CONNECTING THE DOTS TO INNOVATION

CONOWINGO RESERVOIR MODELING STUDY UPDATE

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OVERVIEW

Background
- Objectives of the effort
- Team and Partnerships

Modeling approach
- Hydrodynamics
- Nutrient water quality
- Sediment transport

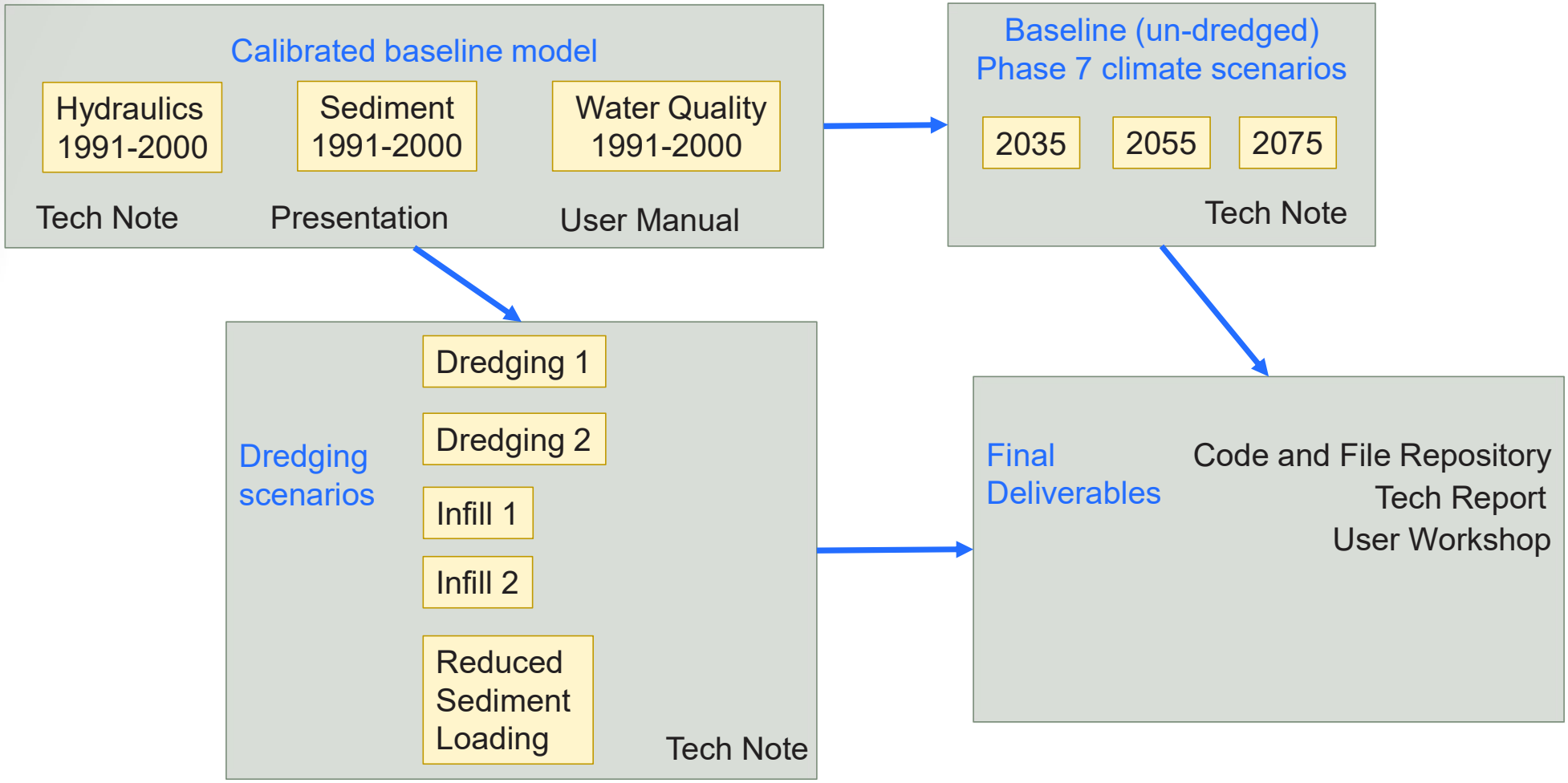
Model applications
- Dredging scenarios
- Extreme event scenarios

Project and reporting schedule

Questions

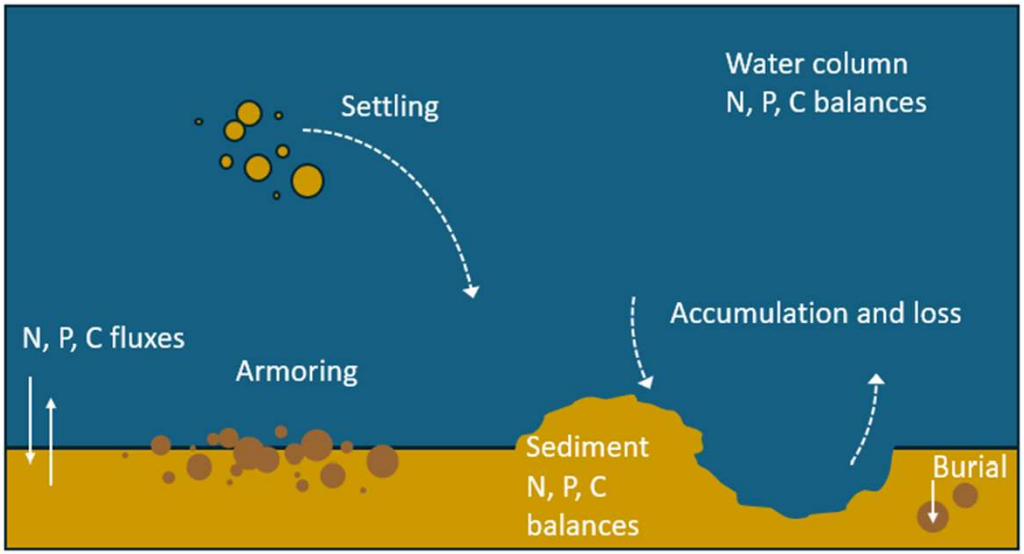
Regional View of Conowingo Reservoir

Potential Scenario plan

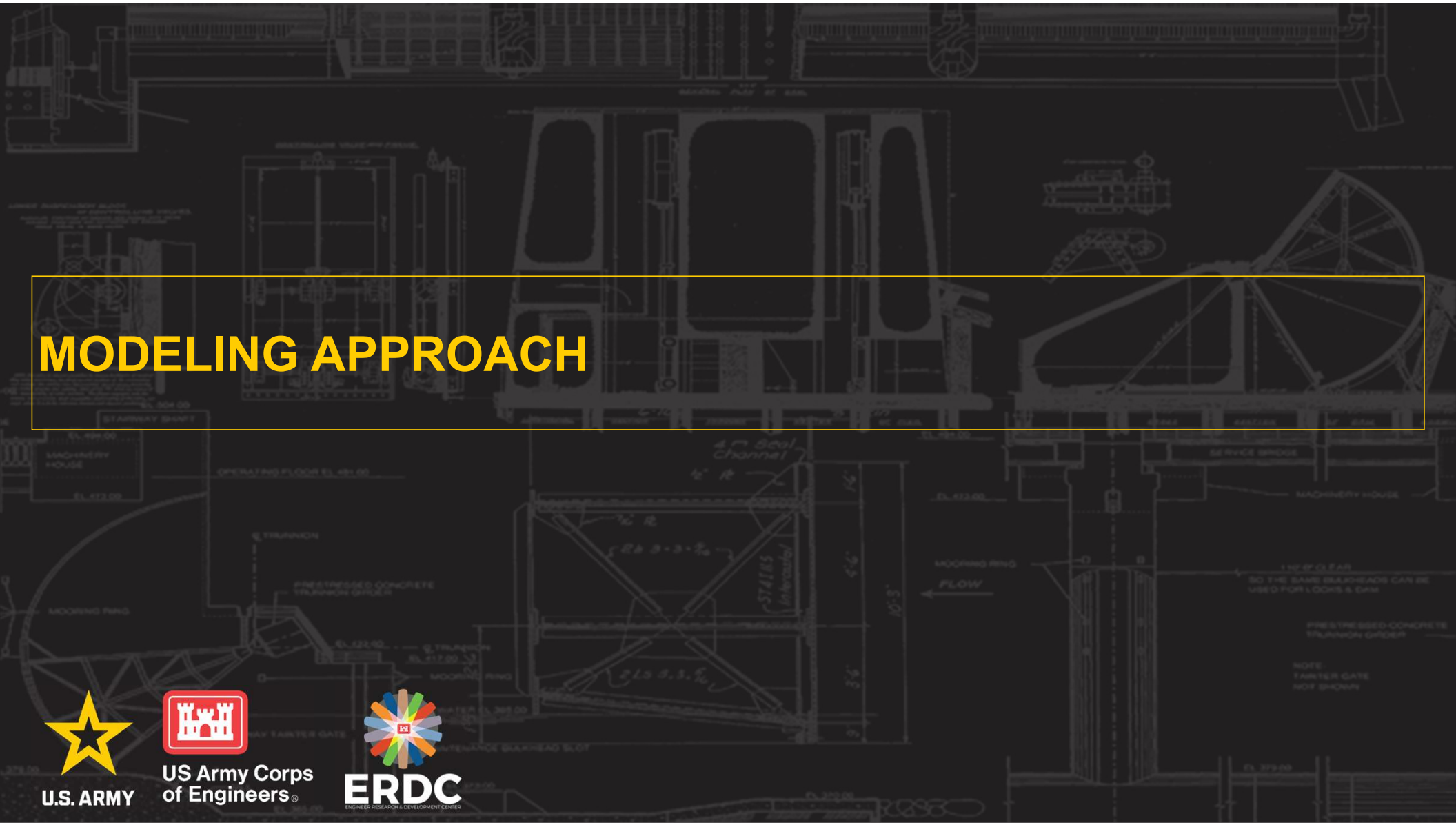


MODEL REQUIREMENTS

- 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



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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 will provide Phase 6 → Phase 7
  - Constellation Energy for dam operations (Muddy Run)

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

- Sediment characteristics
  - grain size distributions (including percentage of organic matter)
  - historical cores and new collection for performing SEDFLUME erodibility tests

Description	FY25			
	Q1	Q2	Q3	Q4
DATA ACQUISISTION	X			

MODELING APPROACH

Modeling approach

Hydrodynamics
Nutrient water quality
Sediment transport
Baseline calibration

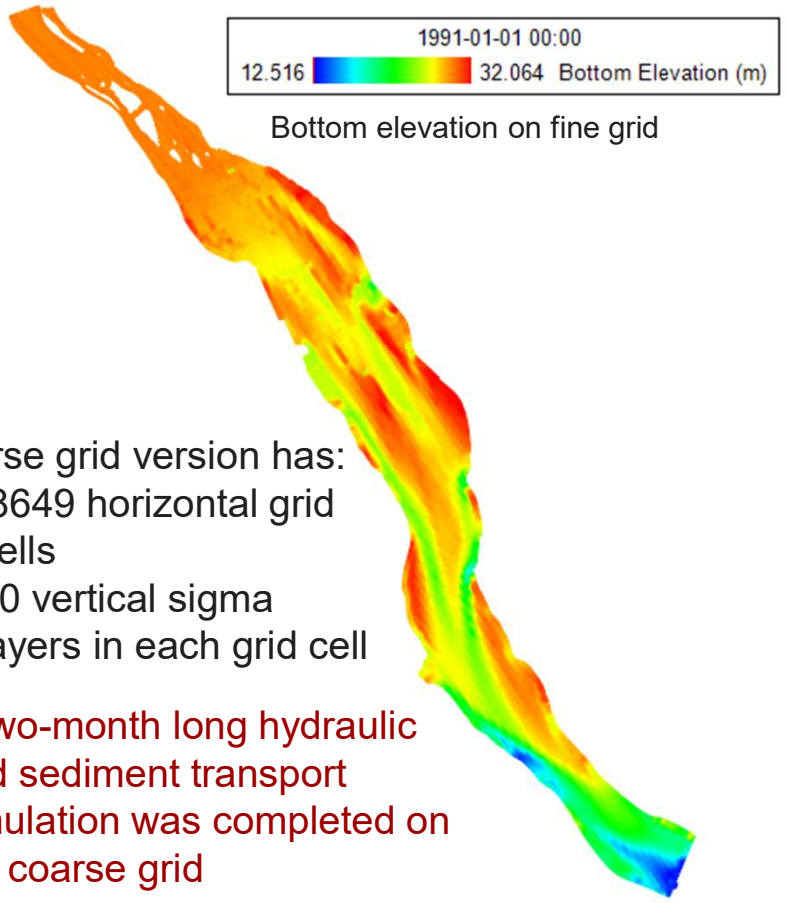
Model Selection

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

Description	FY25			
	Q1	Q2	Q3	Q4
DEVELOPMENT OF CRMS				
Hydrodynamics	X	X		
Nutrient Water Quality		X	X	X
Sediment Transport		X	X	X

COARSE GRID



Bottom elevation on fine grid

Coarse grid version has:

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

A two-month long hydraulic and sediment transport simulation was completed on the coarse grid

Final coarse grid

MODELING APPROACH

EFDC+ and Model Runtime Considerations

Initial grid ~ 490,000 cells
Coarse grid ~ 86,490 cells

During WQ and sediment simulations runtimes on a PC could be prohibitive for efficient calibration.

Custom installation of EFDC+ on two DoD High Performance Computing (HPC) systems completed September 2025.

HPC Installation validation underway

- Comparison of the two-month long sediment transport simulation run on a Windows workstation and HPC shows significant differences in calculated changes to the sediment bed between the two runs in some grid cells.
- The comparison was performed as part of the QA/QC performed on the HPC installation.
- The differences are believed to be caused by different versions of the Fortran compiler as well as the other libraries utilized by EFDC+.
- Earl should have this analysis completed and corrections made (if necessary) in about one week.

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

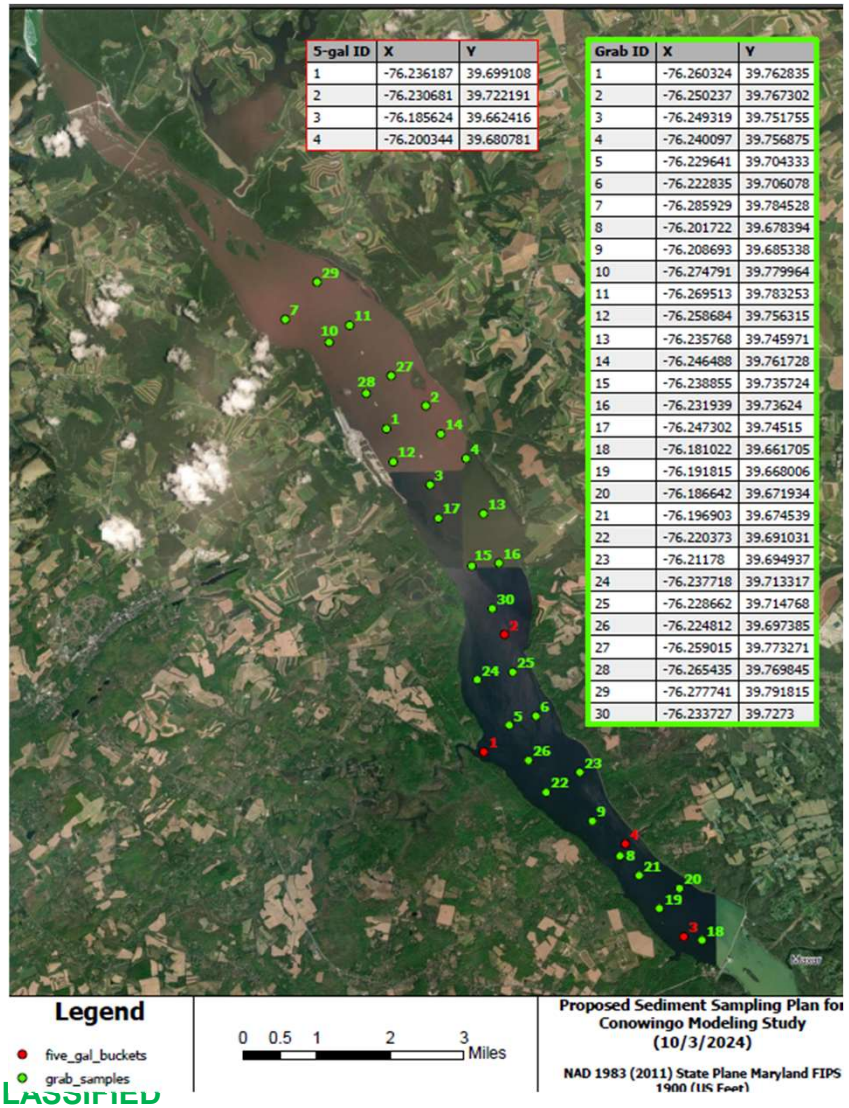
Sampling supports 2 needs:

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



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

SEDIMENT CARBON ANALYSIS

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

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

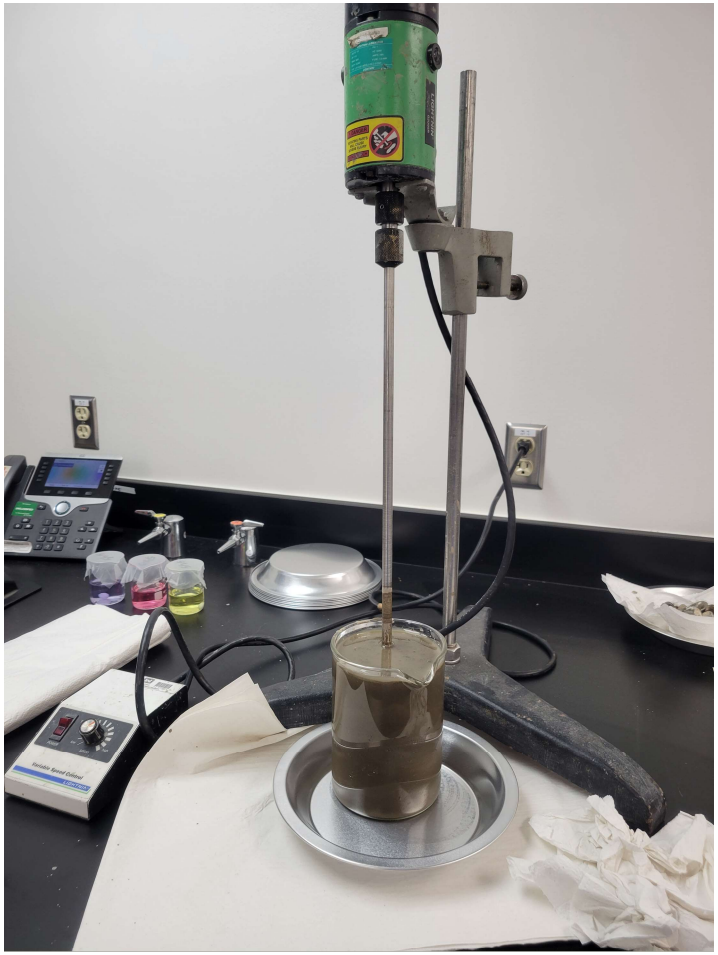
CBOD trial in progress (~Day 94 of 90)

Will be used to:
-select dilutions that satisfy the minimum DO and DO difference requirements.
-determine if nutrient seed is needed for longer term samples.

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

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

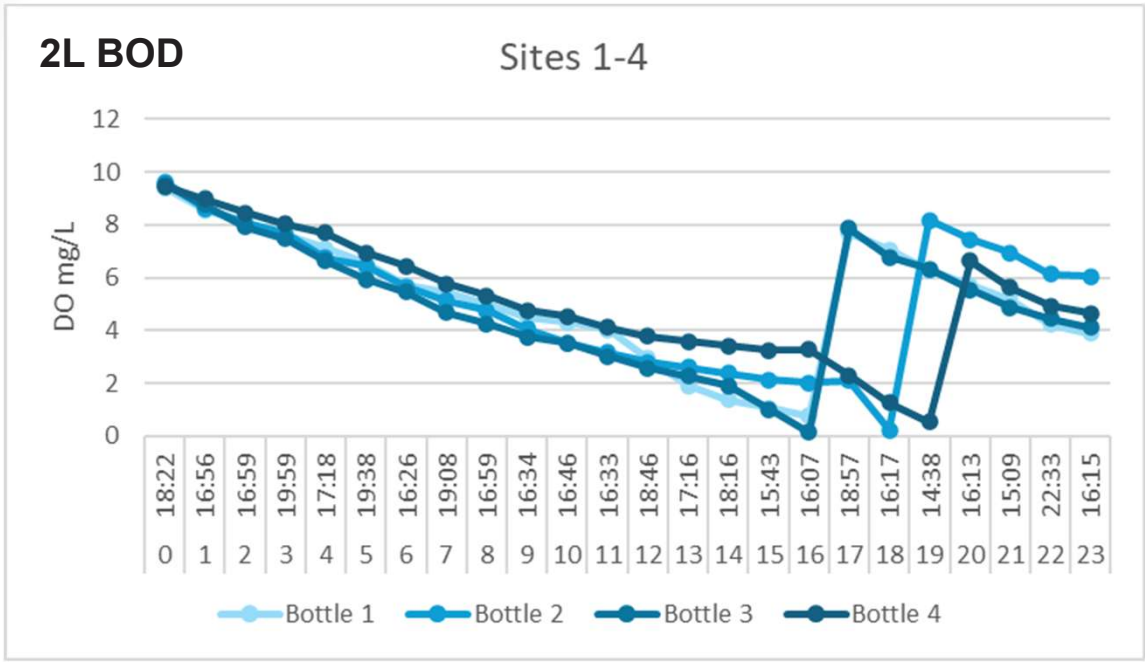


SEDIMENT CARBON ANALYSIS

Running standard 300 mL and 2L BOD bottles + 500mL

Reoxygenation was needed for all

Run repeat 2L at lower initial sample volumes



MODEL LINKAGE WATER QUALITY

Table 1. Linkage of constituents simulated in HSPF to the constituents simulated in EFDC+

	EFDC+ Input	Units	Conversion factor / Equation	HSPF Output1	HSPF Output Description	Units
1	Flow	m3/s	1	HYDR:RO or HYDR:O	Total Outflow or Outflow from a Reach	m3/s
2	Water temperature	Â°C	1	HTRCH:TW	Water Temperature	Â°C
3	Inorganic cohesive solids	mg/l	1	SEDTRN:SSED:2, SEDTRN:SSED:3	Silt Concentration, Clay Concentration	mg/l
4	Inorganic non-cohesive solids		1	SEDTRN:SSED:1	Sand concentration	mg/l
5	Algae concentration for each group	g Carbon /ml	(C/Chl)2 * fraction of the algae group	PLANK:PHYTO	Phytoplankton as Chlorophyll *a*	Âµg/l
6	Refractory Particulate Organic Carbon	mg/l	(CBOD3/(CVBO4/CDW5)+ORC6)*F_R7	OXRX:BOD and PLANK:PKST3:3	CBOD concentration, dead refractory carbon concentration	mg/l
7	Labile Particulate Organic Carbon	mg/l	(CBOD/(CVBO/CDW) + ORC)* F_L8			mg/l
8	Dissolved Organic Carbon	mg/l	(CBOD/(CVBO/CDW) + ORC)* F_D9			mg/l
9	Refractory Particulate Organic Phosphorus	mg/l	(CBOD/(CVBO/CDW) *P/C10 + ORP11)* F_R	OXRX:BOD and PLANK:PKST3:2	CBOD, dead refractory phosphorus	mg/l
10	Labile Particulate Organic Phosphorus	mg/l	(CBOD/(CVBO/CDW) *P/C + ORP)* F_L			mg/l
11	Dissolved Organic Phosphorus	mg/l	(CBOD/(CVBO/CDW)*P/C + ORP)* F_D			mg/l
12	Total Phosphate	mg/l	1	NUTRX:DNUST:4	Orthophosphorus as phosphorus	mg/l
13	Refractory Particulate Organic Nitrogen	mg/l	(CBOD/(CVBO/CDW)*N/C12 + ORN13)* F_R	OXRX:BOD and PLANK:PKST3:1	CBOD, dead refractory nitrogen	mg/l
14	Labile Particulate Organic Nitrogen	mg/l	(CBOD/(CVBO/CDW)*N/C + ORN)* F_L			mg/l
15	Dissolved Organic Nitrogen	mg/l	(CBOD/(CVBO/CDW)*N/C + ORN)* F_D			mg/l
16	Ammonia as Nitrogen	mg/l	1	NUTRX:DNUST:2	Total ammonia as nitrogen	mg/l
17	Nitrate as Nitrogen	mg/l	1	NUTRX:DNUST:1 and NUTRX:DNUST:3	Nitrate as nitrogen, nitrite as nitrogen	mg/l
18	COD	mg/l	n/a	NA		mg/l
19	DO	mg/l	1	OXRX:DOX	Dissolved oxygen	mg/l

From: https://eemodelingsystem.com/efdc-insider-blog/coupling-hspf-water-quality-model-with-efdc

MODEL APPLICATIONS

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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.

Description	FY25				FY26			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
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	

APPLICATIONS – EXTREME EVENT SCENARIOS

Scenario selection Q1 FY25

Initial loads:

Based on 1991-2000 hindcast

Critical period:

1993-1995

Big melt 1996

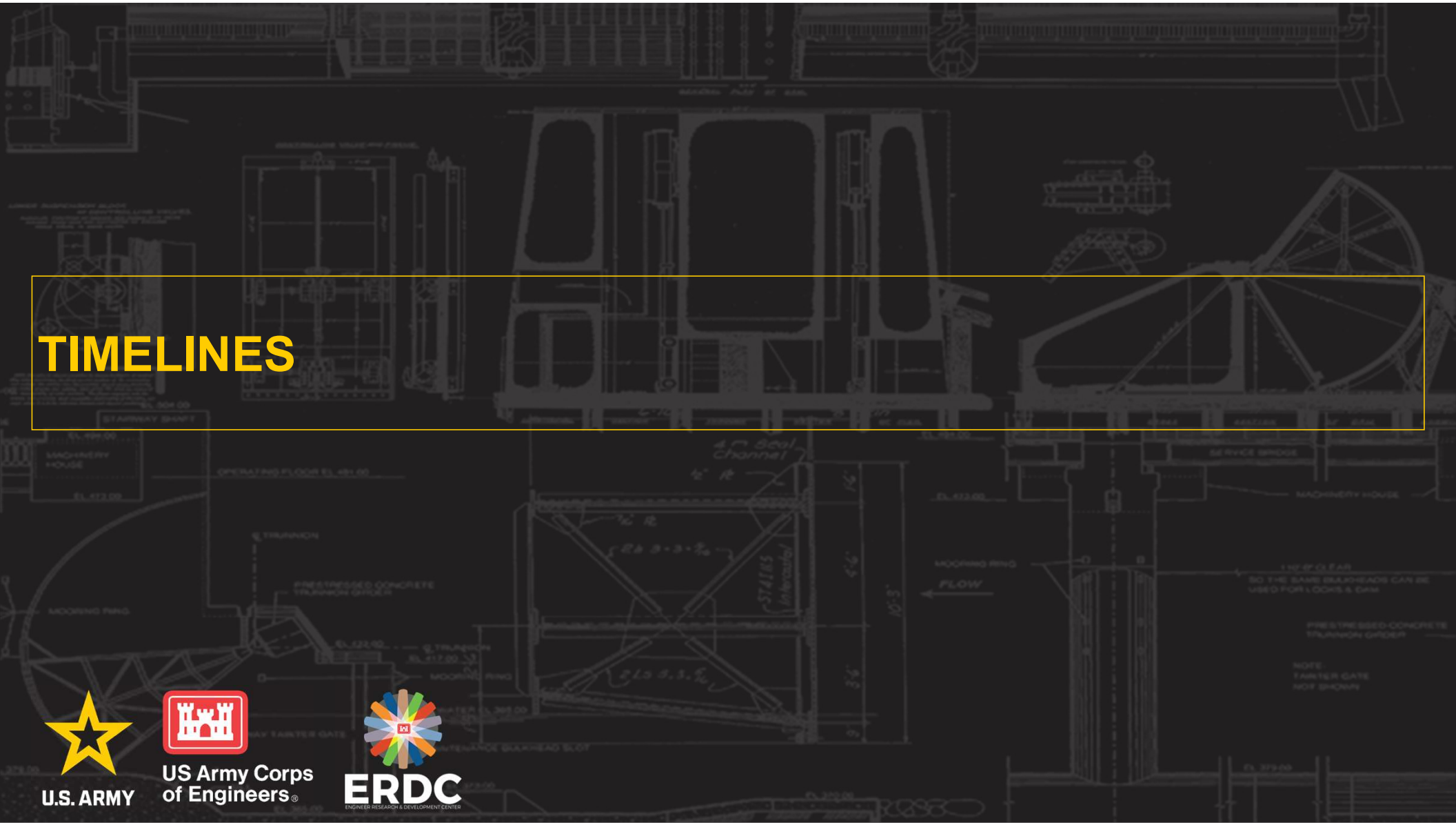
Scenario characteristics:

Two back-to-back extreme storms (probably in excess of 400,000 cfs) during the warm season (April-September) in close succession

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

Now: Potentially revising timeline plan to use Phase 7 climate inputs

TIMELINES



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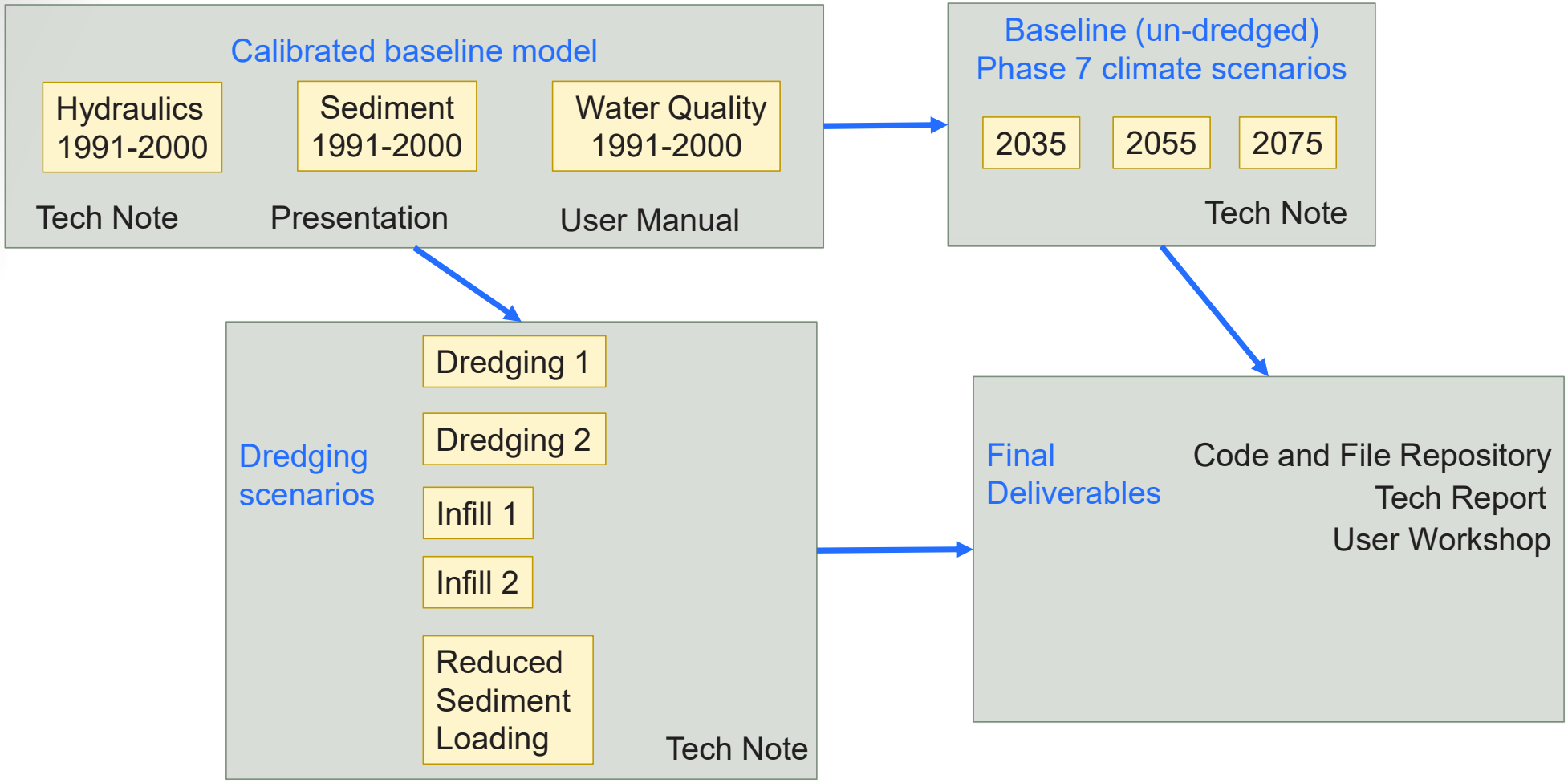
Potential Scenario plan



CURRENT PROJECT AND REPORTING SCHEDULE

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

Recent ERDC milestones:

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

-1st run CBOD reached 90 days – Quantization begins

Next ERDC milestone:

-Initial parameterization of Water Quality Model (December 2025)

CONNECT WITH US

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