Consensus Study Report

HIGHLIGHTS

September 2018

Review of the New York City Department of Environmental Protection Operations Support Tool for Water Supply

The Operations Support Tool, a computer model developed by New York City's Department of Environmental Protection, helps water managers optimize the timing and volume of water releases from reservoirs to manage turbidity levels, enhance ecological conditions in downstream systems, and maintain delivery of high quality drinking water. This report provides a review of the Operations Support Tool, finding that the tool offers a dynamic water routing platform that is both adaptable and capable of continuous improvement, if properly resourced with data, validated, and continually maintained.

New York City's water supply system is one of the oldest, largest, and most complex in the nation. Managed by the New York City Department of Environmental Protection's (NYC DEP's) Bureau of Water Supply, the system delivers more than 1.1 billion gallons of drinking water each day from three upstate watersheds (Croton, Catskill, and Delaware) to meet the needs of over nine million people in New York City and its surrounding counties.

Turbidity is a measure of the amount of incident visible light scattered by particles in water. Because drinking water regulations consider turbidity to be an effective surrogate for the presence of harmful particulate contaminants such as the pathogenic microorganism Cryptosporidium, providing low turbidity drinking water is an important component of public health protection. Waters from the Catskill and Delaware watersheds, which make up 90 percent of the New York City water supply, are typically low in turbidity and thus need no filtration or treatment other than disinfection. However, extreme storm events can elevate the turbidity of the water from the Catskill system. In these cases, alum (aluminum sulfate) is added to the water and the suspended solids are deposited in Kensico Reservoir prior to delivery to the City.

In response to evolving permitting requirements and storm events, NYC DEP developed the Operations Support Tool (OST), a mathematical modeling tool that can help support water management decision-making under conditions of high turbidity. OST is a combined water quantity and water quality mathematical simulation model that predicts future storage and water quality in New York City's reservoir system by incorporating data on dozens of variables such as current and projected precipitation, temperature, and streamflow, current and projected demand for water, and current and projected operations of the water supply system.

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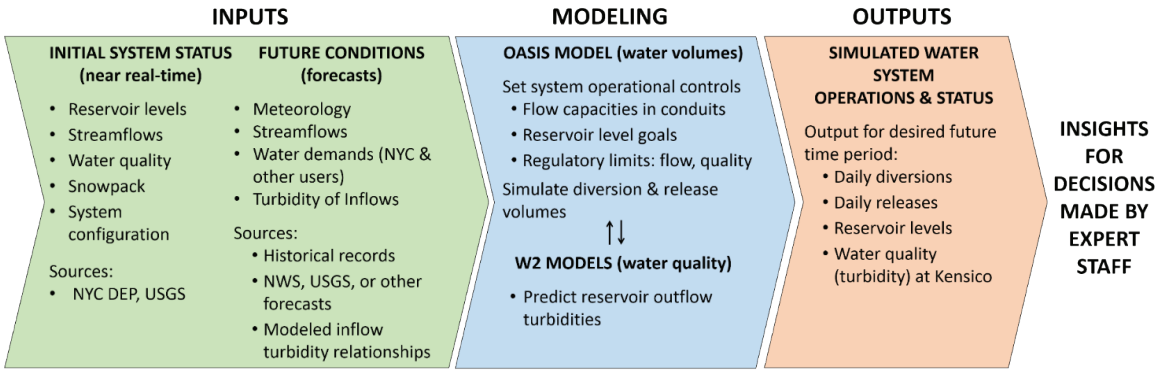

Figure 1. An Overview of the Operations Support Tool
This figure summarizes the conceptual framework of the Operations Support Tool (OST). Near real-time data (shown in green) describe the current status of the water system, providing "situational awareness" for NYC DEP as well as the initial system conditions for model forecasts. Also in green are the ensemble forecasts of future stream flows that are a major input to OST. Models (in blue) for water quantity (OASIS) and water quality (CE-QUAL-W2) combine forecasts of future water inputs (precipitation and streamflow) and system attributes to simulate future water flows and reservoir storage conditions. The model produces an ensemble of outputs (in red), such as diversions, releases, reservoir levels, and water quality conditions. Managers can use the results from OST simulations to develop conditional probabilities for specific events that may occur, providing a basis for assessing system reliability, understanding metrics of system performance, and making day-to-day decisions about system operation.

OST provides a systematic approach for evaluating the competing risks that must be considered in decisions about whether to divert or release water from reservoirs to moderate the use of alum. OST simulates decisions that closely approximate the decisions a knowledgeable operator would make after considering and processing all the available data, constraints, and possible operational controls. In this way, OST provides insights that operators can use to ensure delivery of the lowest turbidity water while also benefitting downstream communities by managing water releases, enhancing the health of local streams, and reducing the risk of flooding.

To develop and plan for future improvements of OST, the NYC DEP asked the National Academies to review the use of OST for water supply operations in New York City and consider potential ways in which the NYC DEP can more effectively use the tool.

NEW YORK CITY'S USE OF OST FOR WATER SUPPLY OPERATIONS

In its review, the report's authoring committee discussed the strengths and weaknesses of OST and made suggestions for how the tool could be improved. Overall, the committee found that OST is one of the most advanced and complex water supply tools of its kind, and it applauds the NYC DEP for its continued pursuit of such a capability. The following conclusions and recommendations are intended to improve the quality of data inputs to OST and, consequently, improve the tool's outputs and the ability of NYC DEP to make better use of it.

Source Data for the OST

The primary forecast tool used in OST is the National Weather Service's Hydrologic Ensemble Forecast Service (HEFS). This tool relies on meteorological inputs from a combination of three different systems that are blended together to form a single forecasting method. One problem with the HEFS approach is that the precipitation and temperature records that are used to derive streamflow forecasts are from the period from 1950 to 1997—meaning that important trends in hydrology over the past 20 years are not being captured. In light of the changes in climate and resulting hydrology that are already underway, it is crucial that the data driving ensemble forecasts are kept up to date.

The historical data used in the HEFS to create the ensemble streamflow forecasts need to be updated now to include the most recent 20 years, and this updating needs to occur on a regular schedule into the future.

Validation of ensemble streamflow forecasts is a complex task but vital to OST's quality and to maintaining trust in the process within NYC DEP management and the stakeholder community. Most hydrologic forecast modeling has focused on the accuracy of a point estimate—for example, how well does the model predict the streamflow entering a reservoir over the coming month? However, in the case of OST, validation should focus on the degree to which ensemble forecasts correctly capture the range and probabilities of potential outcomes. In presentations to the Committee in late 2017, there were descriptions of work to validate HEFS forecasts in general and forecasts specific to OST, but no published results were available.

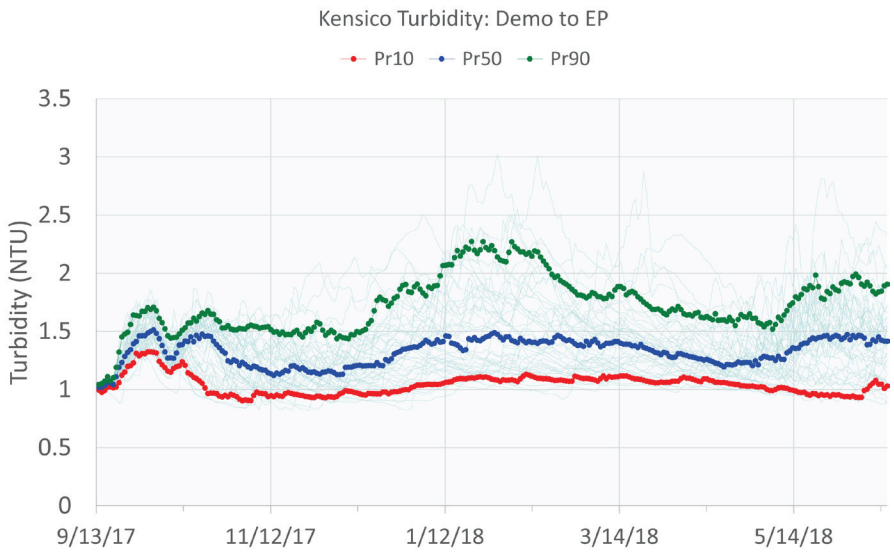

Figure 2.
This figure shows example output from OST predicting turbidity at Kensico Reservoir from the day of the model run (9/13/17) to 6 months into the future. The ensemble approach used in OST generates probabilities of a range of possible outcomes. The blue line is the median of the ensemble, and the green and red lines are the 90th and 10th percentile lines, respectively.

Probabilistic validation results for the ensemble streamflow forecasts need to be published for the New York City watershed region.

Since its inception, the institutional memory and expertise of NYC DEP staff has been critical to refining the numerous data inputs, representing the operational complexities of the water supply, and weighting the various model components within the OST framework. The biggest risk to OST failing to fulfill its role as a water management decision tool is a lack of continuous improvement, knowledge transfer, and knowledge mobilization through succession planning. Pursuing these measures would ensure that the best and most appropriate data and operational insights are used to inform the inputs, the models, and the other relationships that OST relies upon.

The Committee encourages the NYC DEP to continuously improve OST so that is remains operationally relevant, particularly in the face of growing environmental pressures like climate change and more stringent regulations.

METRICS FOR THE CATSKILL TURBIDITY CONTROL PROGRAM

The actions of the NYC DEP to control turbidity in the Catskill System are collectively called the Catskill Turbidity Control Program. The activities generally fall into three categories: (1) turbidity source control measures in the Schoharie and Ashokan watersheds; (2) improvements to infrastructure, most notable along the Catskill aqueduct; and (3) operational changes, some of which are facilitated by OST. The Committee was asked to identify metrics that will help determine whether these activities have been effective.

The NYC DEP's existing network of data collection systems provides a strong basis for evaluating metrics such as: (1) turbidity levels in diversions from the reservoirs and in aqueducts, (2) the frequency and/or duration of alum treatment events, and (3) mass of alum used during treatment events. The next step is analyzing the data to improve understanding of the dynamics of the system. This may help improve existing control strategies, optimize the data collection systems by learning which sensors provide the most important information, and demonstrate the effectiveness of the Program.

NYC DEP should be putting substantially more effort into ongoing assessment of the overall effectiveness of the Catskill Turbidity Control Program by conducting more data analysis. In particular, the use of Exploratory Data Analysis would help analysts understand the sources of variability in the data. NYC DEP should use analysis-of-covariance statistical techniques to determine the effectiveness of the Catskill Turbidity Control Program.

USE OF THE OST WITHIN THE ENVIRONMENTAL IMPACT STATEMENT FOR THE MODIFICATIONS TO THE CATALUM SPDES PERMIT

The committee reviewed NYC DEP's plan for using OST to evaluate the environmental impacts of proposed modifications to the State Pollution Discharge Elimination System (SPDES) permit for adding alum to the Catskill water supply. These modifications include operation of the Ashokan Release Channel, dredging alum floc from Kensico Reservoir, and the addition of alum to the Catskill Aqueduct.

Overall, the Committee found that the NYC DEP's plans for using OST in the Environmental Impact Statement (EIS) are systematic and appropriate. The details of how OST will be used in the analysis of each of the 19 impact

areas, and how the simulations are run, should be more transparent.

A second area of concern relates to streamflow and other data that will be used as input to OST, and whether they properly address the range of flow and environmental conditions required in the Final EIS. Input data should include all years up to the most recent available, as conditions are changing. **The EIS team needs to expand the range of hydrologic inputs it uses in OST and not be limited to historical data through only 2013.**

USE OF OST IN A CHANGING CLIMATE

Future climate conditions—including changes in the seasonality, frequency, duration, and magnitude of precipitation events and streamflow in the Catskill and Delaware watersheds--are likely to affect water supply. Indeed, these changes have already been detected in observational data for the region over the last several decades.

There are ways in which OST and its inputs can be improved and utilized so that it can be effective as a decision support tool even under changing climate conditions. Regularly updating the OST with the latest climate and hydrologic data so that the model parameterizations reflect current trends is essential to prepare for the future under changing climate conditions.

Given the Committee's review of the NYC DEP's and other studies on climate change in the watershed region, there is no reason why OST cannot continue to be an effective tool for operational support into the future if the recommendation to update OST with the most recent data is taken.

Additionally, NYC DEP can use OST in simulation mode in future climate studies. In doing so, it will be important to consider a range of approaches as inputs to OST, including output from Global Climate Models and hydrological models, historical climate analogs, and using current conditions and trends.

NYC DEP should consider structuring future planning studies with OST to identify the range of changes in hydrologic and water quality conditions that would trigger the need for operational changes, and then estimate the likelihood of such conditions.

COMMITTEE TO REVIEW THE NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION OPERATIONS SUPPORT TOOL FOR WATER SUPPLY

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For More Information . . . This Consensus Study Report Highlights was prepared by the Committee to Review the New York City Department of Environmental Protection Operations Support Tool for Water Supply, Water Science and Technology Board based on the Consensus Study Report *Review of the New York City Department of Environmental Protection Operations Support Tool for Water Supply* (2018). The study was sponsored by the New York City Department of Environmental Protection. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Water Science and Technology Board web page at http://www.nationalacademies.org.

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