CONNECTING THE DOTS TO INNOVATION

CONOWINGO RESERVOIR MODELING STUDY OVERVIEW

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September 2025

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OVERVIEW

Background
- Objectives of the effort
- Team and Partnerships

Modeling approach
- Hydrodynamics
- Nutrient water quality
- Sediment transport

Model applications
- Dredging scenarios
- Extreme event scenarios

Project and reporting schedule

Questions

Conowingo Reservoir on the Susquehanna River

BACKGROUND

OBJECTIVES

1. Develop a non-proprietary, 3D water quality modeling system of Conowingo Reservoir for the purpose stated above. The modeling system should be capable of simulating hydrodynamics, biogeochemical, and sediment transport processes within CR. Modeling package output will be consistent with requirements of the CBP modeling suite.

2. Application of the modeling system to current and future dredging scenarios, specifically the evaluation of sediment and associated nutrient reductions from different dredging scenarios. It must leverage the additional CR sediment characterization work done and lessons learned through Maryland's innovative and beneficial reuse pilot.

3. Application of the modeling system to future hydrologic-climate scenarios. This information will help various Chesapeake Bay partnerships better understand and institutionalize the resiliency and response of CR to extreme weather events, flows, future climate change hydrology, and determine CR scour and sediment resuspension and associated nutrient/contaminant increases within the reservoir and transport downstream.

TEAM AND PARTNERSHIPS

Maryland Department of the Environment

Matt Rowe
Christina Lyerly

Cost Share

US Army Corps of Engineers

Baltimore District (NAB)
Planning Assistance to States Program
Karl Kerr – Program manager
Vanessa C. Campbell – Project manager

Chesapeake Bay Program
Science. Restoration. Partnership.

USEPA Chesapeake Bay Program Office
Lewis Linker - CBP Modeling Coordinator and SAIB Team Leader for Science and Analysis

Data Share

Conowingo Reservoir Model

Dredging scenarios

Extreme event scenarios

Data Share

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Dr. Jodi L. Ryder – Technical manager, Water Quality modeling
Dr. Earl J. Hayter – Technical lead, Hydraulic and Sediment modeling

SITE OVERVIEW

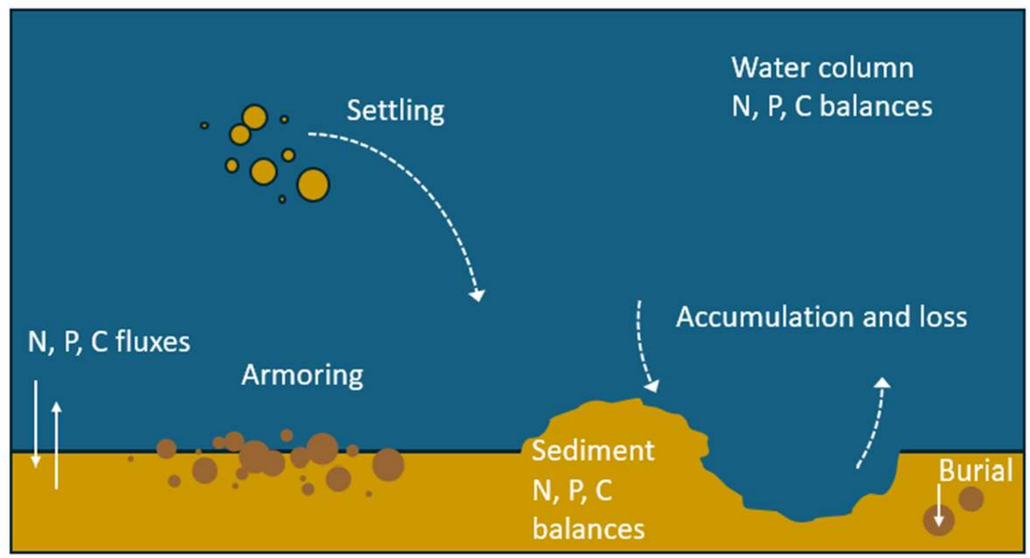
Conowingo Reservoir:
Lowest impoundment on the Susquehanna
94’ tall dam (owned by Constellation Corp.)
9,000 acre impoundment

Concern:
Increased risk of intense summer and winter season storms leading to increased risk of sediment and nutrient releases to Chesapeake Bay

Previous Models:
-proprietary
-lack of spatial sediment capability
-not integratable (as is) to CBP models

MODEL REQUIREMENTS

- Continuous simulation of the reservoir pool including selected hydrometeorological events; (1991-2000)
- Change in hydrodynamics from reservoir infill of sediments from the CR watershed, and removal of material through dredging
- Biogeochemistry in the reservoir pool, responding to the amount and speciation of nitrogen, phosphorus, and sediment inputs from upstream and bottom sediment
- Biogeochemical changes in sediments, including burial, species changes, and water column exchanges
- Physical changes in sediment characteristics due to erosion, bed armoring, and deposition of sediment and the resulting morphological changes in the reservoir
- Dredging of the reservoir.



MODELING APPROACH

MODELING APPROACH

Modeling approach

Hydrodynamics
Nutrient water quality
Sediment transport
Baseline calibration

Model Selection

Environmental Fluid Dynamics Code+ (EFDC+)
Based on EFDC (originally developed by John Hamrick @ VIMS)

- Refined by DSI, LLC
- Code is open source
- 3D hydrodynamics that uses a curvilinear (structured) grid
- Fully coupled hydrodynamics, sediments, water quality
- Custom installation on ERDC supercomputer (HPC) for rapid calibration and testing

MODELING APPROACH – DATA ACQUISITION

- Bathymetry in the model domain, i.e., the CR.

- Meteorological data time series
  - Wind speed and direction
  - Atmospheric pressure
  - Incident solar radiation
  - Air temperature (both wet and dry bulb)
  - Precipitation

- Hydrologic data time series for watershed
  - CBP provided Phase 6 → Phase 7
  - Constellation Energy for dam operations (Muddy Run)

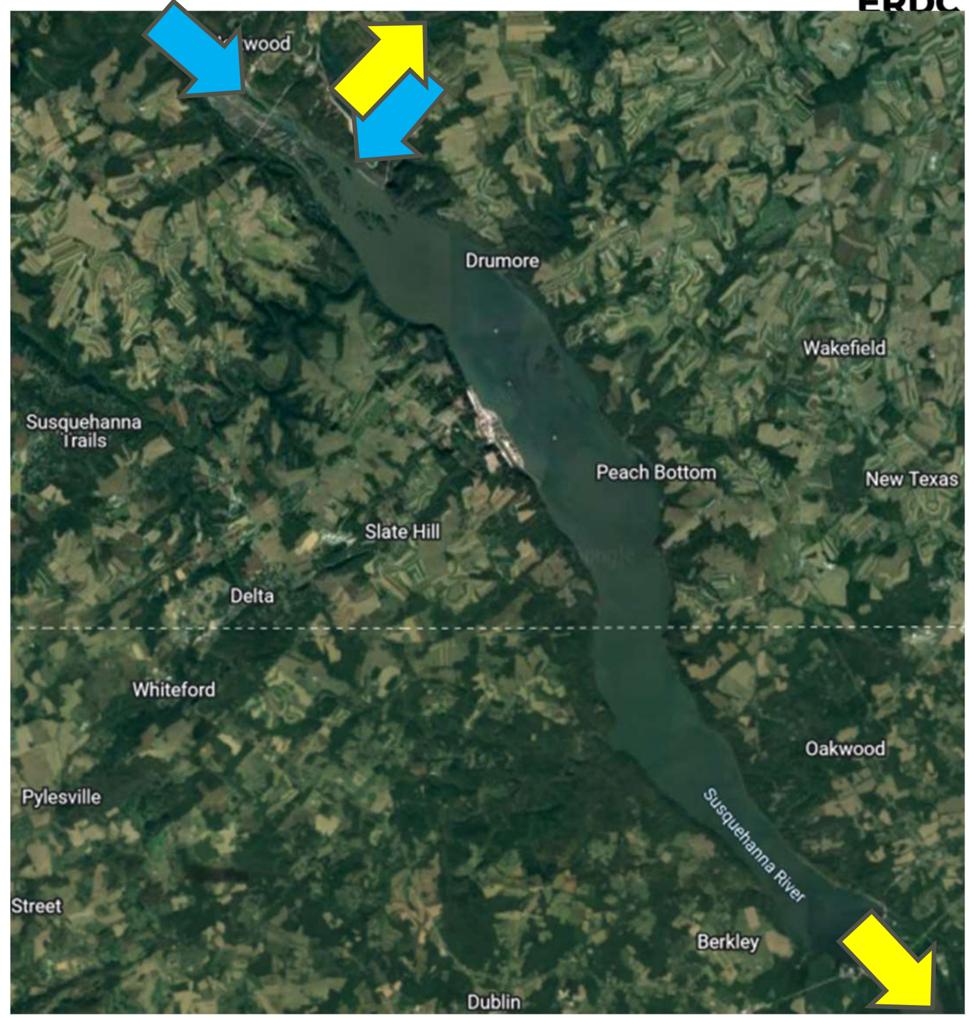
- Water quality in-situ –
  - Water temperature, DO, SOD, nitrogen, phosphorus, and other

- Sediment characterization –
  - MDE pilot study
  - Grain size distributions (including fractions of organic matter)
  - SEDFLUME erodibility tests

MODELING APPROACH - HYDRODYNAMICS

Major Inflows
-Holtwood Dam (Upstream)
-Muddy Run Power Reservoir
Operational boundary
-Watershed Direct runoff through tributaries
Initiate with Phase 6 HSPF
Upgrade to Phase 7

Major Outflows
-Muddy Run Power Reservoir
-Conowingo Dam (Downstream)
outlet grid constructed to mesh with --
CBP model



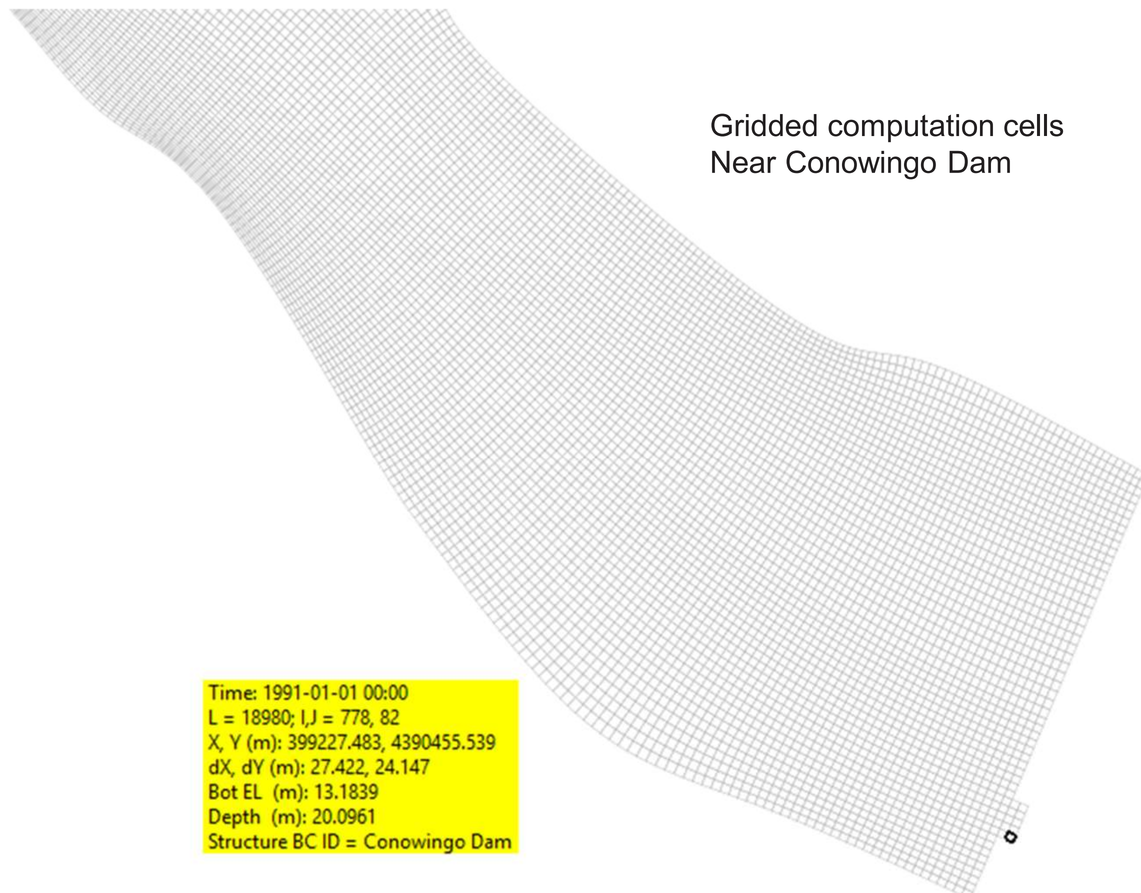
EFDC+ 3D MODEL

Fine grid version (exploration):

- 49,051 horizontal grid cells
- 10 vertical sigma layers in each grid cell

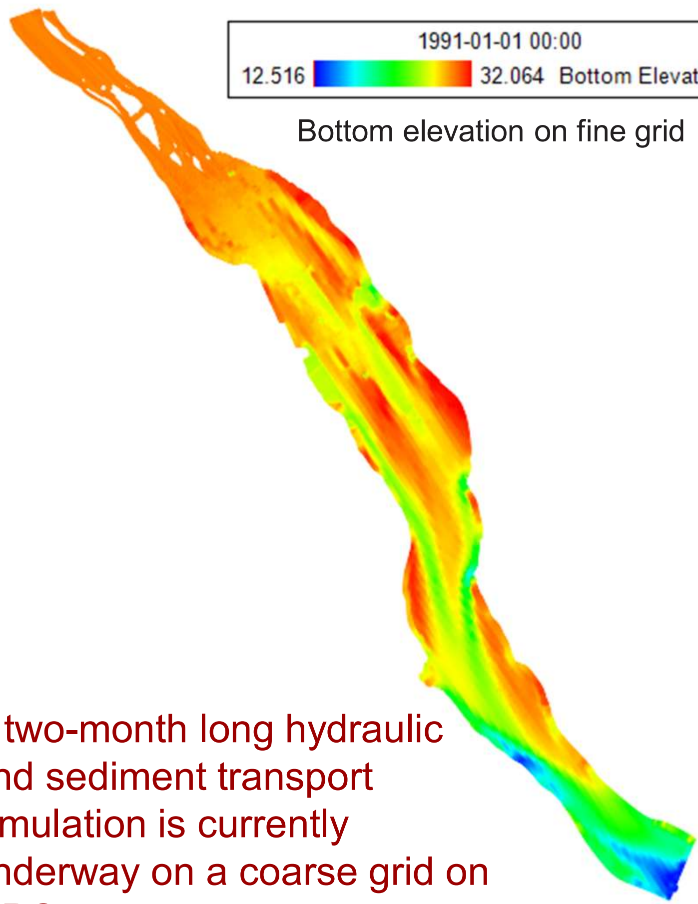
Coarse grid (production):

- 8649 horizontal grid cells
- 10 vertical sigma layers in each grid cell



Gridded computation cells
Near Conowingo Dam

COARSE GRID



Bottom elevation on fine grid

A two-month long hydraulic and sediment transport simulation is currently underway on a coarse grid on a PC

Final coarse grid

MODELING APPROACH – SEDIMENT TRANSPORT

- Model will represent the different bed layer sources as scour occurs during different limbs of the hydrograph

- Will simulate the different classes and composition of sediment as well what's eroded into the water column

- Use field observations to set up the sediment bed model vertical variation of the different components - with spatial variation in the vertical composition in different parts of the reservoir

Data development:

- Historical cores with chemical analysis

- Additional data collection for erosion rates with SEDFLUME
  - Facilitated through MDE
  - 30 sediment grabs
  - 4x5 gal buckets

Model runtime:
1 week for EFDC+
Model emulation may be used for linkage to Bay model

SEDIMENT SAMPLING

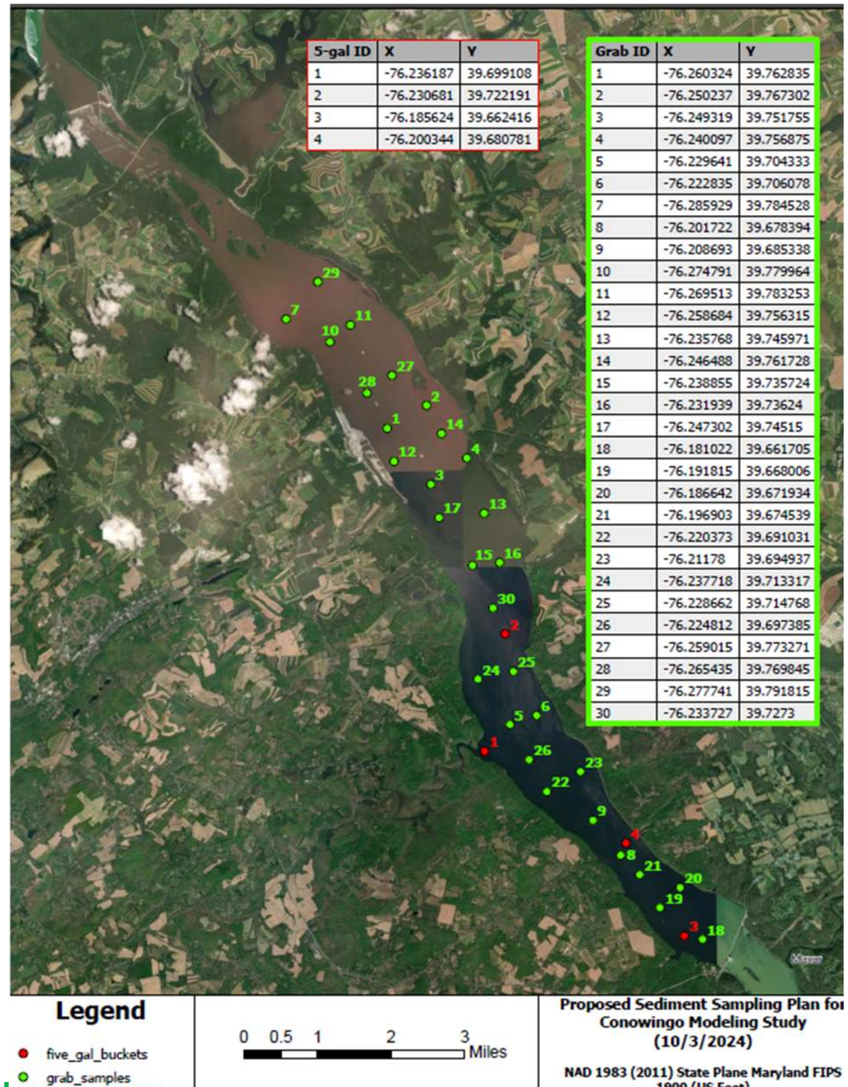
Sampling supports 2 needs:

SEDFLUME

- Ponar grab samples for grain size distribution (green)
- 4x 5GAL Buckets for SEDFLUME (red)
- Push core/gravity core (red)
- Sampling occurred on 6/27/25

BOD → sediment carbon fractionation

- Surficial Eckman dredge (red)
- Sampling occurred on 6/30/25



5-gal ID	X	Y
1	-76.236187	39.699108
2	-76.230681	39.722191
3	-76.185624	39.662416
4	-76.200344	39.680781

Grab ID	X	Y
1	-76.260324	39.762835
2	-76.250237	39.767302
3	-76.249319	39.751755
4	-76.240097	39.756875
5	-76.229641	39.704333
6	-76.222835	39.706078
7	-76.285929	39.784528
8	-76.201722	39.678394
9	-76.208693	39.685338
10	-76.274791	39.779964
11	-76.269513	39.783253
12	-76.258684	39.756315
13	-76.235768	39.745971
14	-76.246488	39.761728
15	-76.238855	39.735724
16	-76.231939	39.73624
17	-76.247302	39.74515
18	-76.181022	39.661705
19	-76.191815	39.668006
20	-76.186642	39.671934
21	-76.196903	39.674539
22	-76.220373	39.691031
23	-76.21178	39.694937
24	-76.237718	39.713317
25	-76.228662	39.714768
26	-76.224812	39.697385
27	-76.259015	39.773271
28	-76.265435	39.769845
29	-76.277741	39.791815
30	-76.233727	39.7273

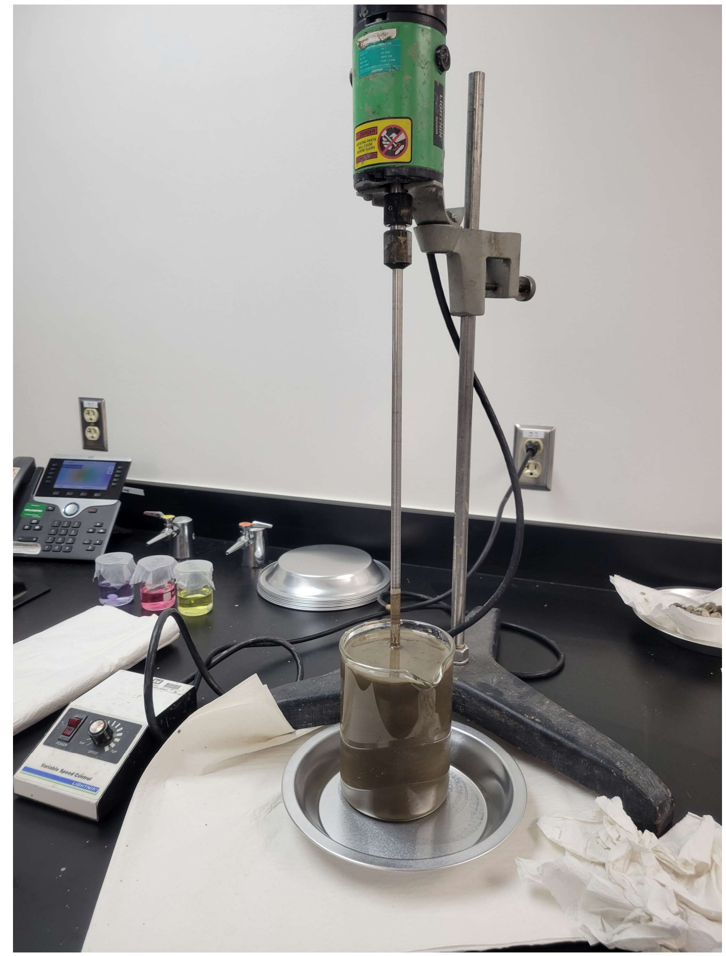
SEDIMENT CARBON ANALYSIS

Objective is to develop field derived G1, G2, and G3 Carbon fractions

Samples collected Jun 30th
Samples received July 3rd
Temp during transit (?)
Stored at ERDC @ 30-40^{o}F fridge

$CBOD_{90}$ trial in progress (Day 65 of 90)
G1~ Carbon fraction consumed after 5 days
G2 ~ Carbon fraction consumed after 90 days
G3 ~ Carbon fraction remaining after 90 days

SEDIMENT CARBON ANALYSIS



4 sites, replicate samples
3 dilutions of each with nitrification inhibition
Total carbon measurements at days 0, 5, 90, and potentially longer
Day 90 = October 7

Anticipating doing a repeat analysis from stored samples
-high oxygen consumption
-4 day power outage in lab

Preliminary model parameterization using fractionization from Palinkas, 2019:
G1; 26%
G2: 20%
G3: 54%

MODELING – NUTRIENT WATER QUALITY

Based in CE-QUAL-ICM kinetics

Unlimited algae and macrophyte groups
- Mostly defined through half-saturation and uptake rates
- Utilizes temperature effects on coefficients

Carbon treatment
- DOC
- Labile G1
- Refractory G2+G3

Key component for sediment impact on nutrient water quality

Processes
- Reaeration
- Benthic mass fluxes\sediment diagenesis
  - (DiToro kinetics)
  - can be spatially varying

Boundaries
- Point sources
- Wet/dry deposition

ID	Description
1	Refractory Particulate Organic Carbon
2	Labile Particulate Organic Carbon
3	Dissolved Organic Carbon
4	Refractory Particulate Organic Phosphorus
5	Labile Particulate Organic Phosphorus
6	Dissolved Organic Phosphorus
7	Total Phosphate
8	Refractory Particulate Organic Nitrogen
9	Labile Particulate Organic Nitrogen
10	Dissolved Organic Nitrogen
11	Ammonia Nitrogen
12	Nitrate Nitrogen
13	Particulate Biogenic Silica
14	Dissolved Available Silica
15	Chemical Oxygen Demand
16	Dissolved Oxygen
17	Total Active Metal
18	Fecal Coliform
19	Carbon Dioxide
20	Cyanobacteria
21	Diatoms
22	Green Algae
23	Macrophytes
24	MesoZooplankton

MODEL APPLICATIONS

APPLICATIONS – DREDGING SCENARIOS

- Continuous simulation period (of 1991-2000)

Dredging 1 & 2: Different dredging scenarios in different locations in the CR to determine associated nutrients reduction within the CR and transported to Chesapeake Bay

Infill 1& 2: Different infill scenarios based on availably of bathymetry (e.g., 1995 and 2010 conditions or other years depending on data availability).

Reduced loading: A scenario that simulates watershed BMPs and in-reservoir dredging to reduce sediment loading from CR to Chesapeake Bay.

APPLICATIONS – EXTREME EVENT SCENARIOS

Scenario selection Q1 FY25

Initial loads:
Based on 1991-2000 hindcast

Critical period:
1993-1995

Scenario characteristics:
-Two back-to-back extreme storms (probably in excess of 400,000 cfs) during the warm season (April-September) in close succession
-Model after Tropical Storm Lee

Description	FY25				FY26			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
DEVELOPMENT AND SIMULATION OF EXTREME EVENT SCENARIOS				X	X	X	X	

TIMELINES

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PROJECT AND REPORTING SCHEDULE

ERDC

Description	FY25				FY26				FY27			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
DATA ACQUISISTION	X											
DEVELOPMENT OF CRMS												
Hydrodynamics	X	X										
Nutrient Water Quality		X	X	X	X							
Sediment Transport		X	X	X	X							
DEVELOPMENT AND SIMULATION OF DREDGING SCENARIOS												
dredging 1				X	X	X	X					
dredging 2				X	X	X	X					
Infill 1				X	X	X	X					
Infill 2				X	X	X	X					
Reduce sediment loading to ChesBay				X	X	X	X					
DEVELOPMENT AND SIMULATION OF EXTREME EVENT SCENARIOS				X	X	X	X					

CBP phase 7 → moving to right

Next ERDC milestones:

-Installation of EFDC+ on HPC (Sept. 2025)

-Initial parameterization of Water Quality Model (December 2025)

CONNECT WITH US

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