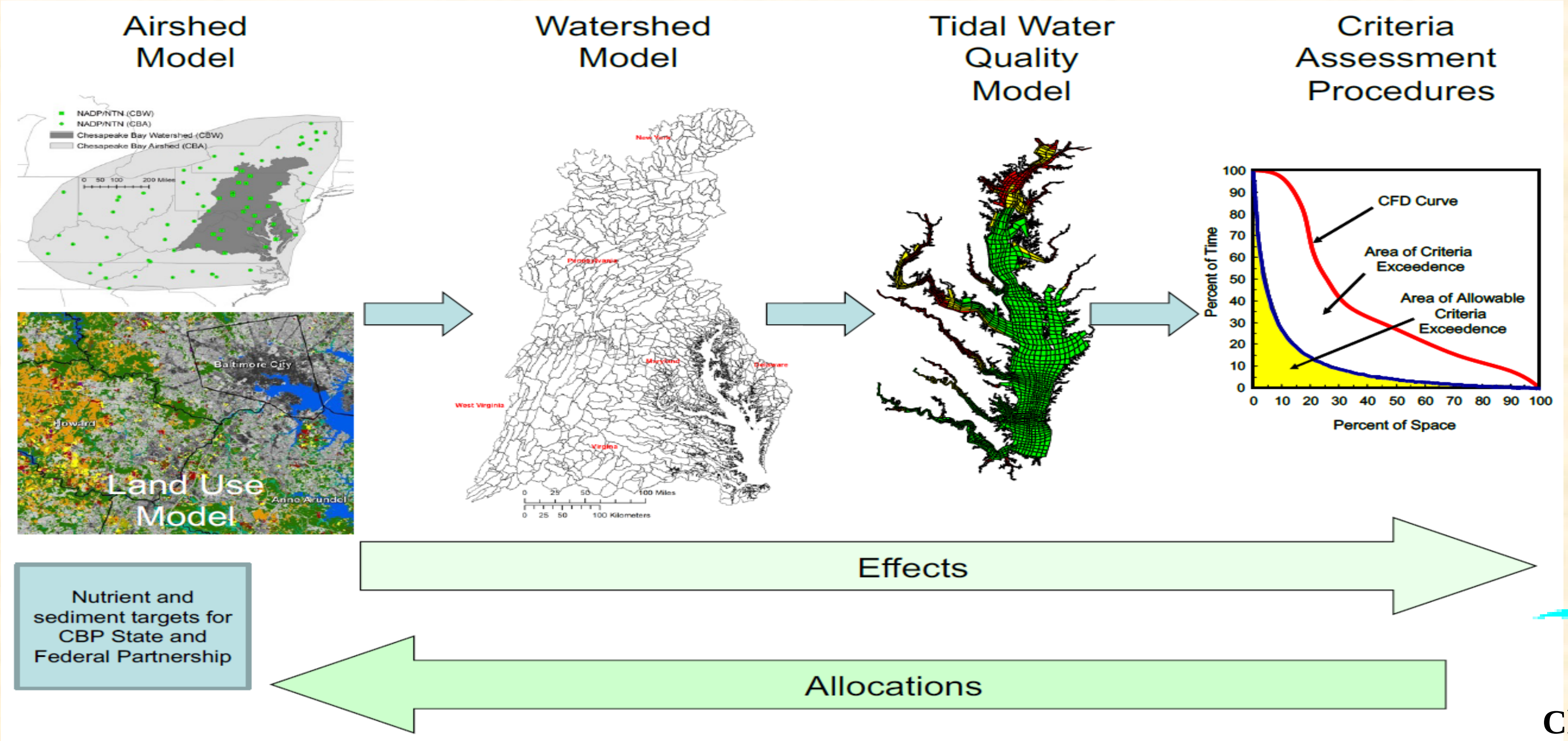
Estimating CSO Loads in the CBP Watershed Model

CSO Small Group Meeting
July 30, 2025

Lew Linker (EPA-CBPO) and CBP Modeling Team
linker.lewis@epa.gov



Chesapeake Bay Program
Science, Restoration, Partnership

Chesapeake Bay Program

Science, Restoration, Partnership

What We'll Cover

- What was run for CSO loads in the Phase 5 and Phase 6 versions of the WSM?
- If States have separated or are using large underground storage systems and WWTP treatment, between 2010 and the current period, will that be accounted for in the Phase 7 Model?
- Can future CSO conditions be accommodated in the Phase 7 Model?

Chesapeake Bay Program
Science, Restoration, Partnership

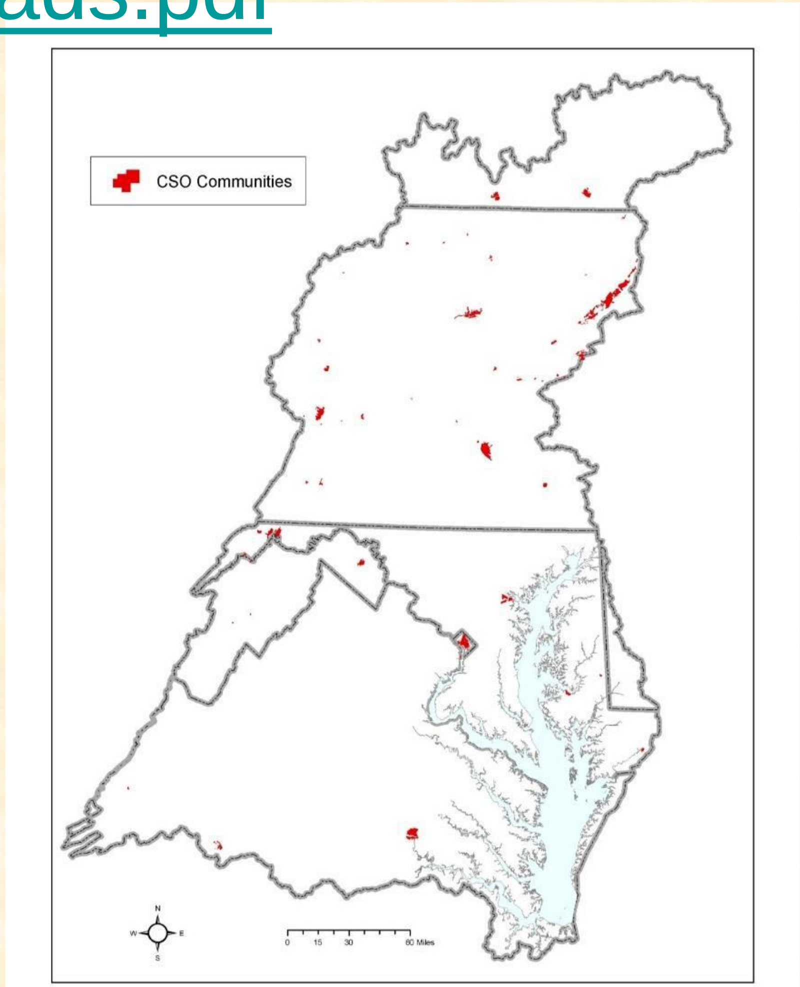
What was run for CSO loads in the Phase 5 and Phase 6 versions of the WSM?

Phase 6 documentation of CSO methods and loads can be found here in Section 8.5: [8 Direct Loads.pdf]

The Chesapeake watershed has 64 communities with combined sewer systems (Figure 8-17).

Initial CSO work was performed by TetraTech for the Phase 5 CBWM. This work is preserved in Phase 6 and automated by CBPO staff for scenarios and extensions of the simulation period.

For four of the largest CSO communities in the watershed — Alexandria, Lynchburg Richmond, Virginia; and the District of Columbia — The CBP relied heavily on readily available and relatively detailed Long-Term Control Plans (LTCPs) to characterize overflows. In addition, TetraTech ran simulations of existing sewer models for those communities to support developing overflow and water quality estimates.



What was run for CSO loads in the Phase 5 and Phase 6 versions of the WSM?

Chesapeake Bay Program
Science, Restoration, Partnership

Event Mean Concentrations were available for the four largest CSO municipalities.

Table 8-10. CSO water quality constituent EMCs developed by DCWASA (2002)

	EMCs (mg/L)					
Water quality constituent	**CSO 10**	**CSO 021**	**CSO 12**	**CSO 19 (location 1)**	**CSO 19 (location 2)**	**Outfall 001 (CSO bypass)**
TKN	6	3.8	4	4	2.4	17
NH_3-N	2.9	0.96	0.66	0.69	0.46	8.7
NO_3+NO_2-N	0.6	0.85	0.81	0.79	0.78	0.7
TP	1.31	1	0.98	0.85	0.83	2.4
DIP (PO_4)	0.37	1.04	0.11	0.23	0.15	0.8
TSS	147	130	186	96	182	130.1

Note: CSO 19 was monitored at two locations.

Member	**TN**	**NH_3-N**	**NO_2-N + NO_3-N**	**PO_4-P**	**TP**	**TSS**
Alexandria CSO	5.88	1.53	0.79	0.16 [b]	0.78	70.5
Richmond CSOs (Virginia Tributary Strategy)	8	1.4	1.1	0.2	1	130
Lynchburg[c] (Virginia Tributary Strategy)	8	1.4	1.1	0.2	1	130

Chesapeake Bay Program
Science, Restoration, Partnership

What was run for CSO loads in the Phase 5 and Phase 6 versions of the WSM?

"The remaining 60 communities with Combined Sewers were assessed using an average concentration and a relationship between rainfall (using a Theissen polygon method) and overflow depth derived from the available data. Thirty-two of the 60 communities submitted data in one form or another, e.g., hard copy data, ESRI shapefiles, PDF files, JPEG files, or KML files. Twenty-eight facilities did not respond to the request for data."

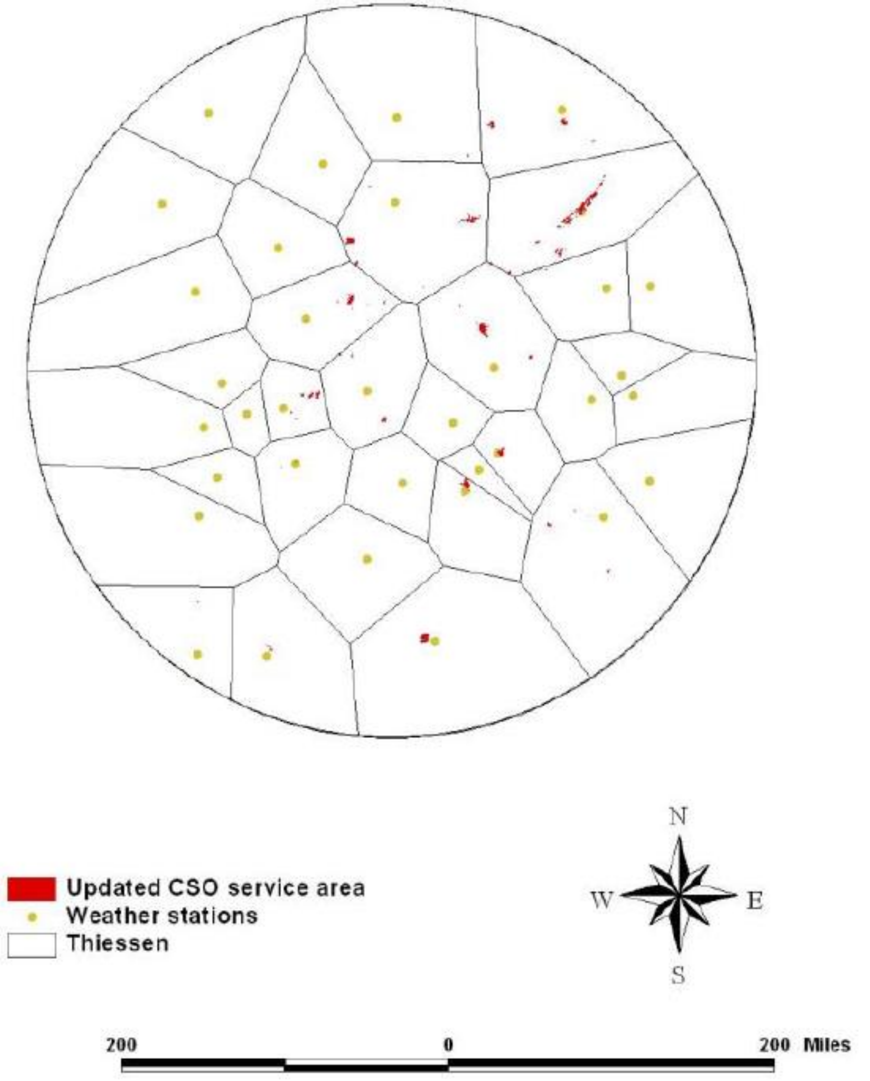


Figure 8-19: Theissen polygon method applied to daily rainfall stations

If States have separated or are using large underground storage systems and WWTP treatment, between 2010 and the current period, will that be accounted for in the Phase 7 Model?

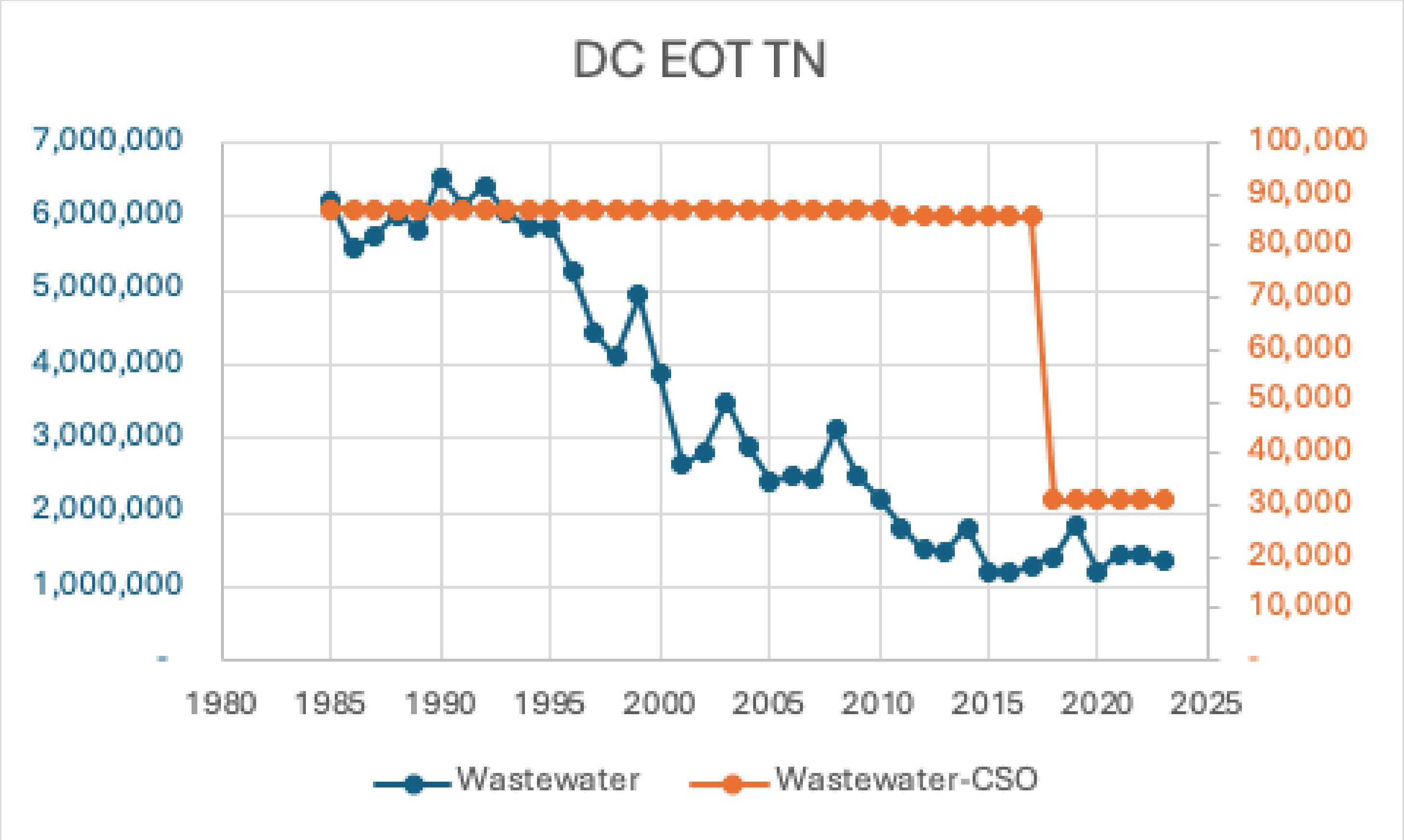
Chesapeake Bay Program
Science, Restoration, Partnership

- We have 1985 to 2014 daily flow and load CSO estimates from either a modeled outcome (Tetra Tech Model) or from state provided data. We are not proposing a major change to the base condition or method.
- The 1991-2000 daily estimated CSO loads and flow were used as the basis for all Phase 6 and this will be applied to the Phase 7 scenarios as well.
- For future scenarios, e.g., 2025 or 2035, the CSO loads and flows for the Phase 7 land-river segments can be reduced consistent with the implementation of CSO controls.

If States have separated or are using large underground storage systems and WWTP treatment, between 2010 and the current period, will that be accounted for in the Phase 7 Model?

Chesapeake Bay Program
Science, Restoration, Partnership

An example here is DC controls of CSO loads that were implemented in 2018 and reduced their CSO TN loads by two thirds.



Chesapeake Bay Program

Science, Restoration, Partnership

Can future CSO conditions be accommodated in the Phase 7 Model?

Method of climate change influence on CSOs

Changes in CSO volumes were obtained by first estimating the expected changes in rainfall volume and intensity under the 2025, 2035, 2045, and 2055 climate scenarios and then using an empirical regression between observed rainfall and daily CSO volumes (CBPO, 2020). After generating new time series (1991–2000) of daily precipitation events for each CSO service area and for each climate change scenario, an empirical regression between CSO volume and rainfall was applied to obtain projected daily CSO volumes under each climate change scenario. Loads of constituents were calculated by multiplying CSO volumes by event mean concentrations derived from observations or literature as described in section 8.5 of the Phase 6 Watershed Model documentation (CBPO, 2020).

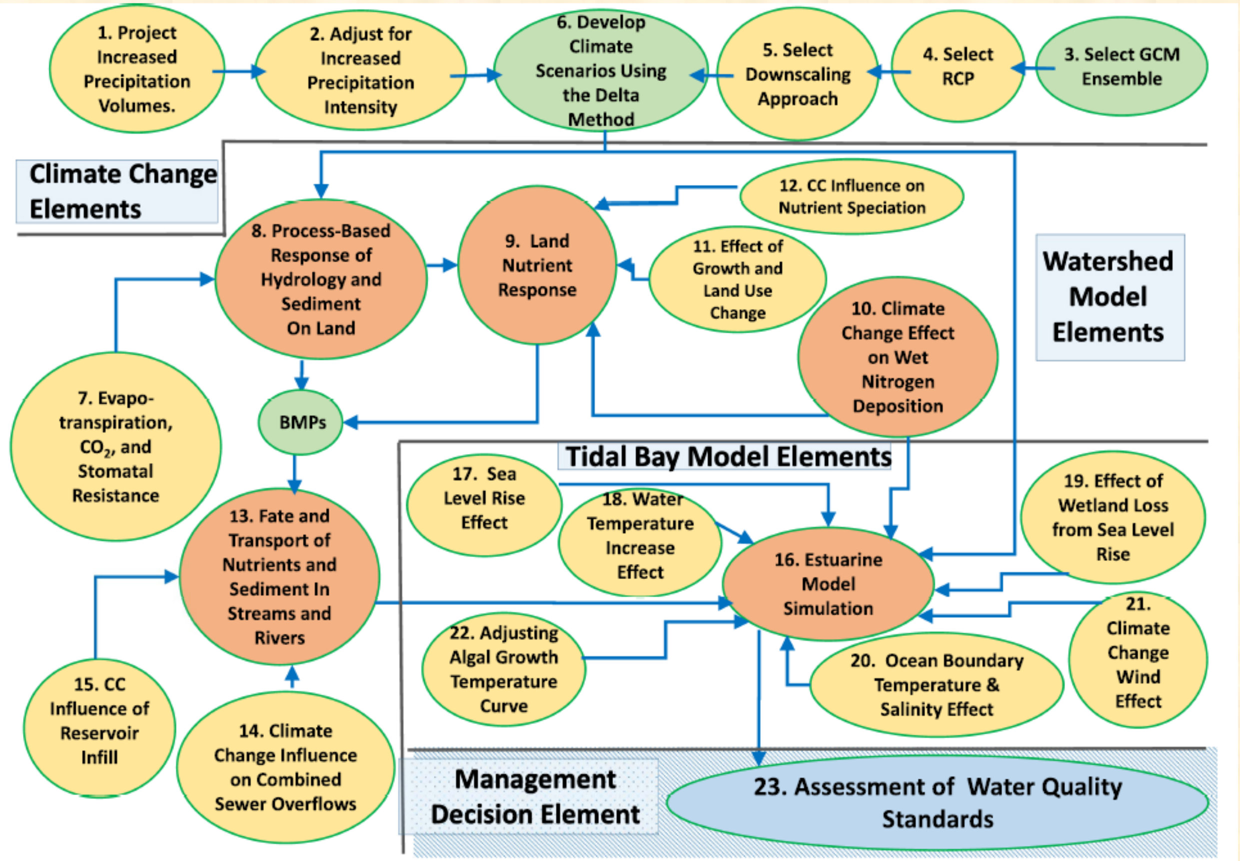


FIGURE 3 Flow chart of model tasks and decisions for a comprehensive assessment of climate change influence on Chesapeake Bay water quality. Green, data set: orange, model component; yellow, project task or decision; and blue, management endpoints.

Source: Linker, L.C., Shenk, G.W., Bhatt, G., Tian, R., Cerco, C.F. and Bertani, I., 2024. Simulating climate change in a coastal watershed with an integrated suite of airshed, watershed, and estuary models. JAWRA Journal of the American Water Resources Association, 60(2), pp.499-528.

Can future CSO conditions be accommodated in the Phase 7 Model?

Results of climate change influence on CSO loads

Increased CSO volumes due to increased precipitation volume and intensity exhibited only a minor influence on nutrient loads. The 2025 climate change influence on CSO nutrient loads was an estimated 5000 kg of nitrogen and 650 kg of phosphorus, which is 0.005% and 0.011%, respectively, of the total Phase 3 WIP loads (Phase 3 WIP target load not to exceed 91.4 million kg nitrogen and 6.4 million kg phosphorus delivered to the tidal Bay). The two cities in the Chesapeake watershed with the largest CSO loads subject to increases due to climate change are the District of Columbia and Richmond, Virginia. As a point of comparison total watershed estimated TN EoS loads were 2.3 M lbs in the 1991-2000 base period and are 1.6 M lbs currently.

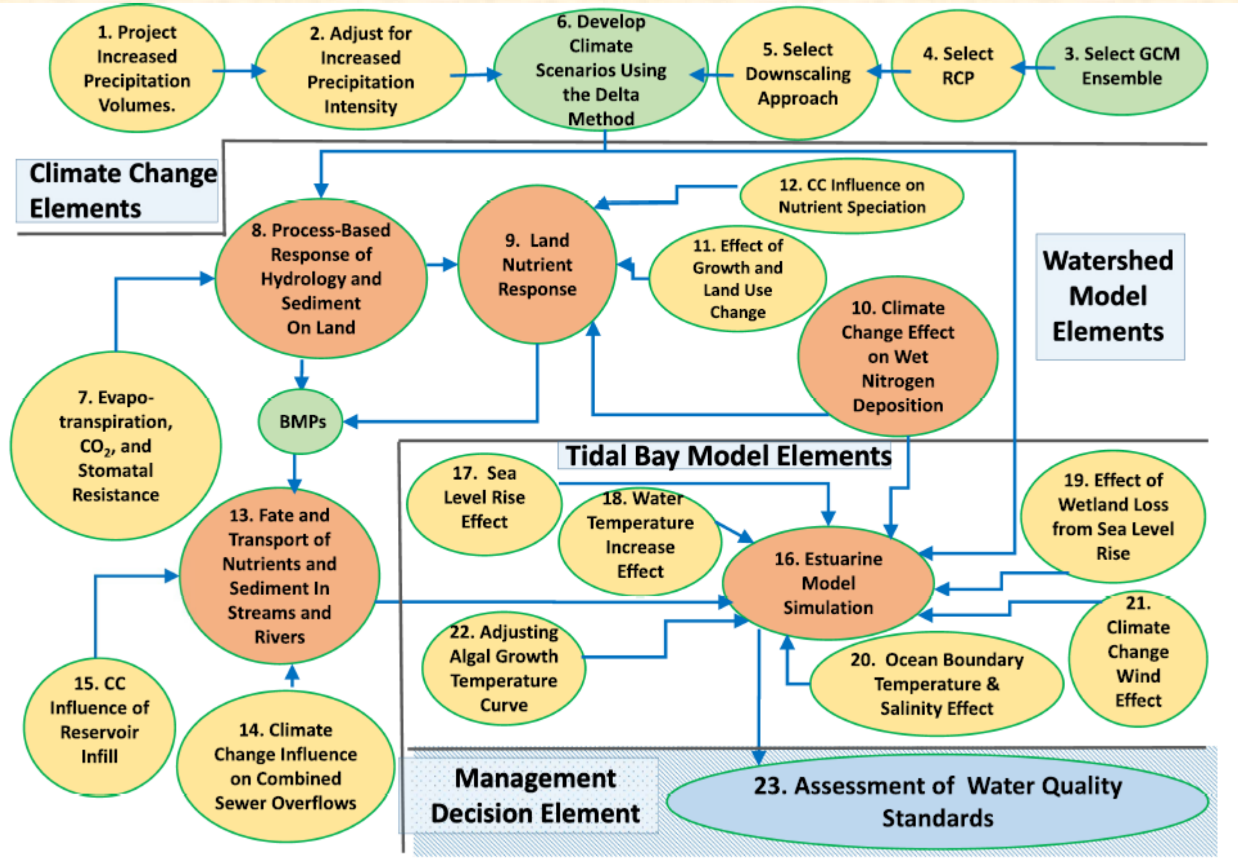


FIGURE 3 Flow chart of model tasks and decisions for a comprehensive assessment of climate change influence on Chesapeake Bay water quality. Green, data set: orange, model component; yellow, project task or decision; and blue, management endpoints.

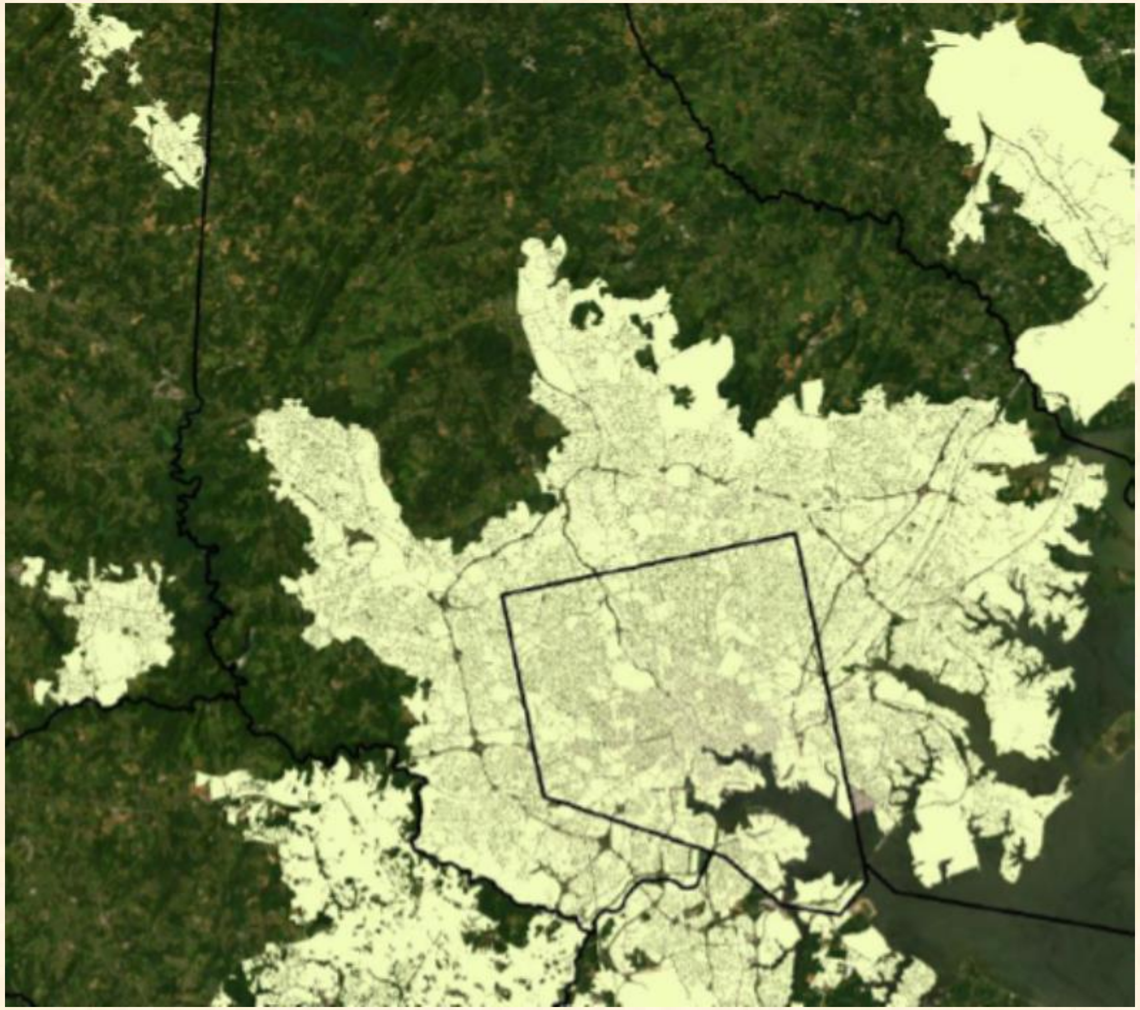
Source: Linker, L.C., Shenk, G.W., Bhatt, G., Tian, R., Cerco, C.F. and Bertani, I., 2024. Simulating climate change in a coastal watershed with an integrated suite of airshed, watershed, and estuary models. JAWRA Journal of the American Water Resources Association, 60(2), pp.499-528.

Challenges In Using Phase 6 CSO Methods in Phase 7 WSM

- With limited modeling staff and resources, it will be difficult to extend the 1985-2014 time series of CSO loads beyond 2014.

- Refinements of rainfall and the spatial extend of CSO service areas would also be difficult.

- Therefore, we recommend an update of the CSO flow and load estimation methods for the Phase 8 Model.



Phase 6 Estimates of Total Nitrogen (TN) Input to the Chesapeake Watershed

CAST 2019