Meeting of Model Expert Panel with DRBC Staff

Report to the Water Quality Advisory Committee

Delaware River Basin Commission

March 20, 2019

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# DRBC Expert Panel Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Service</th>
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<tbody>
<tr>
<td>Carl Cerco</td>
<td>U.S. Army Corps of Engineers (Retired)</td>
<td>Panel Members</td>
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<tr>
<td>Bob Chant</td>
<td>Rutgers University</td>
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<td>Steve Chapra</td>
<td>Tuffs University</td>
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<tr>
<td>Tim Wool</td>
<td>U.S. EPA Region 4</td>
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<tr>
<td>Vic Bierman</td>
<td>LimnoTech</td>
<td>Consultant to DRBC</td>
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<td>Scott Hinz</td>
<td>LimnoTech</td>
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</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Specialty and Responsibility</td>
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<tr>
<td>Tom Amidon</td>
<td>Manager, Modeling Section</td>
<td>Modeling general / multi-task / Atmospheric deposition</td>
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<tr>
<td>Jacob Bransky</td>
<td>Aquatic Biologist</td>
<td>Primary productivity / ichthyoplankton / algal speciation study</td>
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<tr>
<td>Fanghui Chen</td>
<td>Water Resource Engineer</td>
<td>Hydrodynamic modeling / data retrieval / post processing</td>
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<tr>
<td>Vince DePaul</td>
<td>Hydrologist (USGS)</td>
<td>WQ Modeling / wetlands interaction</td>
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<tr>
<td>Elaine Panuccio</td>
<td>Water Resource Scientist</td>
<td>Tributary / point source data management / load calculation</td>
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<tr>
<td>Namsoo Suk</td>
<td>Director, Science and WQ Management</td>
<td>Project management / multi-task / modeling</td>
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<tr>
<td>John Yagecic</td>
<td>Manager, Water Quality Assessment</td>
<td>Data retrieval &amp; analysis / multi-task / light extinction</td>
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<tr>
<td>Li Zheng</td>
<td>Senior Water Resource Engineer</td>
<td>Hydrodynamic and WQ modeling</td>
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Goal

• Develop a technically sound eutrophication model for the Delaware Estuary and Bay utilizing the current state of the science within a timeframe established by the Commission
  • Identify appropriate levels of source controls, especially in relation to dissolved oxygen
Modeling Approach

- Develop a linked hydrodynamic and water quality model
  - Environmental Fluid Dynamics Code (EFDC)
  - Water Quality Analysis Simulation Program (WASP8)

- Assess available data and conduct additional monitoring to fill gaps
  - Sources
  - Ambient water

- Calibrate linked model
  - Historical data, primarily 2012-2013
  - Intensive monitoring period 2018-2019

- Conduct forecast simulations with calibrated model
  - Determine levels of external sources required to achieve varying levels of ambient dissolved oxygen
## Targeted Schedule

<table>
<thead>
<tr>
<th>Designated Use Program Tasks</th>
<th>Activity</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
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<tr>
<td></td>
<td>Hydrodynamic Model Development</td>
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<td>Intensive Ambient Data Collection &amp; Data Analysis</td>
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<td>Water Quality Model Development and Calibration</td>
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<td>Determination of higher levels of DO &amp; protection to aquatic species.</td>
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<td>Develop wasteload &amp; load allocations</td>
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<td>Report Preparation</td>
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**Legend**
- Program Tasks supported by the bordering states/DRBC Agreement
- Lighter shading indicates preliminary or follow-up work
Conceptual Model
Nutrient Load Boundaries

- Tributary Loads
  - Delaware River at Trenton (Zone 1)
  - Schuylkill River
  - ~ 29 other tributaries
- Tidal Boundaries
  - Ocean at mouth of Delaware Bay
  - C&D Canal
- Direct Basin Loads
  - Wasteloads: WWTPs, CSOs, MS4
  - Nonpoint Source (runoff outside MS4)
  - Wet/Dry deposition onto water surface
Boundary Load Estimates for Tribs and WWTPs
“First cut” daily loads for 2012-2013 simulation

Sources

* WWTPs
  * Sampled 2011 – 2015
  * Daily load = concentration × daily flow
  * Average load calculated
* Tributaries
  * As first cut, PWD methodology used
  * Concentrations assigned for 3 seasons and 2 flows (high/low) based on 1990-2013 data
  * High/low flow threshold = 80th percentile
  * Unmonitored tribs borrow assigned concentrations from nearby tribs

Nutrients

* Total Organic Carbon
  * TOC = DOC + POC
  * TOC, DOC measured directly
* Total Nitrogen
  * TN = Nitrate(+Nitrite) + TKN
  * Nitrate, Nitrite, TKN measured directly
* Ammonia (NH₃-N)
  * Measured directly
* Total Phosphorus
  * TP = PO₄ + DOP + POP
  * TP, PO₄ measured directly
Total Organic Carbon

TOC Loads by Source (kg/yr)

- Delaware at Trenton: 49%
- Schuylkill River: 14%
- WWTPs: 18%
- Other Tributaries: 19%

TOC by Zone (MG/yr)

- ZONE 1: 25,000
- ZONE 2: 0
- ZONE 3: 0
- ZONE 4: 0
- ZONE 5: 0
- ZONE 6: 0

Legend:
- Upstream
- Tributaries
- WWTPs
Total Nitrogen

TN Loads by Source (kg/yr)

- Delaware at Trenton: 37%
- Schuylkill River: 16%
- WWTPs: 32%
- Other Tributaries: 15%

TN by Zone (MG/yr)

- ZONE 1: Upstream
- ZONE 2: Tributaries, WWTPs
- ZONE 3: Tributaries, WWTPs
- ZONE 4: Tributaries, WWTPs
- ZONE 5: Tributaries, WWTPs
- ZONE 6: Tributaries, WWTPs
Ammonia-Nitrigen

Ammonia-N Loads by Source (kg/yr)

- Delaware at Trenton: 12%
- Schuylkill River: 2%
- Other Tributaries: 2%
- WWTPs: 84%

Ammonia-N by Zone (MG/yr)

ZONE 1: 1,000
ZONE 2: 500
ZONE 3: 3,000
ZONE 4: 5,000
ZONE 5: 1,500
ZONE 6: 100

Legend:
- Upstream
- Tributaries
- WWTPs
Total Phosphorus

TP Loads by Source (kg/yr)

- Delaware at Trenton: 38%
- Schuylkill River: 8%
- WWTPs: 40%
- Other Tributaries: 14%

TP by Zone (MG/yr)

- ZONE 1
- ZONE 2
- ZONE 3
- ZONE 4
- ZONE 5
- ZONE 6

Legend:
- Upstream
- Tributaries
- WWTPs
2018-2019 Monitoring Program

**WWTPs**

- **Frequency**
  - Weekly for Tier 1 (Top 12)
  - Monthly for Tier 2 (Next 20)

- **Parameters**
  - COD, TOC, DOC, CBOD$_5$
  - Ammonia, Nitrite, Nitrate, TKN, SKN
  - TP, SRP
  - TSS, TDS or conductivity
  - In-situ DO, pH, and temperature

**Tributaries**

- **Frequency**
  - 2x/month (Delaware at Trenton, Schuylkill)
  - Monthly April-Nov at 25 other tribs

- **Parameters**
  - COD, TOC, POC, DOC, CBOD$_5$
  - Ammonia, Nitrate+Nitrite, TKN
  - TP, OrthoP, PIP
  - Chloride, Silica, Sulfate
  - Alkalinity, Chlorophyll-a
  - TSS, TS, TVS
Modeling Progress to Date

- Preliminary calibration of EFDC hydrodynamic model
  - Water surface elevation
  - Salinity
  - Water temperature
- Continued cross-checking of EFDC-WASP8 linkage
  - Flow rates
  - Salinity transport
  - Mass balance check in WASP8
- WASP8 test simulations
  - TN and TP with chemical-biological kinetics turned off
  - Oxygen consumption by NH4-N, CBOD, and SOD
Hydrodynamics Model Grid - Bathymetry

Model Grid and Bathymetry (Grid 5, Grid 1, and Grid 2) – Bathymetry (Based on FEMA 2011 DEM, Reflects 2016 dredging depth). Vertical datum is NAVD88.

- Grid 5, 1933 cells
  - KC = 5

- Grid 1, 2281 cells
  - KC = 10

- Grid 2, 2641 cells
  - KC = 20
Data for Hydrodynamics Model Calibration

Location of NOAA and USGS Stations

NOAA Stations
- Tide/Water Temperature, Conductivity

USGS Stations
- Water Temperature, Specific Conductance

(Data from Reedy Island, Chester, and Ben Franklin Bridge were used)
Calibration Results – Grid 5 (2017-2018): Water Surface Elevation

Reedy Point

Figure XX
Observed and Predicted Water Surface Elevation at NOAA REEYD POINT

Figure --
Comparison of Observed and Predicted Water Surface Elevation at NOAA REEYD POINT

Y = 0.9792 X - 0.0145
R² = 0.9767
N = 17056
RMSE = 0.0961
ubRMSE = 0.0947
Bias = -0.0166
Skill = 0.9939
Calibration Results – Grid 5: Salinity (2017-2018)

Reedy Island

Figure XX

Observed and Predicted Salinity at USGS REEZY ISLAND

Run ID: EFDC_FGD_GVC_MYDRO преприс. 1980-05. Fine grid GVC, KC=5, CTE=3.5, d1=15s. Salinity adjustment = 3.5 psu

Figure XX

Comparison of Observed and Predicted Salinity at USGS REEZY ISLAND during 01-01-2017 to 12-31-2018 period.

Run ID: EFDC_FGD_GVC_MYDRO преприс. 1980-05. Fine grid GVC, KC=5, CTE=3.5, d1=15s. Salinity adjustment = 3.5 psu.
Calibration Results – Grid 5: Water Temperature

Figure XX
Observed and Predicted Water Temperature at NOAA REEYD POINT
Station ID: RS11493, NOAA REEYD POINT
Run ID: ERCI-EDO_SWC_HRDG, Framework: PREPARE, Framework: PREPARE.
Station Adjustment 1.5 ft, NOAA NCEP-NCAR data were used.

2017-2018
Reedy Point
2012-2013
• Eutrophication Process
  • 5 phytoplankton classes
  • 3 Periphyton/Macroalgae (benthic algae)
  • Nutrient cycling – N, P, Si
  • 3 CBOD and dissolved oxygen
  • pH and alkalinity
  • Water Temperature
* Zero loads (except DO)
  * Re-aeration only
* Oxygen consumption by NH4-N
  * Point source loads only
  * Tributary loads only
Zero Loading (Except DO) with Re-aeration

Base case

Average Dissolved Oxygen Saturation during July - August 2012

Dissolved Oxygen

0 20 40 60 80 100 120 140

River Mile

Zone-6 Zone-5 Zone-4 Zone-3 Zone-2

Base Case
Oxygen Consumption by NH$_4$ from point source loads only

Average Dissolved Oxygen Saturation during July - August 2012

Dissolved Oxygen

River Mile

Zone-6
Zone-5
Zone-4
Zone-3
Zone-2

kn = 1.0/day
kn = 2.0/day
Oxygen Consumption by NH$_4$
from tributary loads only

Average Dissolved Oxygen Saturation during July - August 2012

Dissolved Oxygen:

River Mile
Path Forward

- Significant progress on model development and calibration since March, 2018
- Finalize calibration of EFDC hydrodynamic model
- Evaluate and resolve EFDC - WASP8 linkage issues
- Develop and refine remaining model inputs to WASP8
- Begin calibration of WASP8
- Implement Expert Panel recommendations to monitoring program