbody>
</table>

*Not applicable (snow storage is included in the forecast)*

### Use Release Target and Storage Zone to Select Release Schedule

<table>
<thead>
<tr>
<th>Storage Zone, Summer (cfs)</th>
<th>Pepacton L2</th>
<th>Cannonsville L2</th>
<th>Neversink L2</th>
<th>PCN L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table-4a</td>
<td>100</td>
<td>190</td>
<td>75</td>
<td>380</td>
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<tr>
<td>Table-4b</td>
<td>110</td>
<td>245</td>
<td>80</td>
<td>435</td>
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<tr>
<td>Table-4c</td>
<td>115</td>
<td>300</td>
<td>90</td>
<td>505</td>
</tr>
<tr>
<td>Table-4d</td>
<td>125</td>
<td>360</td>
<td>95</td>
<td>580</td>
</tr>
<tr>
<td>Table-4e</td>
<td>135</td>
<td>415</td>
<td>100</td>
<td>650</td>
</tr>
<tr>
<td>Table-4f</td>
<td>140</td>
<td>460</td>
<td>110</td>
<td>710</td>
</tr>
<tr>
<td>Table-4g</td>
<td>150</td>
<td>500</td>
<td>115</td>
<td>765</td>
</tr>
</tbody>
</table>

Selected Schedule: Table(s) 4g
Experience and Lessons learned

Our experience with ensemble forecasts

• Led to a shift in the way we operate the system
  o From deterministic to risk-based
• Initially challenging and difficult
  o How to interpret model results
  o How to display model output to better inform operators
  o Need to be pro-active
• It is dynamic process and involves continuous learning
  o Streamflow forecast performance changes frequently

Now that we have started using the new approach, it would be even more difficult to operate our system without it!
Inflow Patterns Change frequently

PCN inflow accumulated over the next 7 days

Accumulated 7-day inflow (MG)

Date: 5/12/2019 to 6/23/2019
Affecting Forecast Performance

PCN inflow accumulated over the next 7 days

![Chart showing accumulated 7-day inflow over time with different probability levels and observed data.](image-url)
Uncertainty versus Lead Time

Schoharie inflow

30 day lead-time

15 day lead-time

3 day lead-time
NYC Forecast Support Needs

• Working with NWS to add EnsPost
  o For all OST forecast locations
  o Eliminate resources allocation for maintaining own post-processor
  o Employ more resources for ensemble diagnostic
    ▪ Develop diagnostic tools
    ▪ Improve our understanding of ensemble forecasts performance
    ▪ Need hindcasts to expand in-house analysis
• Improved forecast performance is very important
  o Starting with the short-range forecast
  o Under wet and dry hydrological conditions
“One of the most advanced and complex support tools for water supply operations of its kind in the world.” (NASEM)
Thank You!