Progress in Phase 7 Atmospheric Nitrogen Deposition Loads

Modeling Workgroup Quarterly Meeting – July 2025

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Presentation Outline

1. Brief overview
2. Review of Phase 6 atmospheric N-deposition input loads
3. Methods for merging Phase 6, CMAQ, and GCAM loads
4. Estimated Phase 7 atmospheric N-deposition input loads
5. Summary and next steps

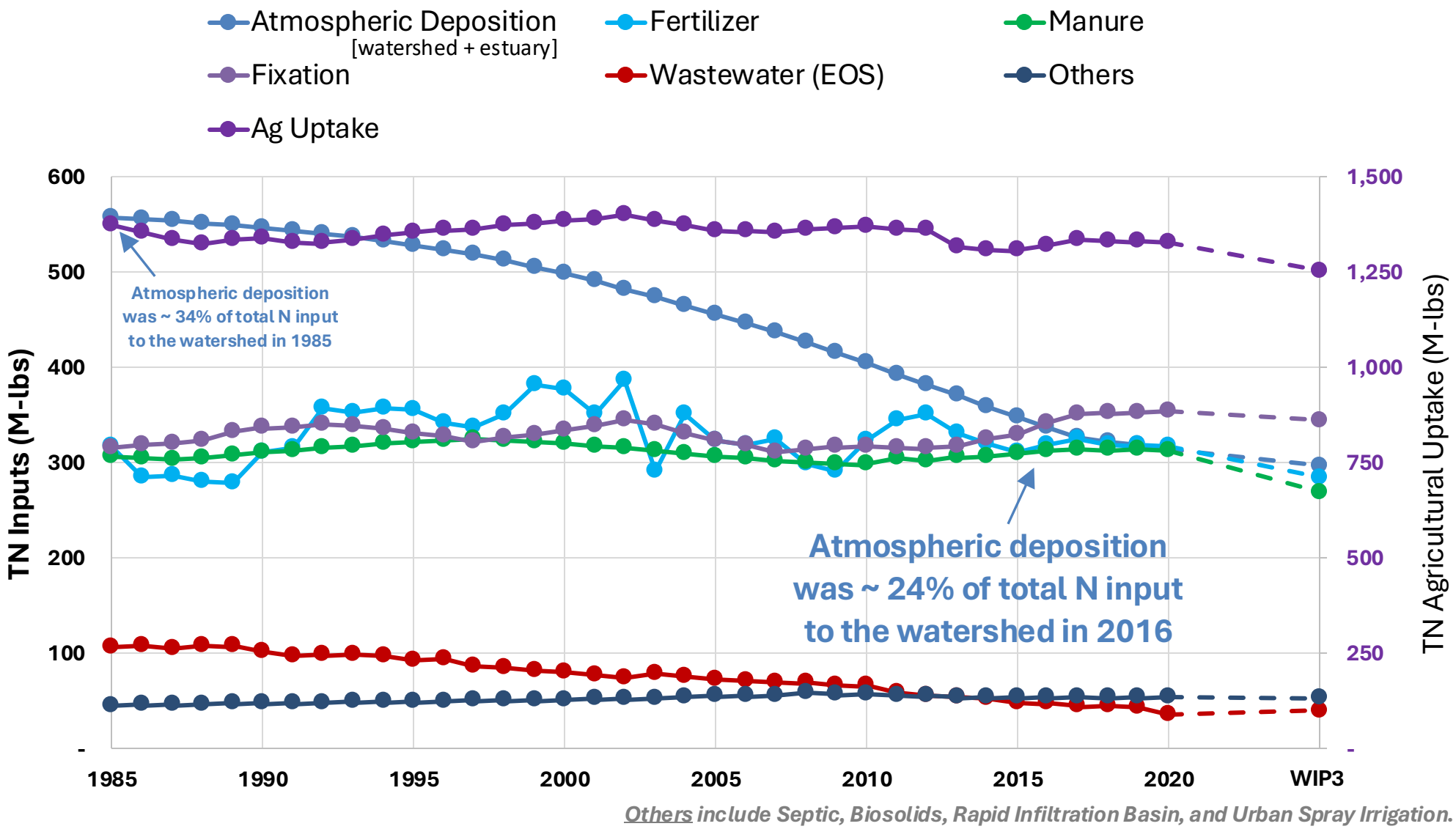
Motivation

Develop atmospheric N-deposition input loads for Phase 7 management models and scenarios

- Estimates of N-deposition loads for the calibration (1985-2024)
- Coverage for the both WSM and MBM (Main Bay and Coastal Ocean)
- Estimates for the past and future trends in loads
- Leverage – (a) 1985-2014 Phase 6, (b) 2002-2019 CMAQ, and (c) 2035 GCAM datasets

Phase 6 estimates of Total Nitrogen (TN) <u>input</u> to the Chesapeake Bay Watershed

CAST 2019



<u>Others</u> include Septic, Biosolids, Rapid Infiltration Basin, and Urban Spray Irrigation.

https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/20231017-BHATT-Integrated-Source-Apportionment-Analysis-of-Atmospheric-N-Deposition.pdf

Phase 6 atmospheric N-deposition loads

- With variability in meteorology (and emissions)
- Trend over time due to trend in emissions
- Detrended loads (i.e., loads at a fixed emission level)
- Trend in deposition without meteorological variability

- Summary of atmospheric N-loads for the Bay watershed

With variability in meteorology (and emissions)

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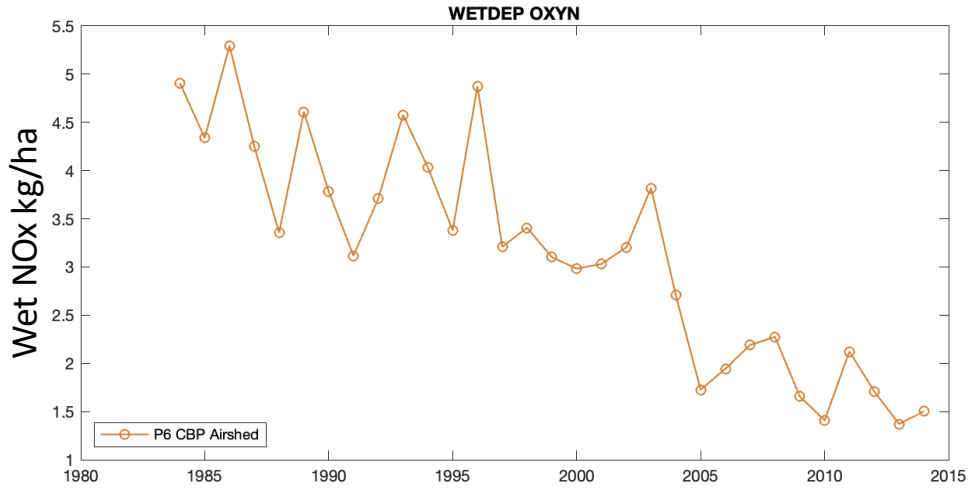

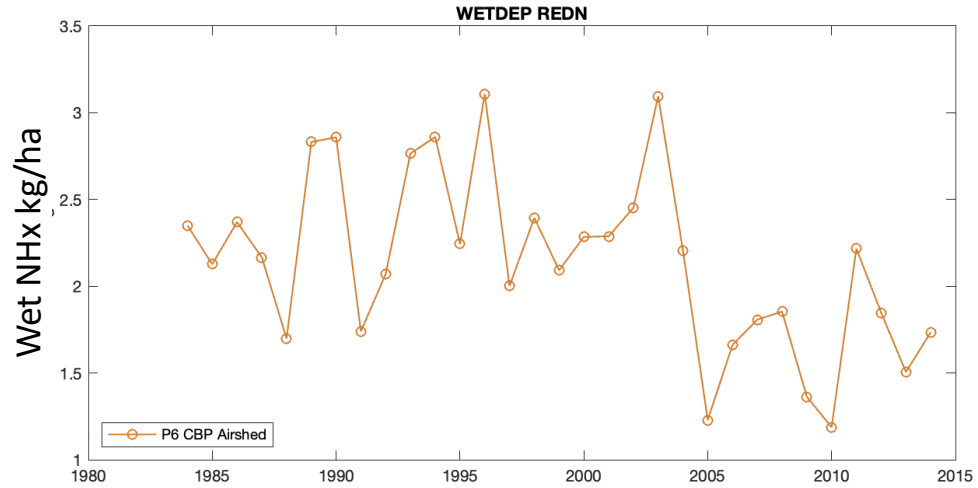

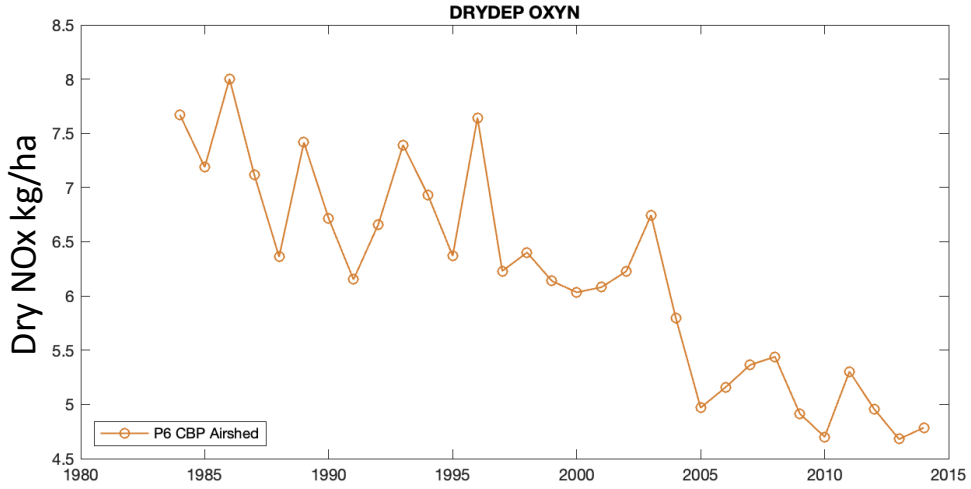

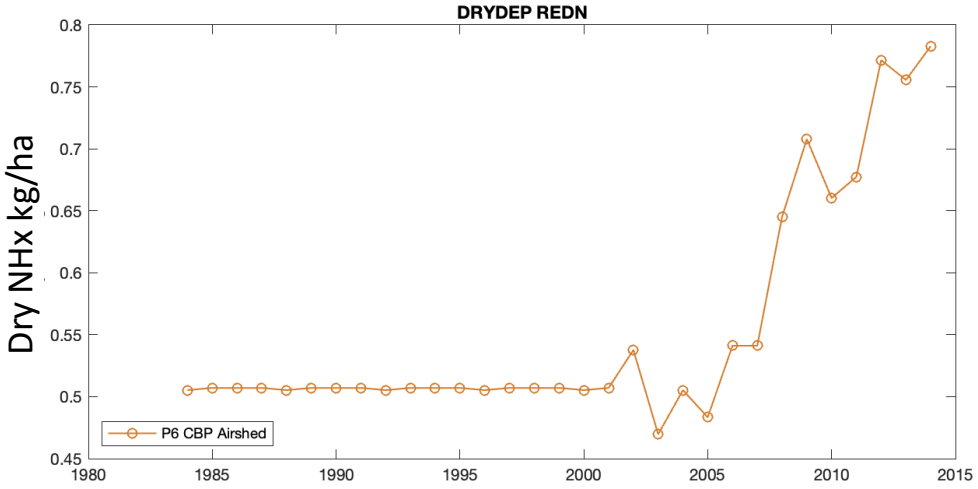

Trend over time due to trend in emissions

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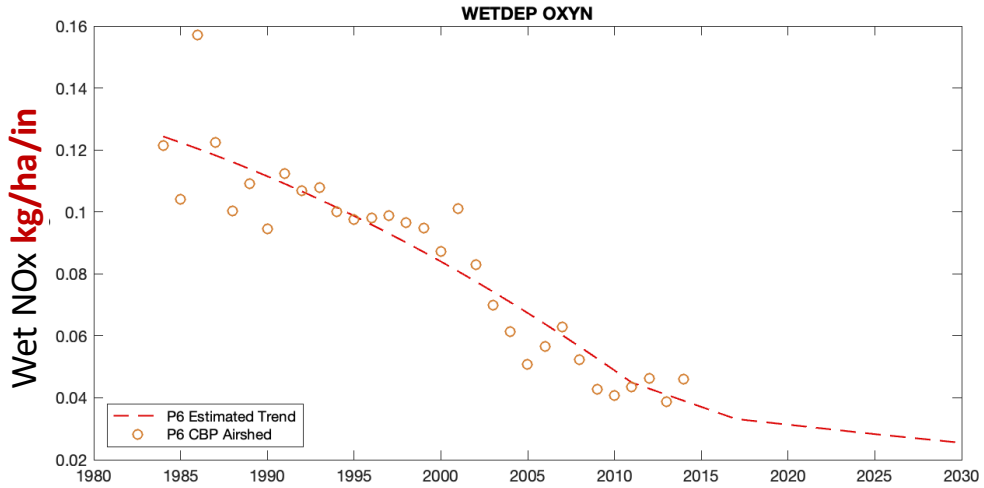

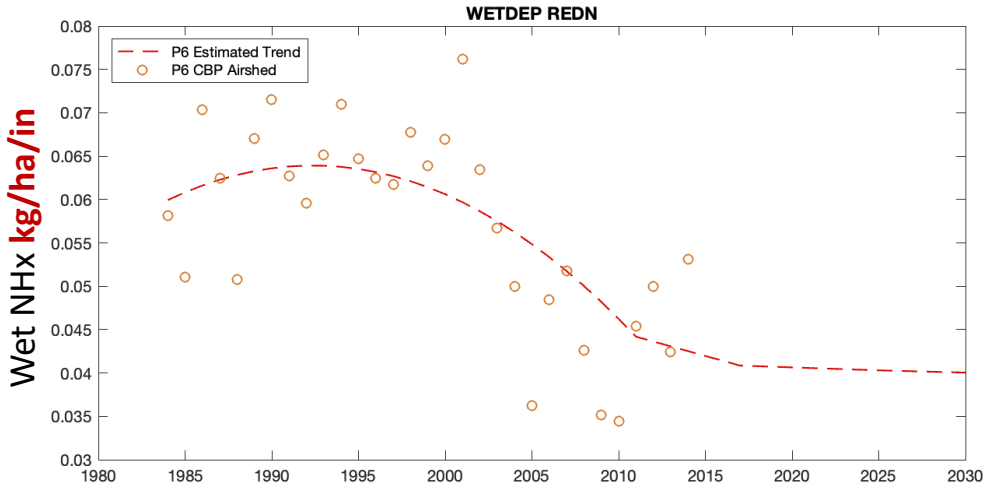

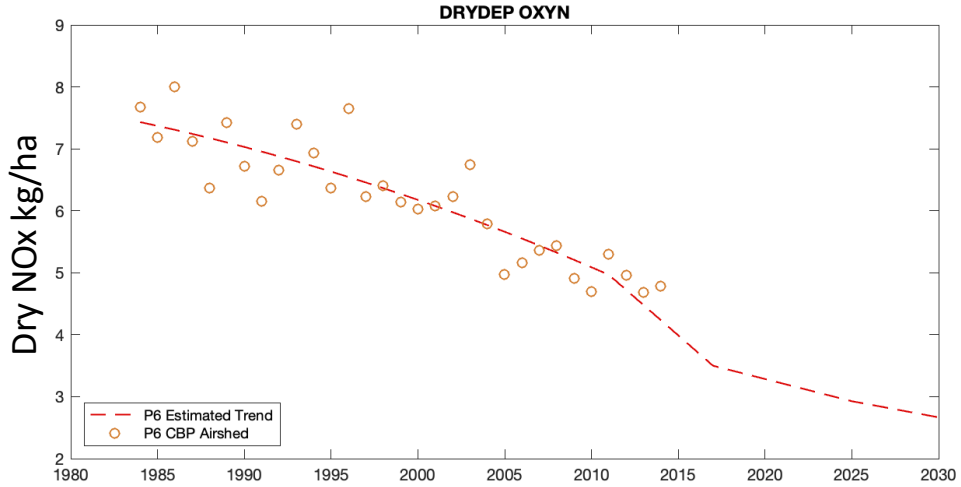

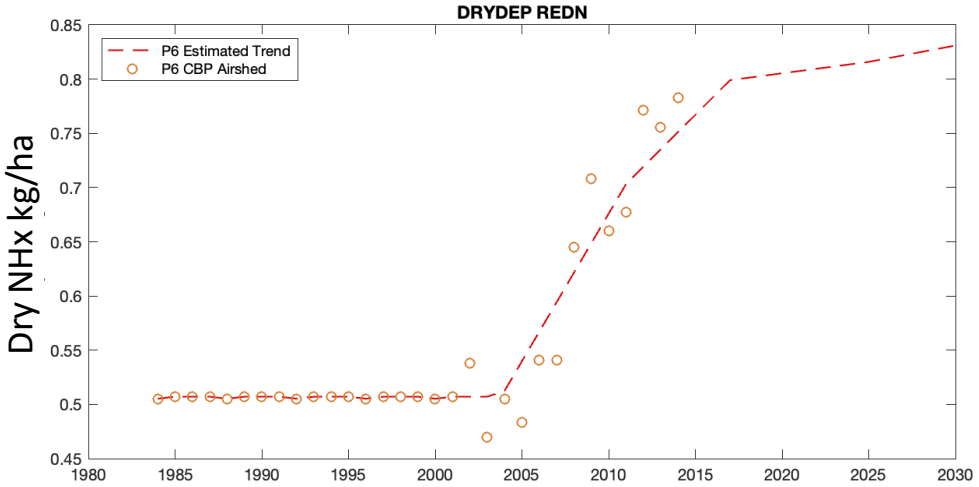

Detrended loads (i.e., loads at a fixed emission level)

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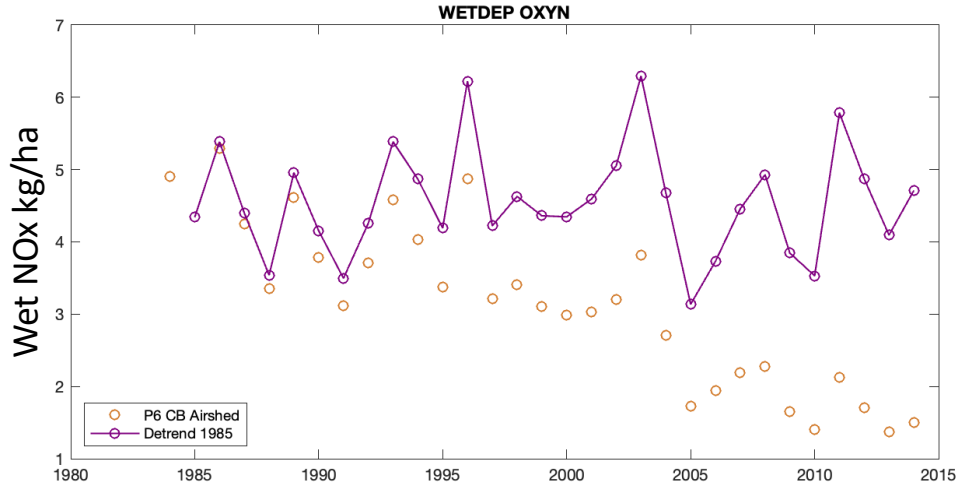
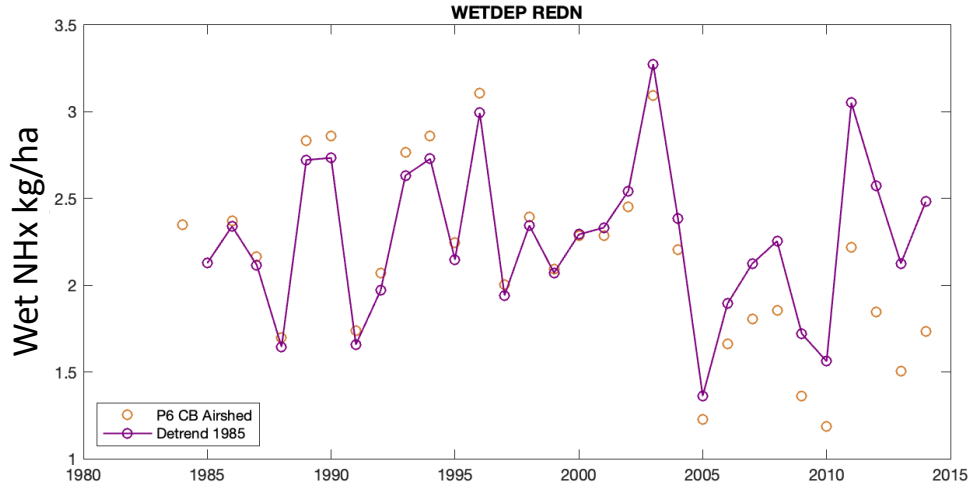
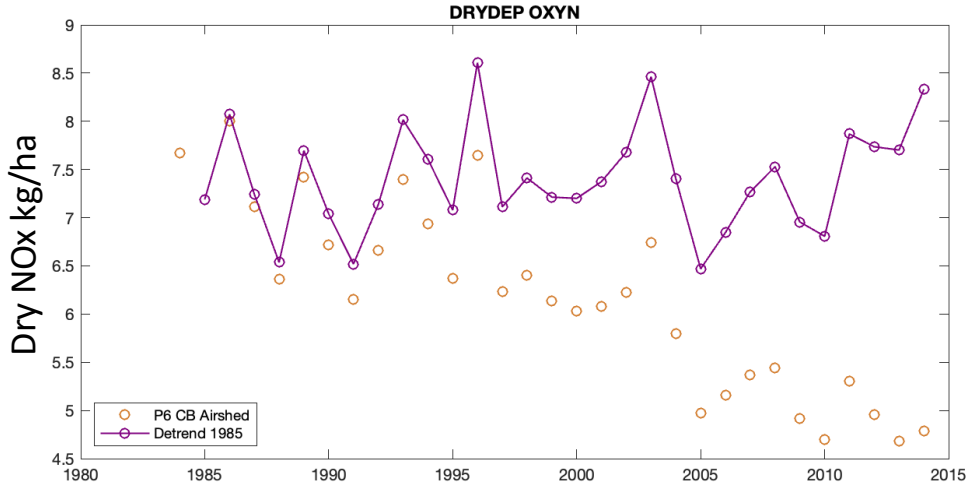
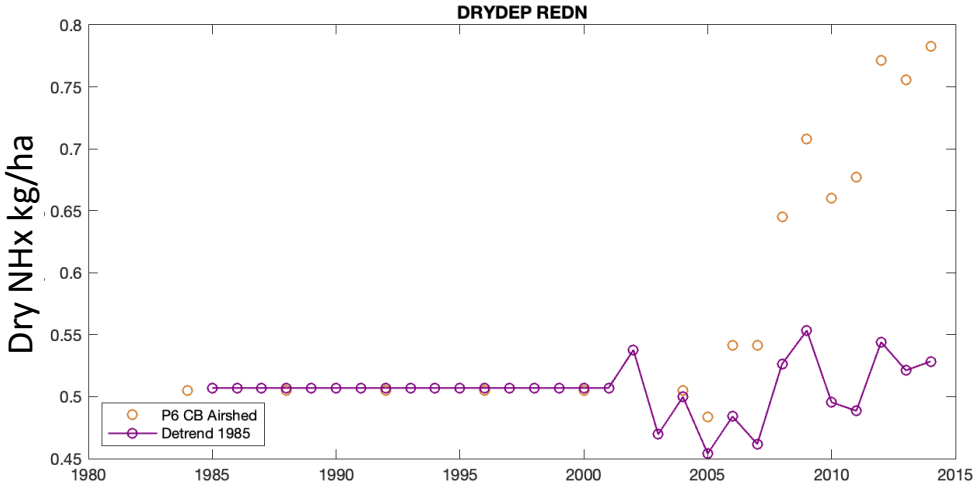
1985 emissions









Detrended loads (i.e., loads at a fixed emission level)

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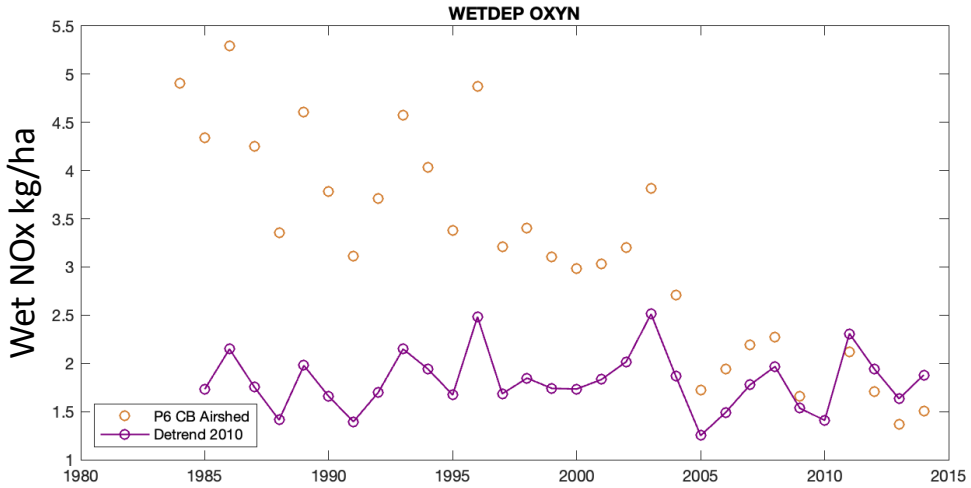
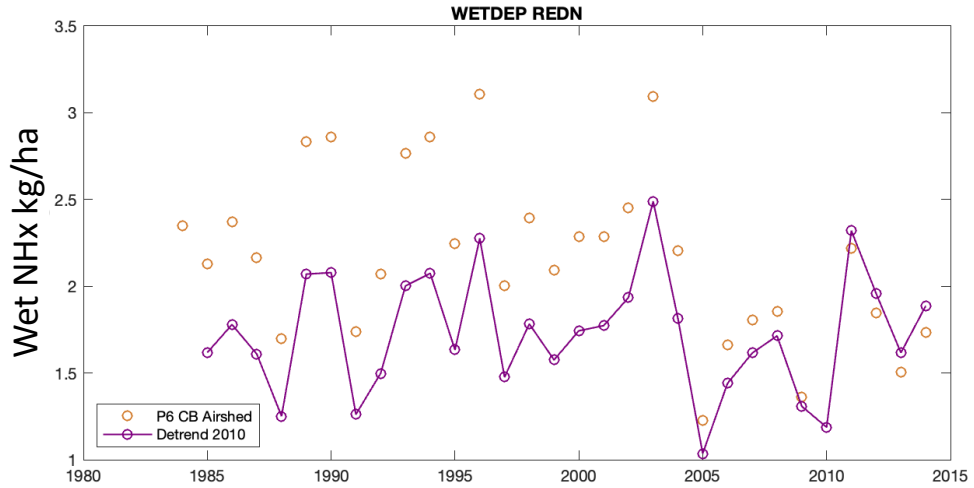
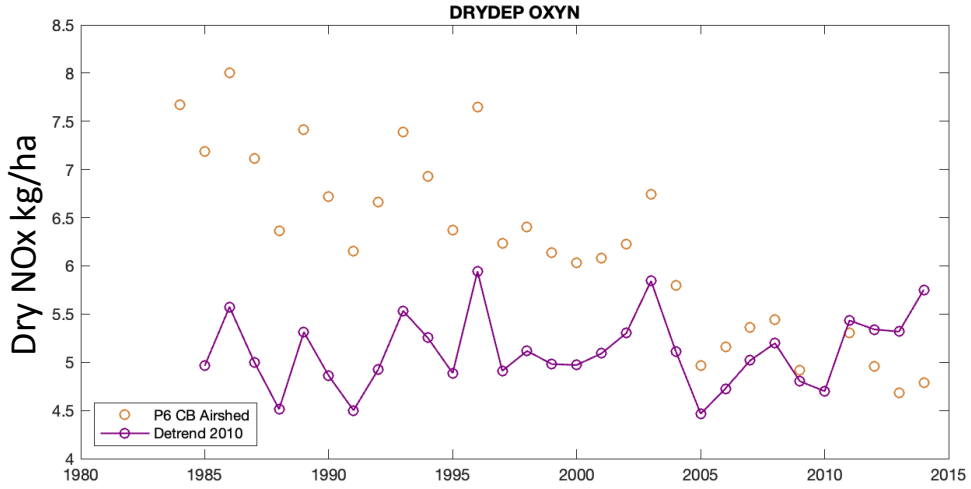
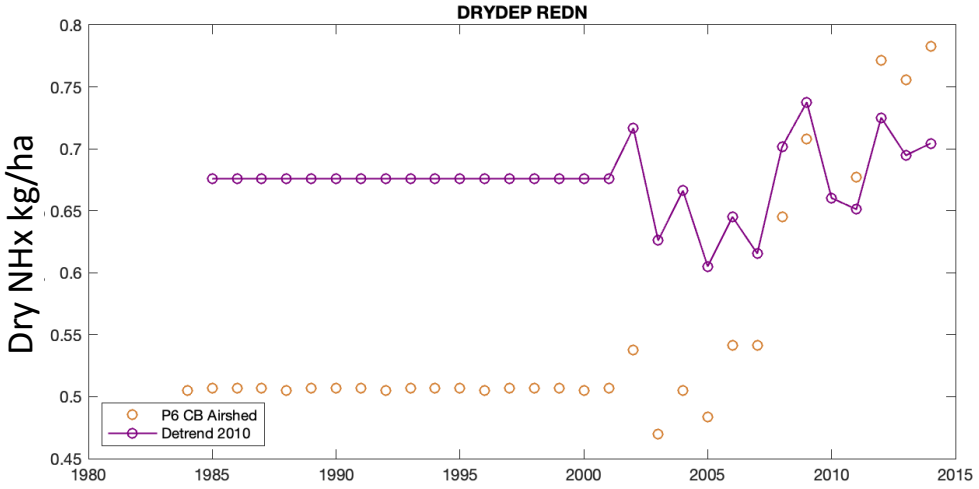
2010 emissions









Trend in deposition without meteorological variability

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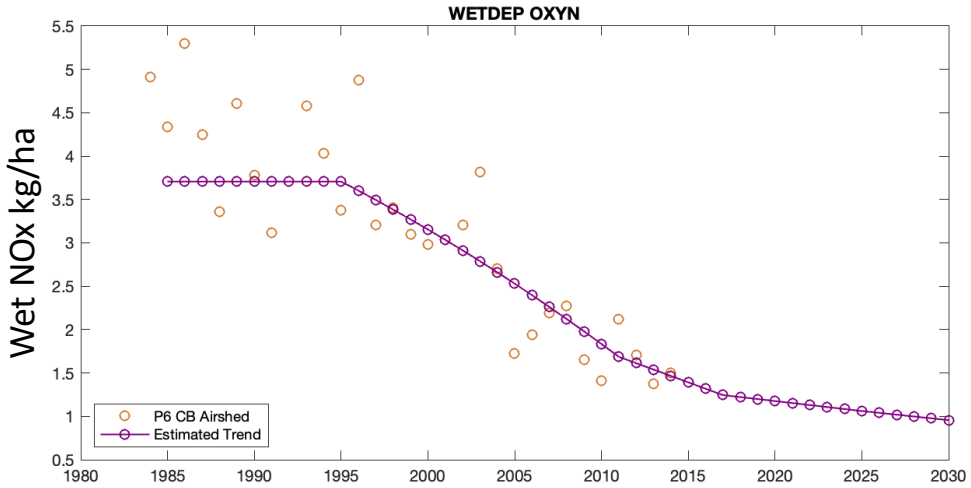
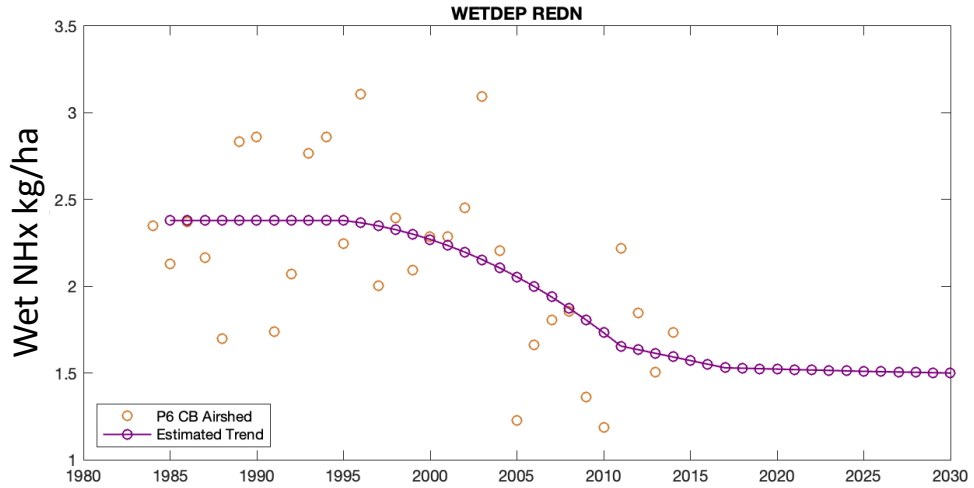
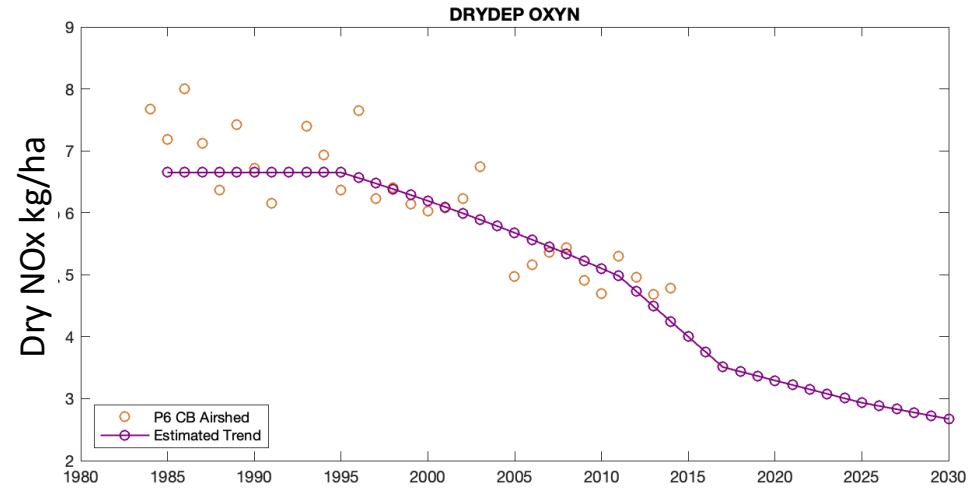
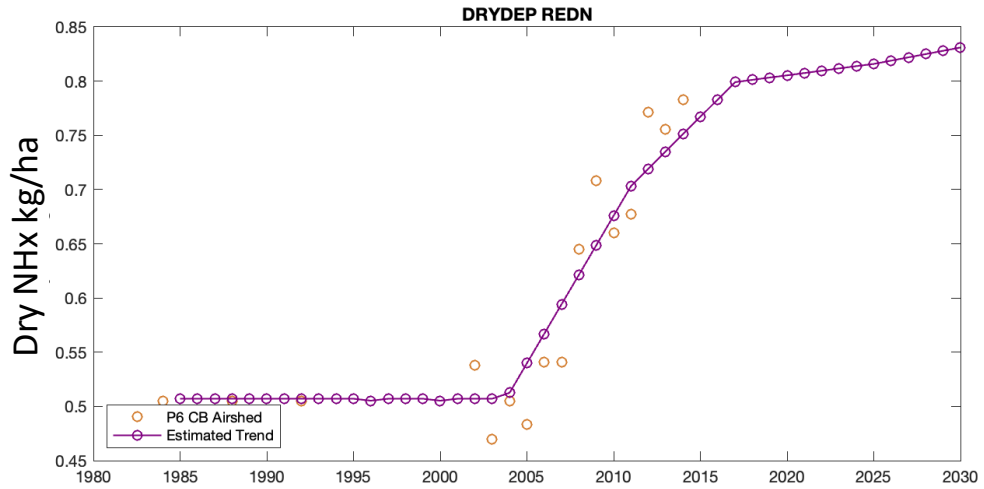
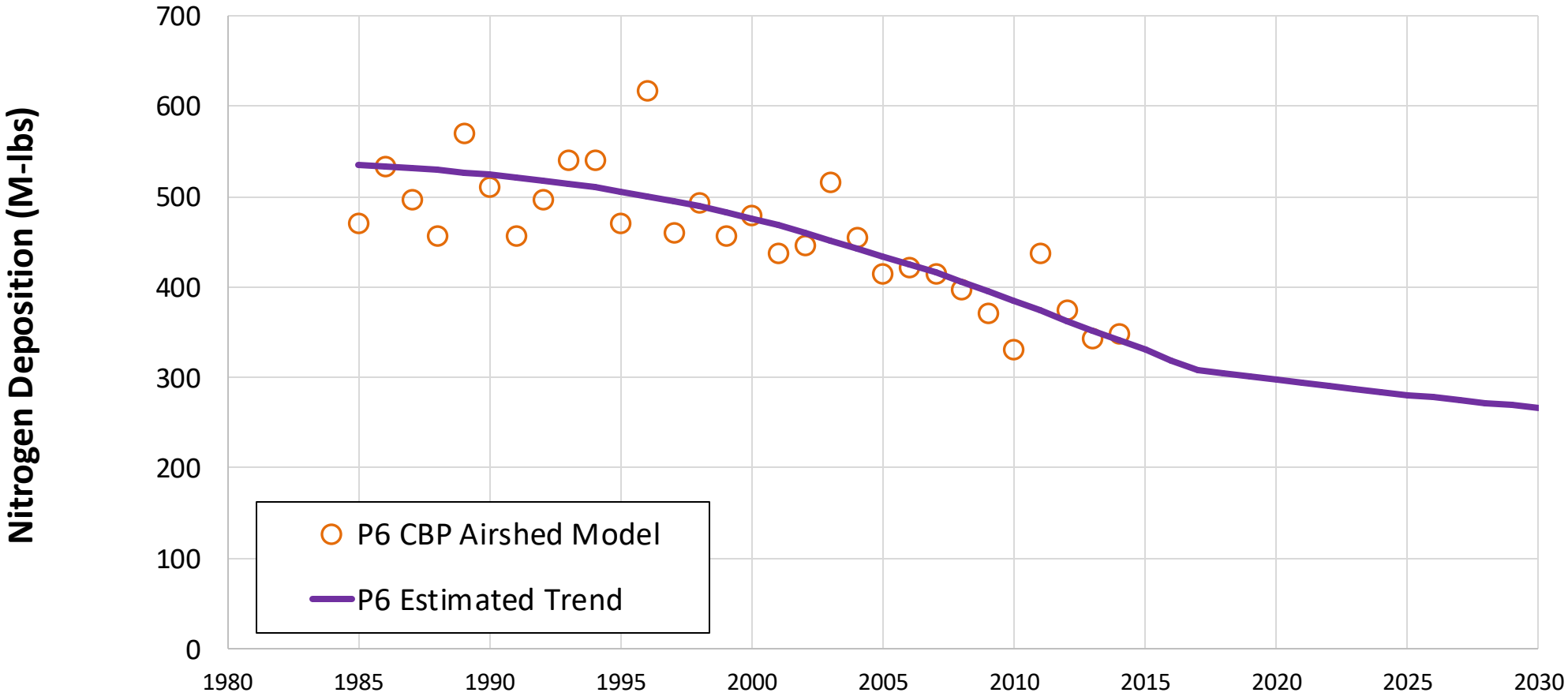








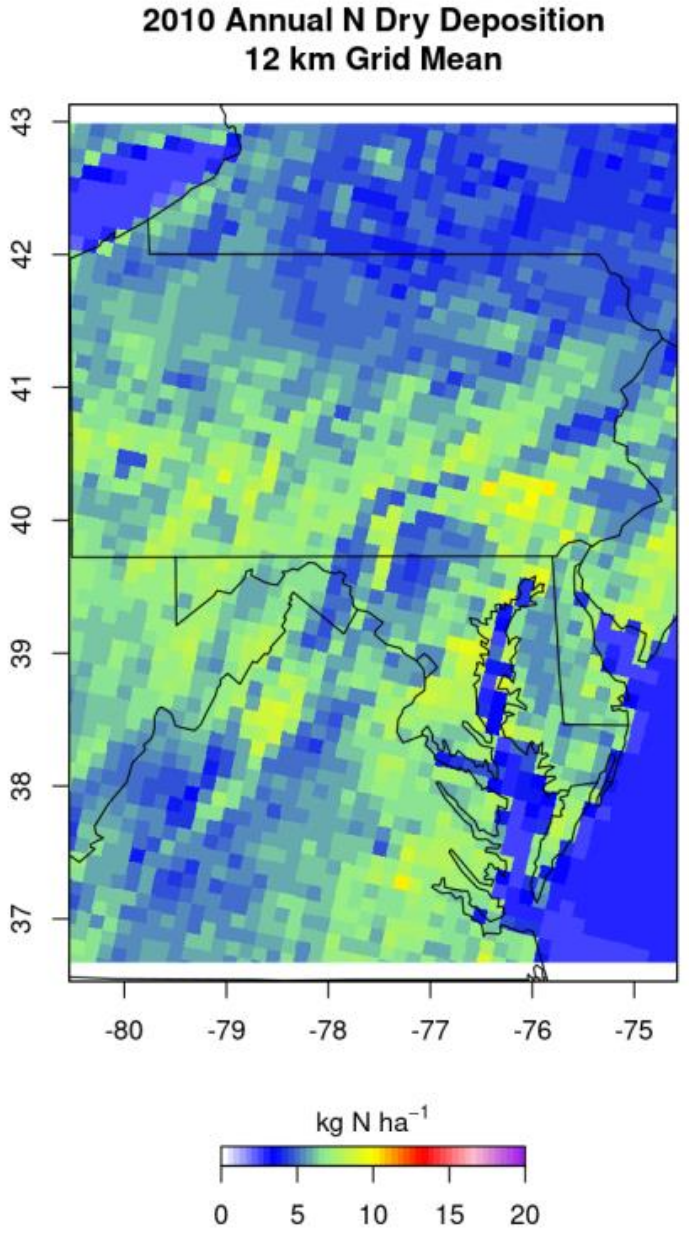
Integrating land segments over the Bay Watershed



→ *Estimates shown in the chart does not include organic N deposition to water land use; 2035 based on Non-IRA;*

New CMAQ data in Phase 7 CBP Airshed N loads

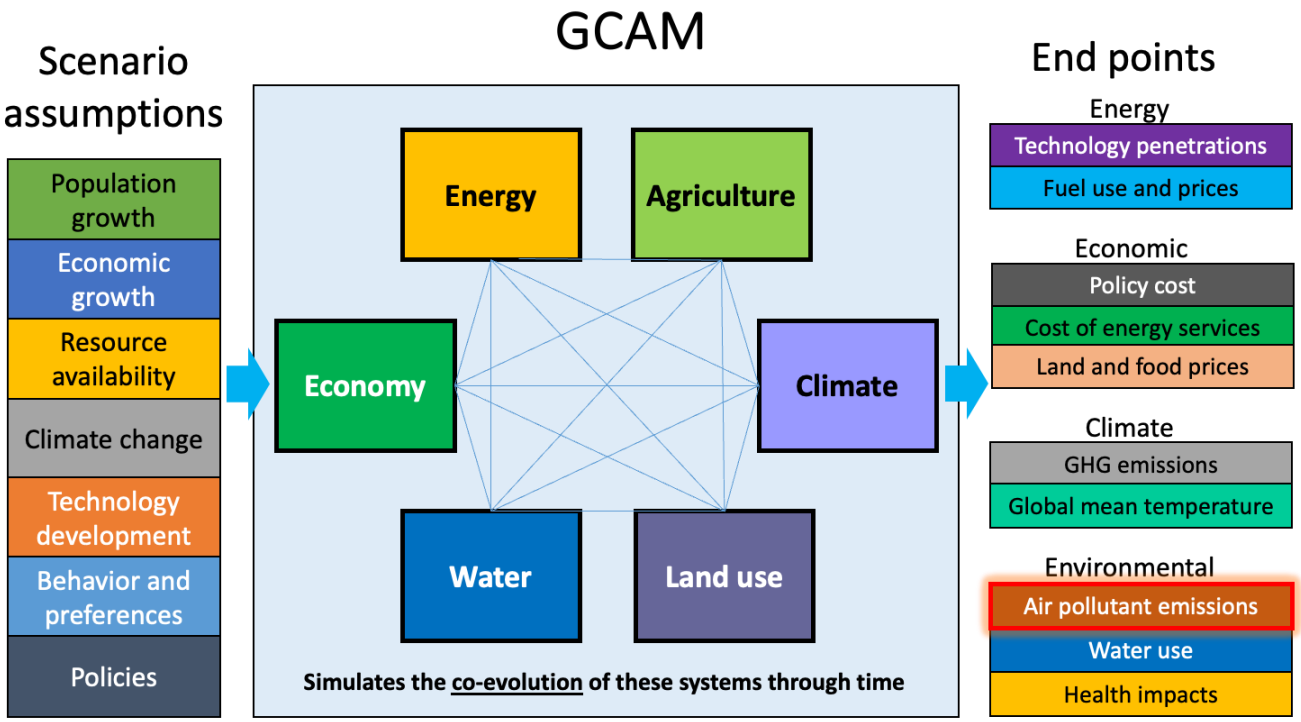
- CBP Phase 6 airshed model has atmospheric N data for 1985-2014 and trends for 1985-2030.
- We received latest wet and dry, oxidized and reduced N-deposition data at 12-km spatial resolution from CMAQ model version 5.3.2 [Jesse Bash, EPA].
- Spatial coverage includes both watershed and estuarine model domains for the 2002 to 2019 period.
- We developed scripts for the processing of loads and performed comparative analyses of CBP P6 airshed and CMAQ deposition estimates for both watershed and tidal water domains.



Global Change Analysis Model (GCAM)

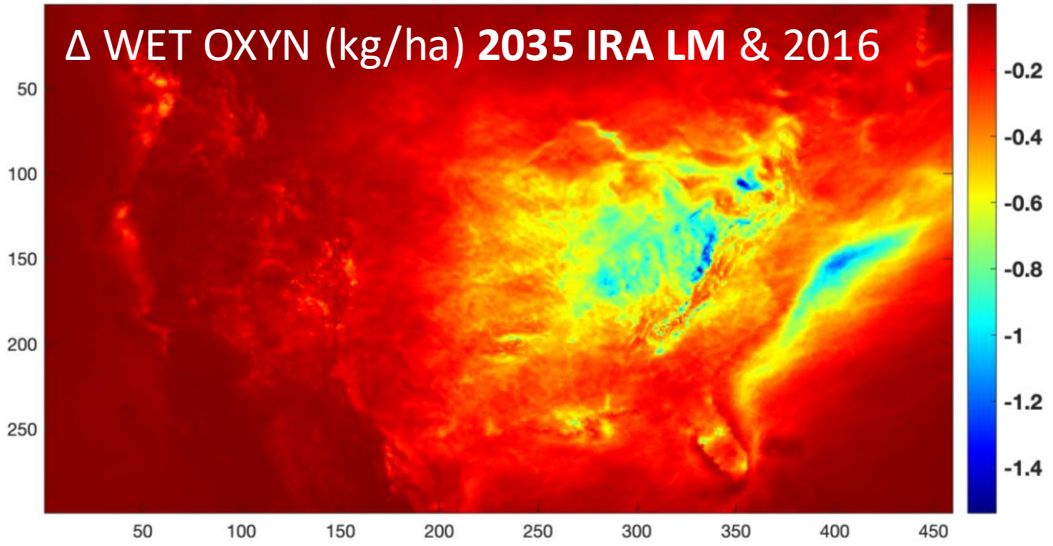
- GCAM simulates the co-evolution of climate, economy, energy, agriculture, land use and water systems through time.

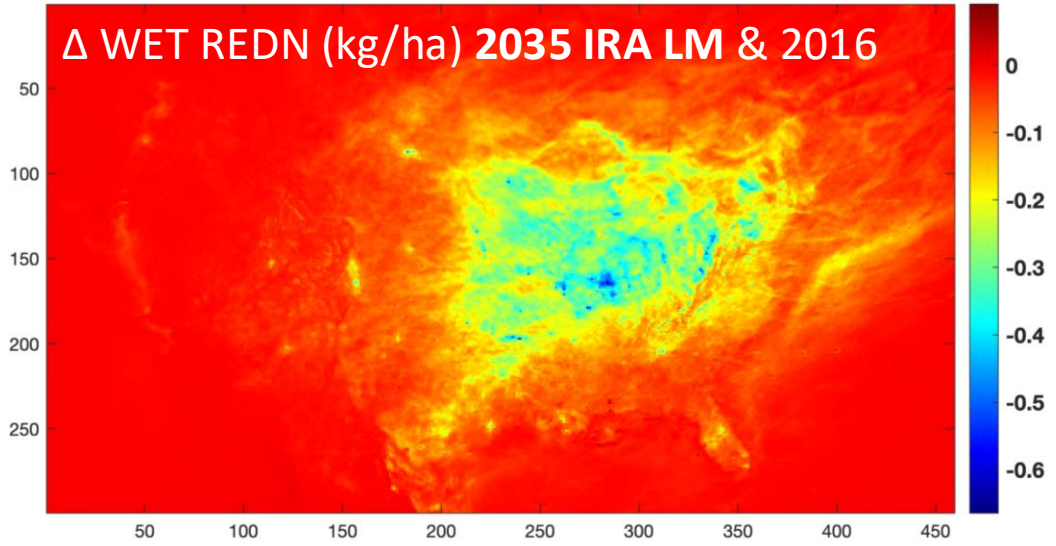
- GCAM's energy related changes were incorporated as state and sector specific emissions through scaling factors into Community Multistate Air Quality (CMAQ) model.

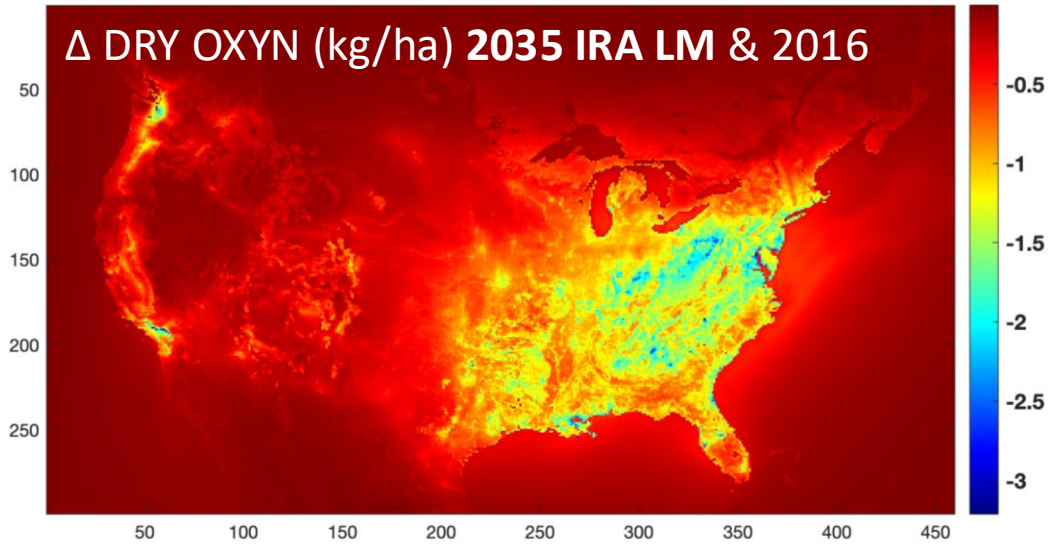


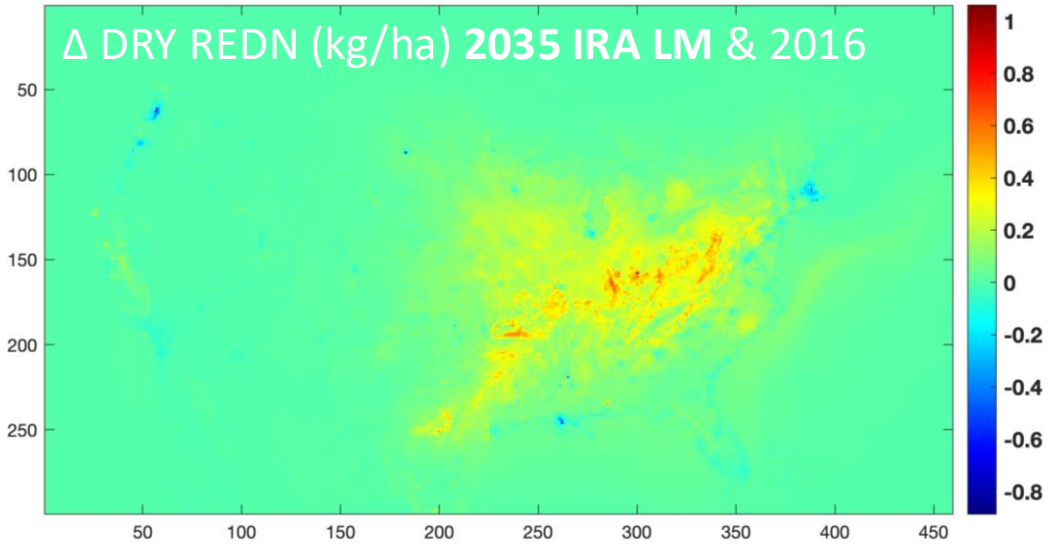
Jesse Bash, Chris Nolte, Dan Loughlin, and Ben Murphy

- We received CMAQ data for 2016 (“ ***2016 Ref*** ”) along with the data for 2035 under Inflation Reduction Act & Limited GHG Mitigation scenario (“ **2035 IRA** ”).









We need a method to effectively blend the datasets…

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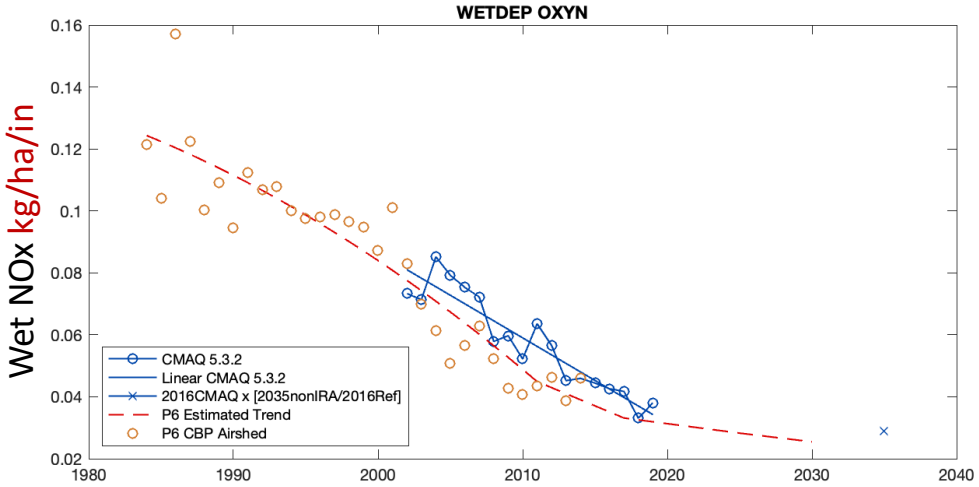
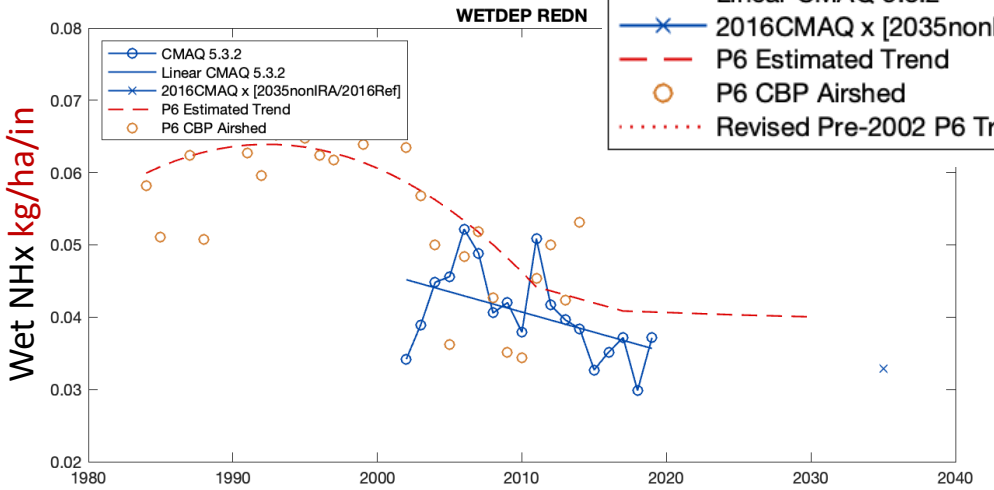
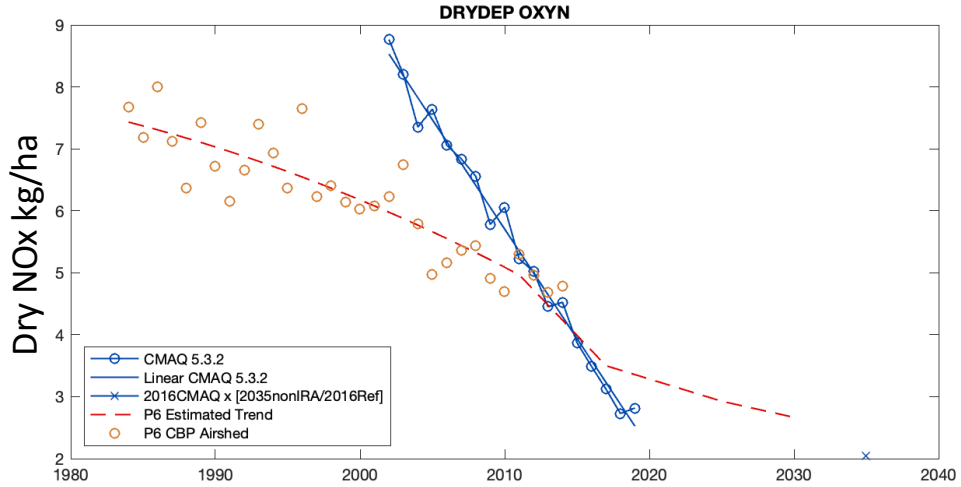
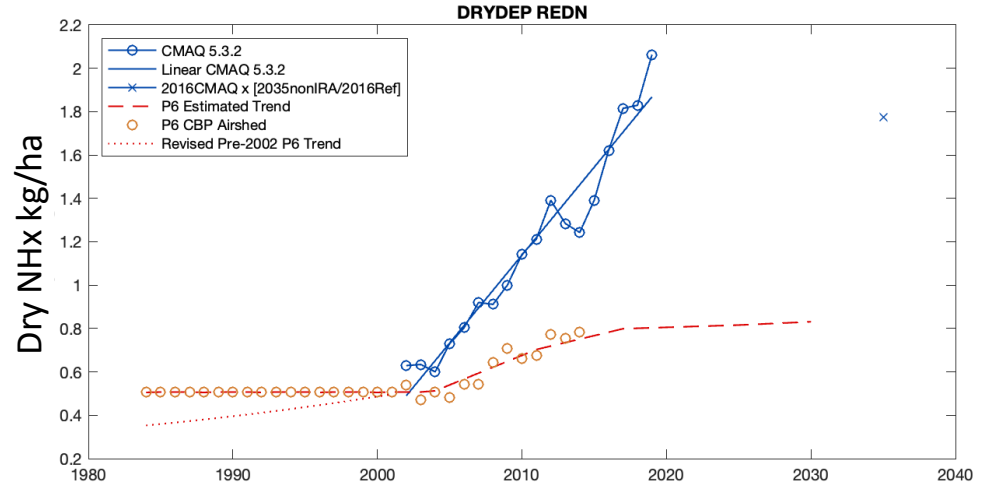


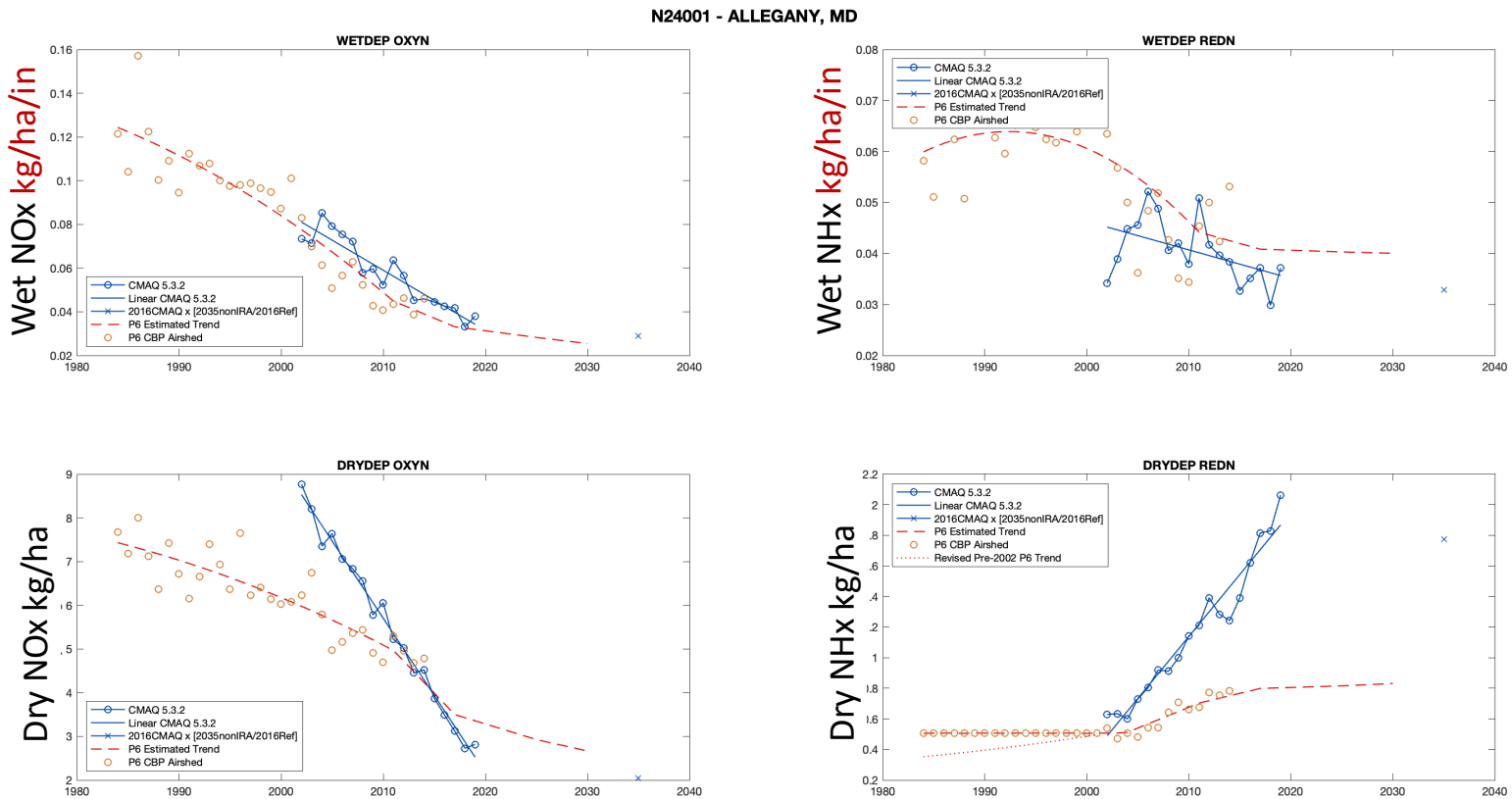


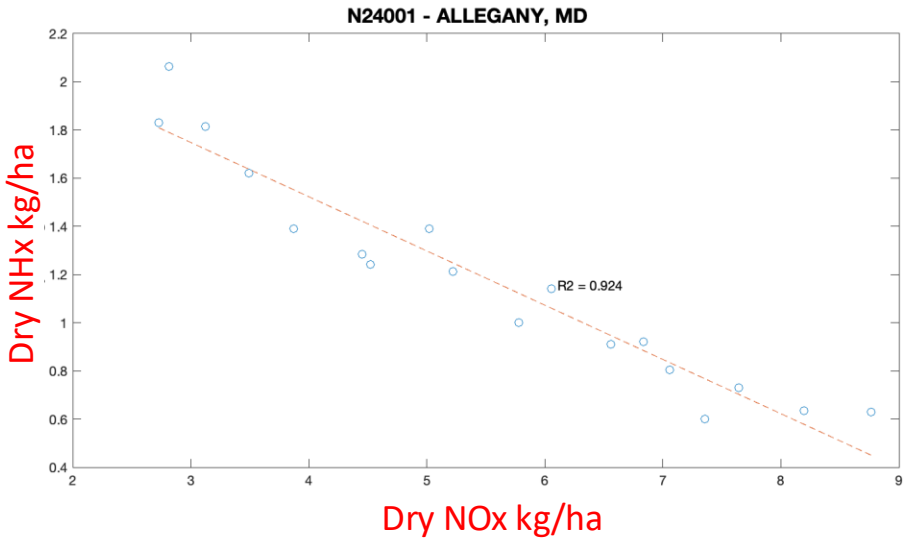




Method for merging Phase 6, CMAQ, and GCAM loads

- Use "*2035 IRA*" as "*2016 CMAQ*" x ("*2035 IRA*" / "*2016 Ref*")
- Fit linear trends to CMAQ 2002-2019 data
- Use linear regression between Dry OXYN and REDN to revise pre-2002 P6 Dry REDN trend
- Use CMAQ linear trends to compute relative change *w.r.t.* 2002
  - Adjust P6 trends for 2003 and onwards
  - 2003-2019 and 2019-2035 are piecewise linear trends





- Inspected NOx trends, and they decrease from 2002 to 2019 and from 2019-2035.

Method for merging Phase 6, CMAQ, and GCAM loads

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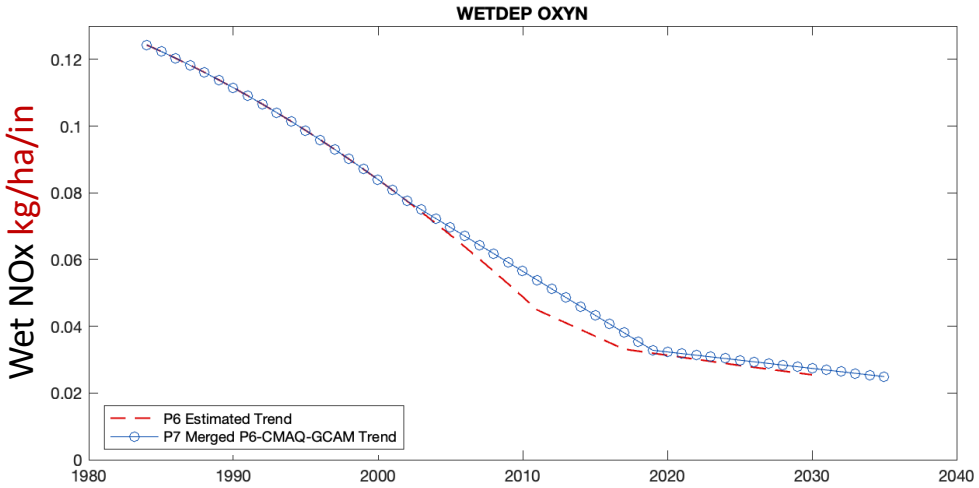

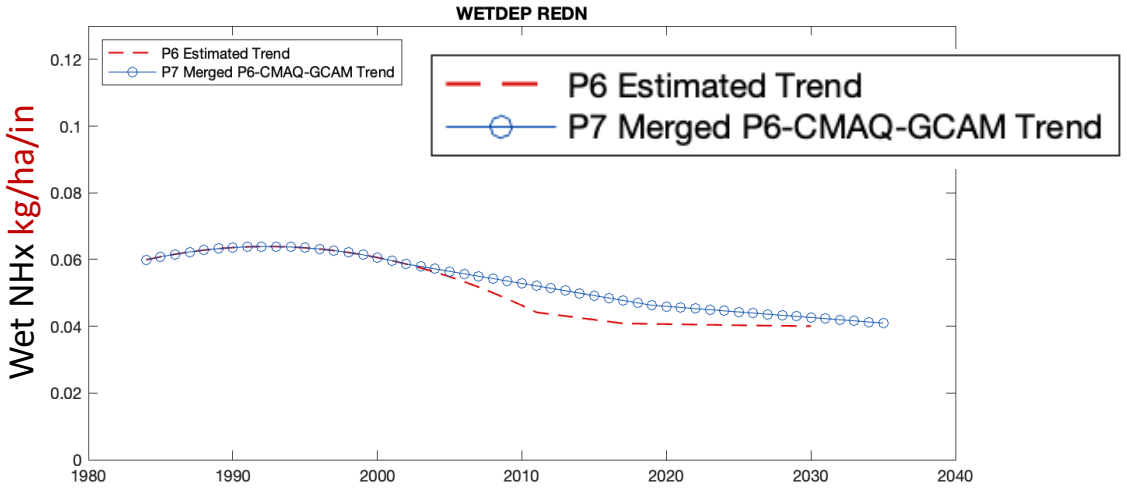

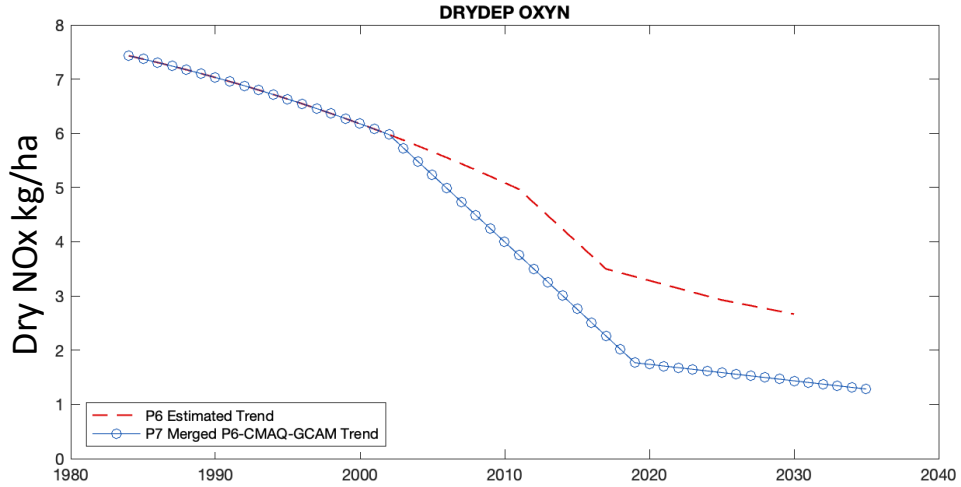

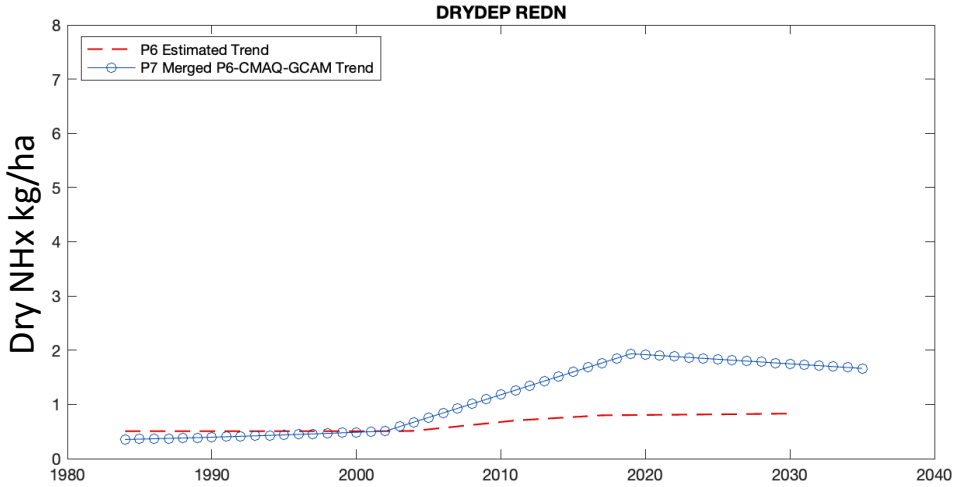

With variability in meteorology (and emissions)

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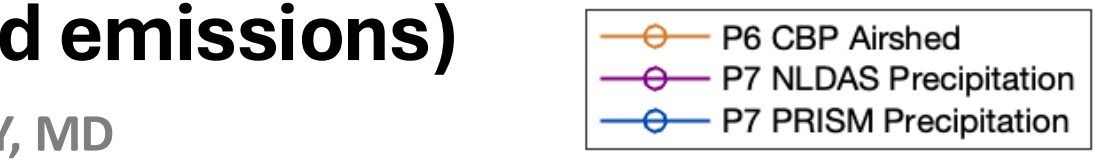
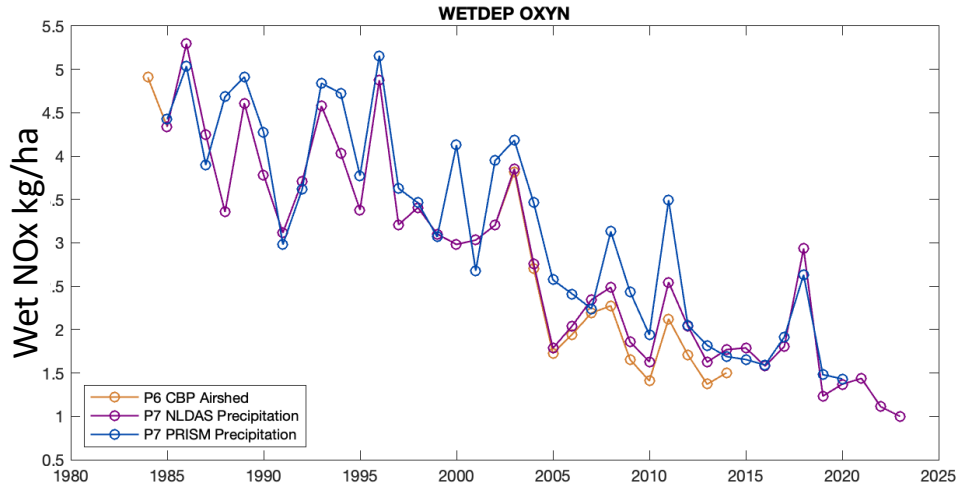
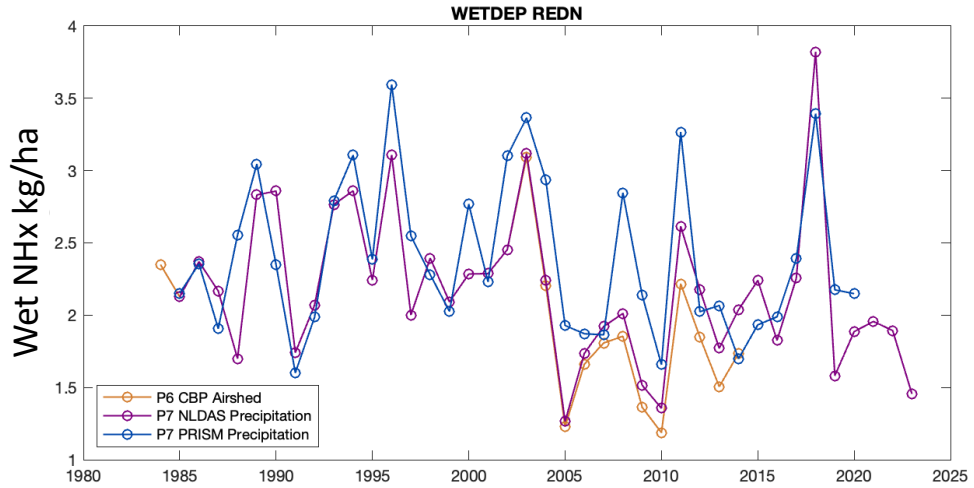
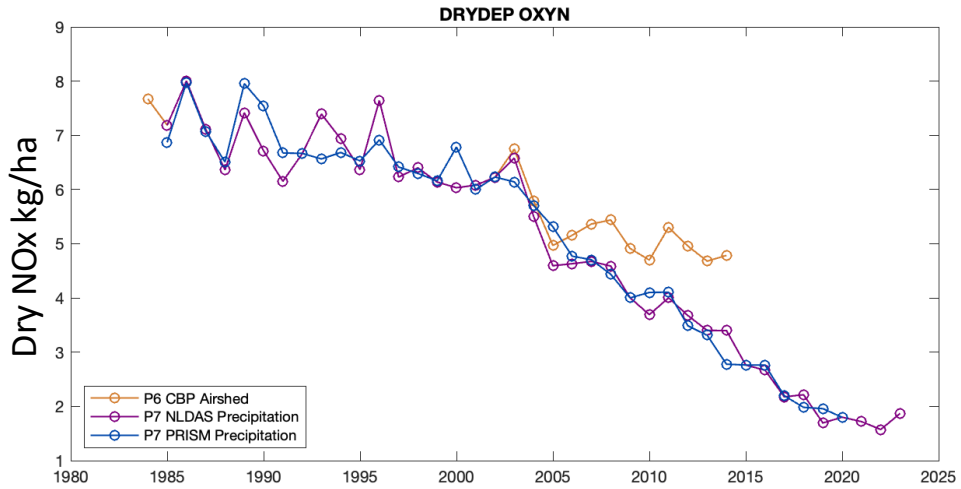
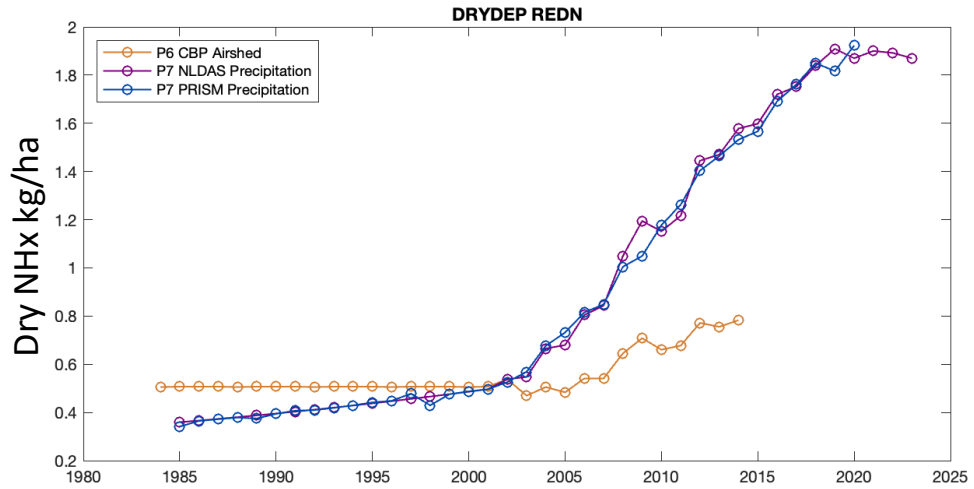


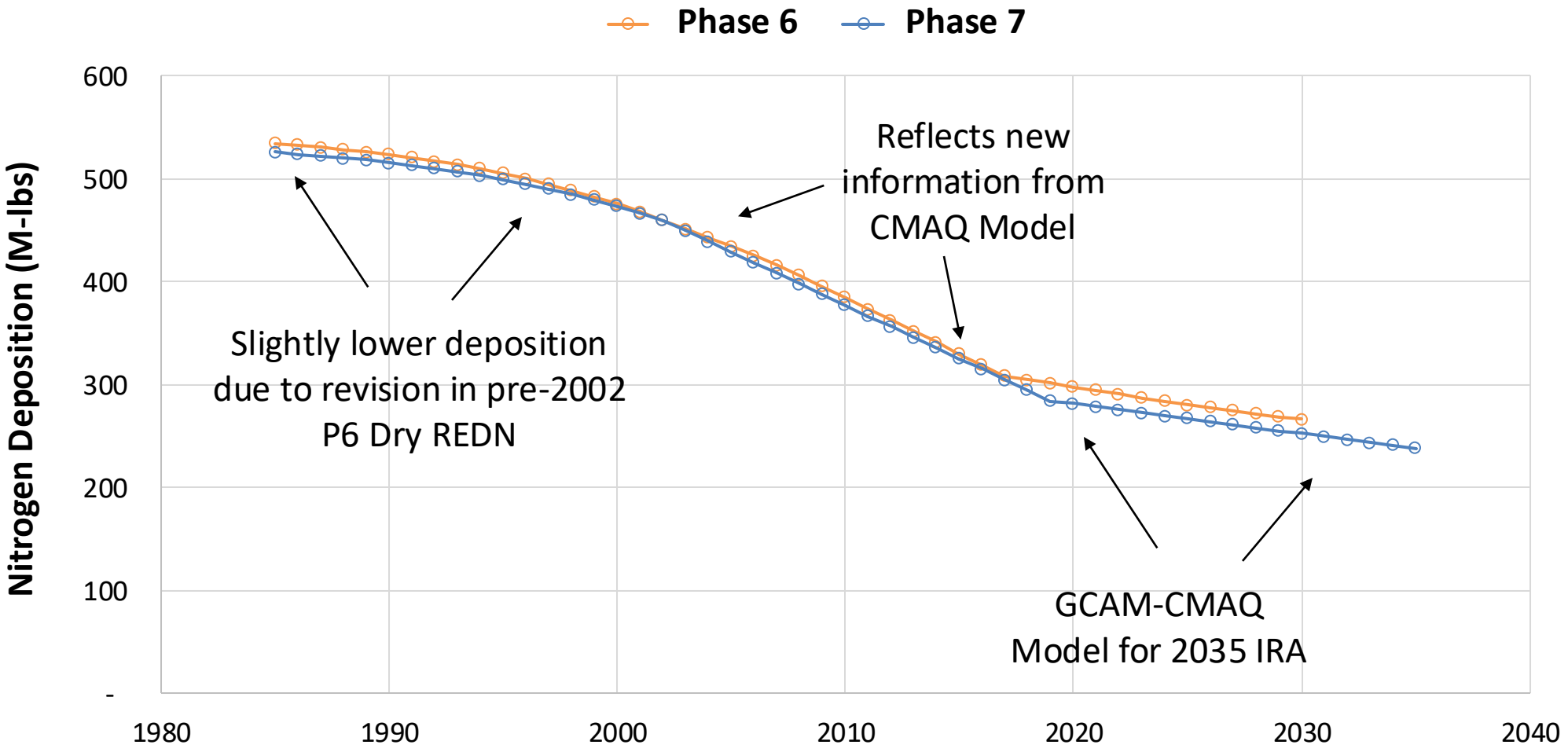






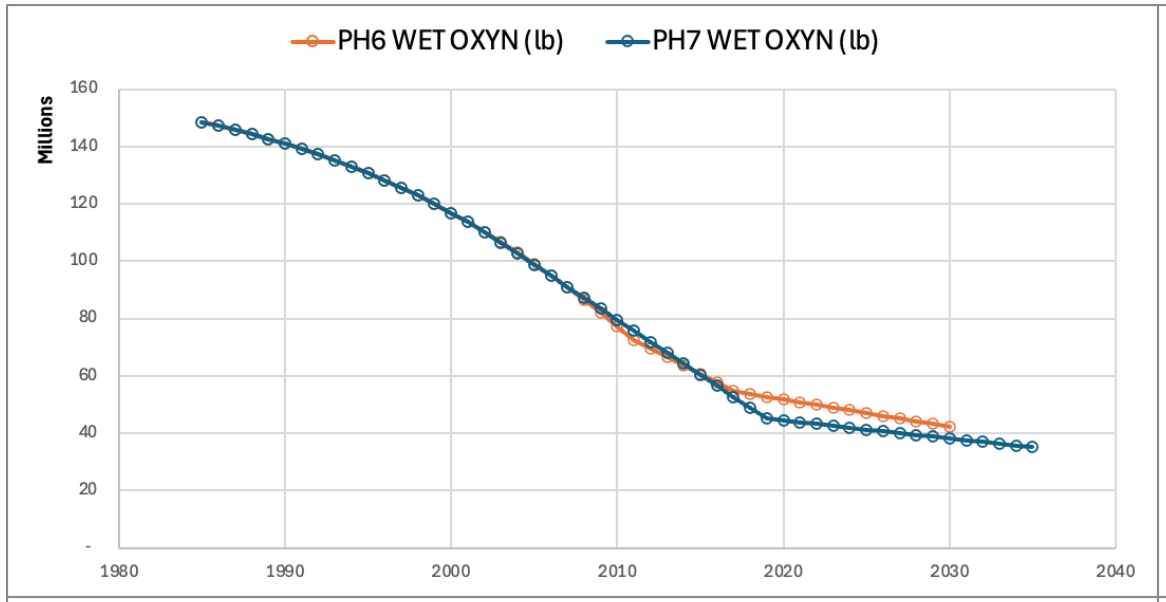


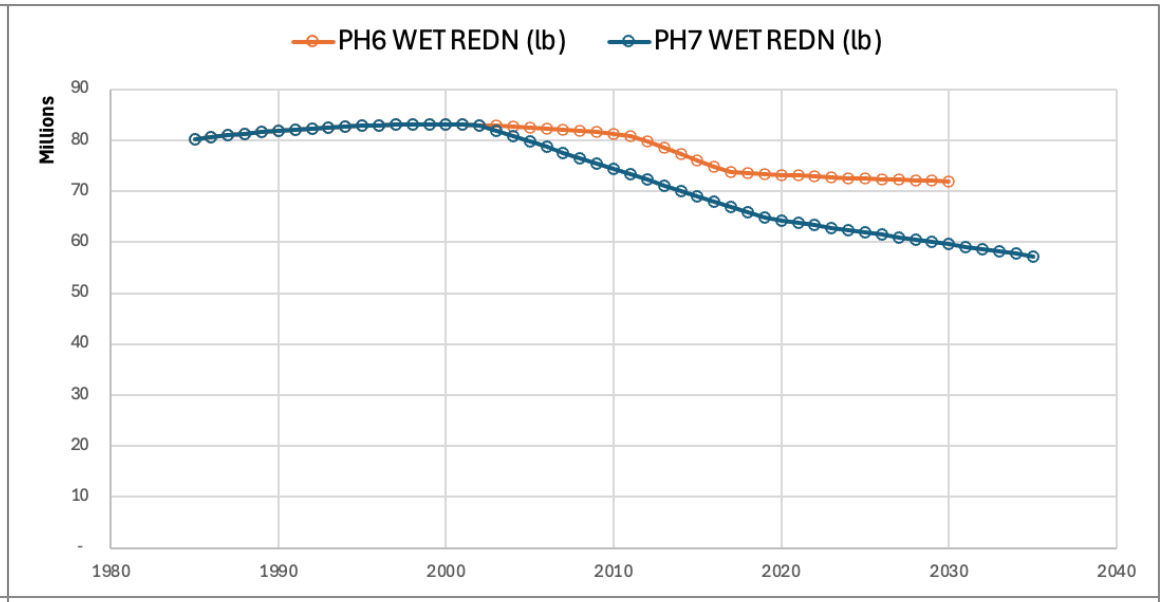
Integrating land segments over the Bay Watershed

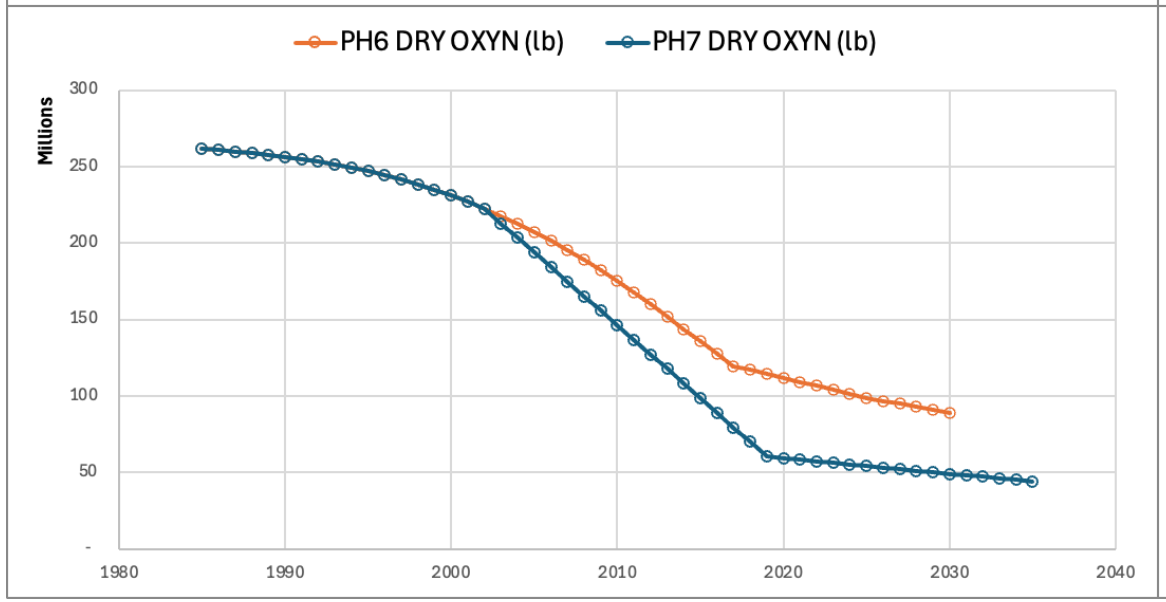


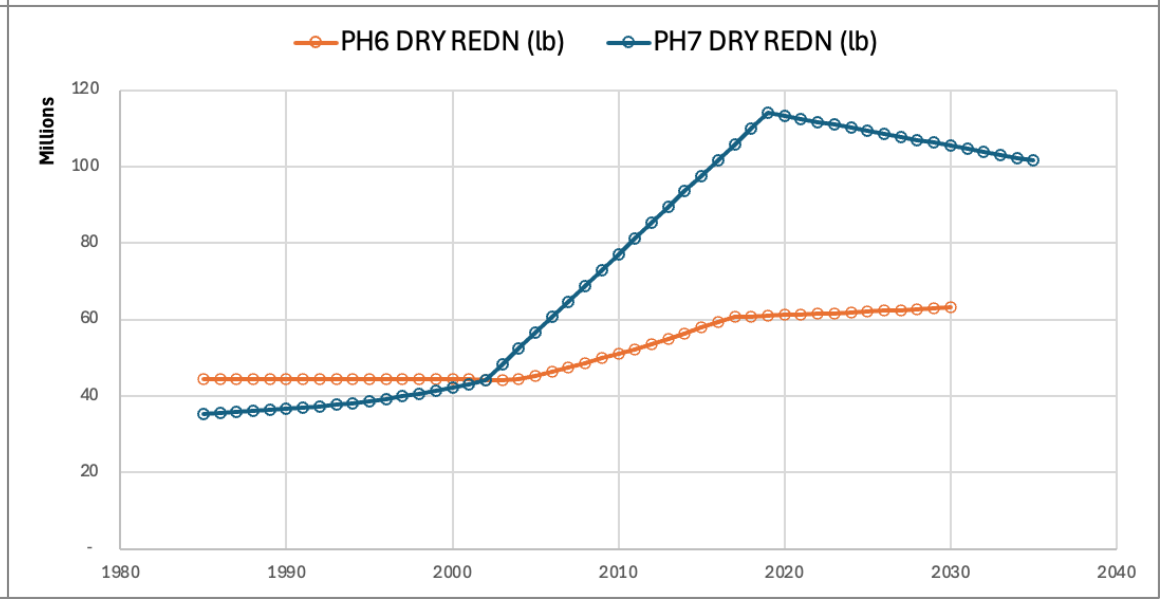
→ *Estimates shown in the chart does not include organic N deposition to water land use*

Integrating land segments over the Bay Watershed

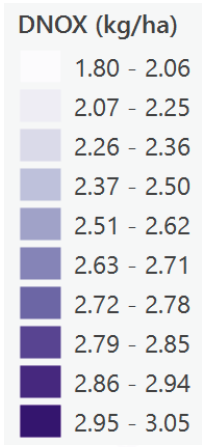


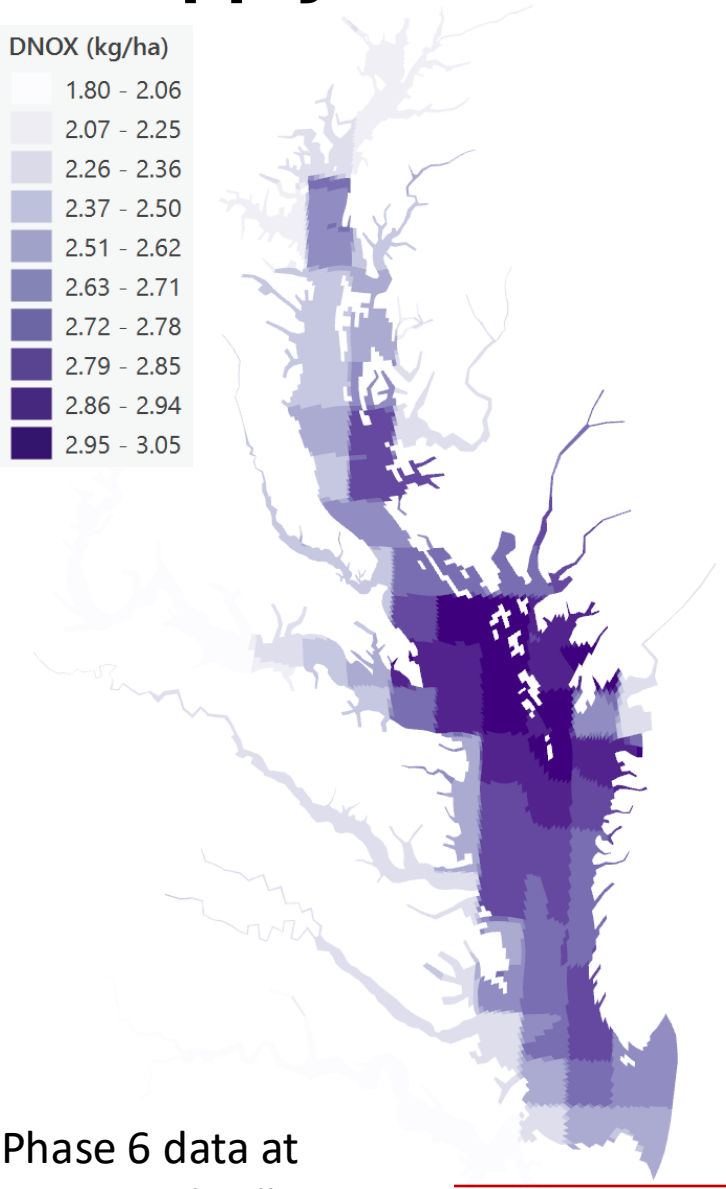


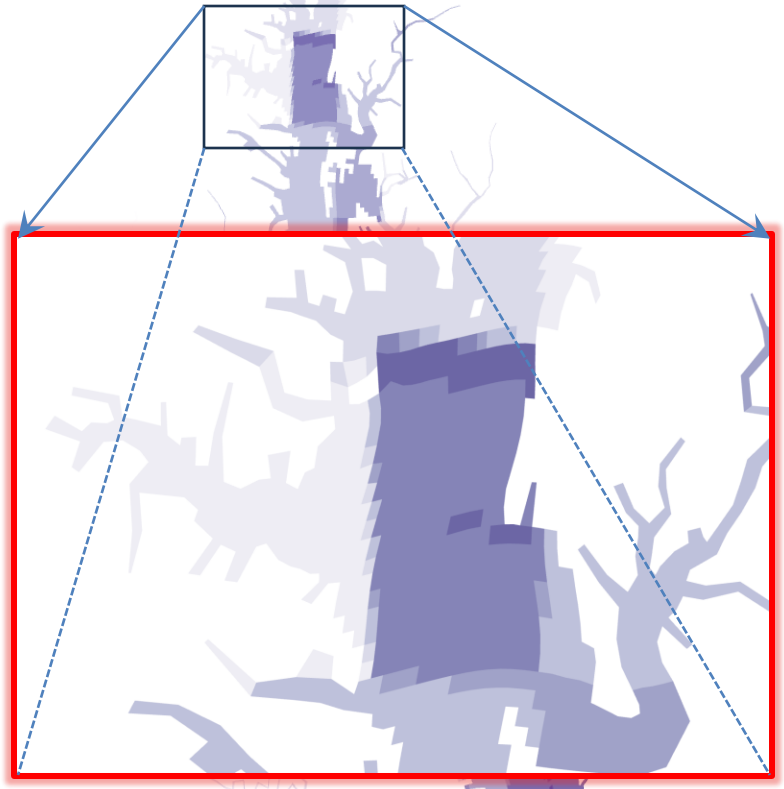


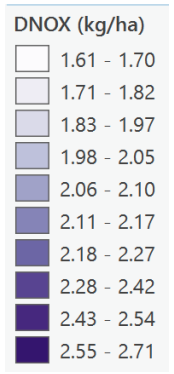


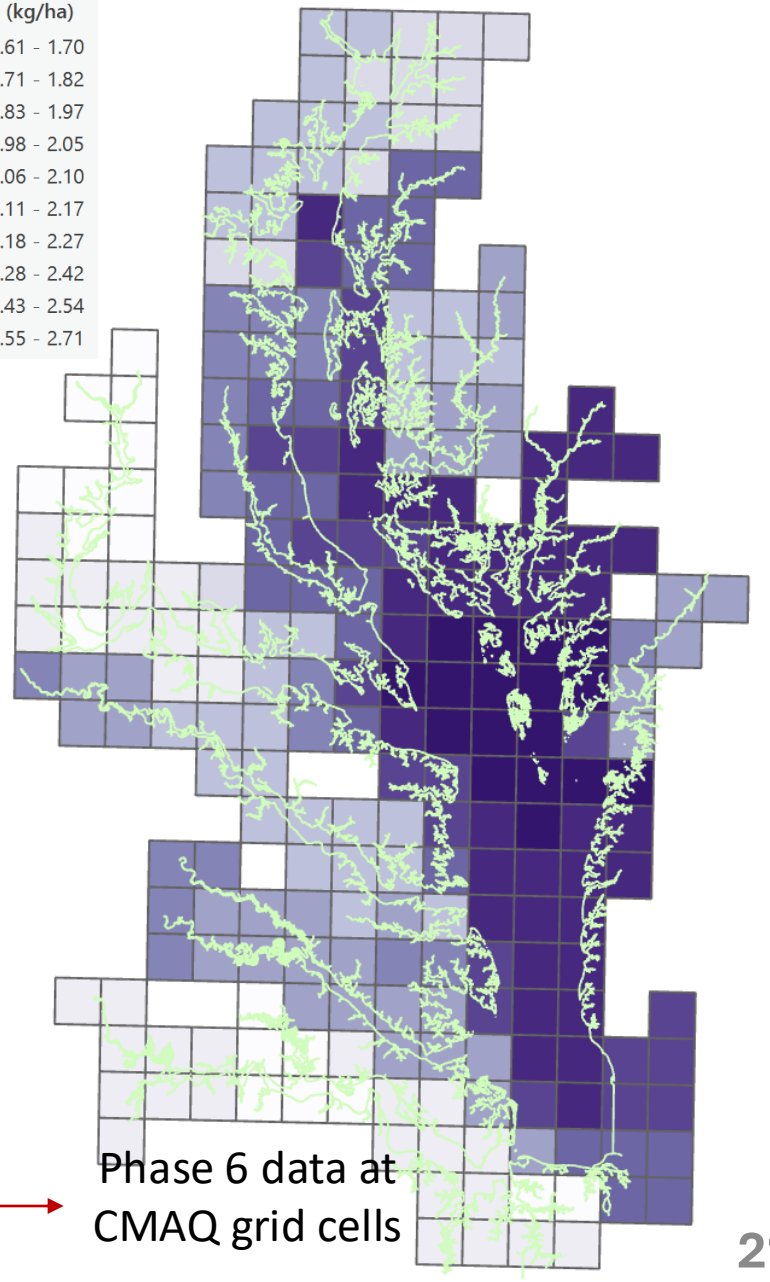
Apply same method for the tidal bay











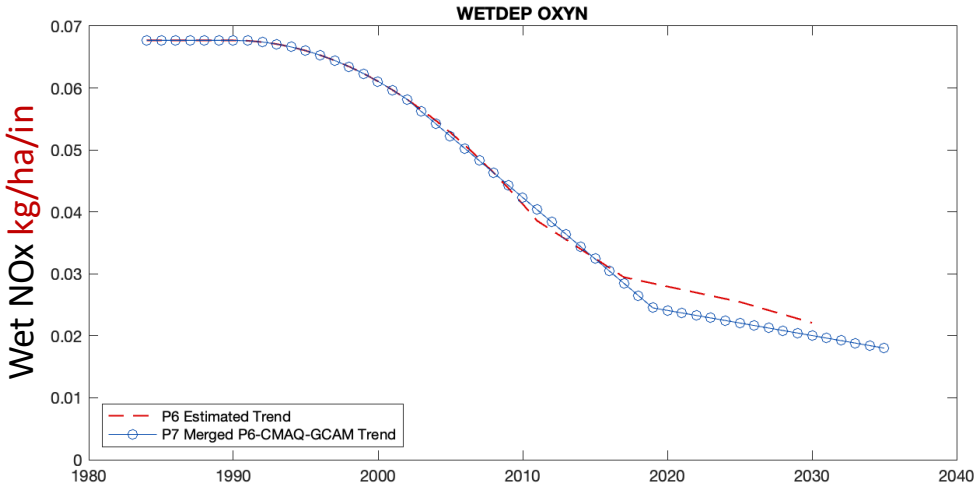
Phase 6 data at CH3D grid cells

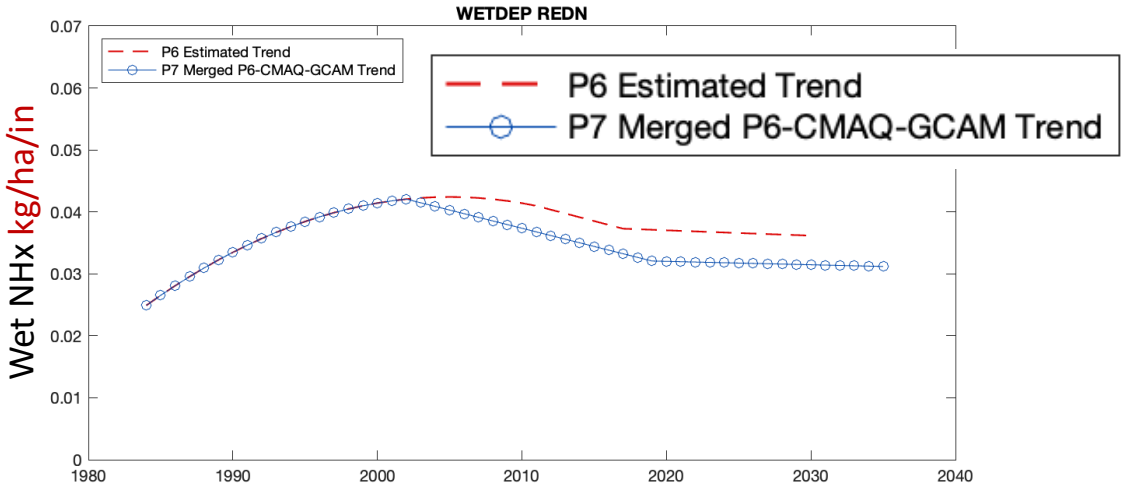
11,101 CH3D grid cells to 248 CMAQ grid cells

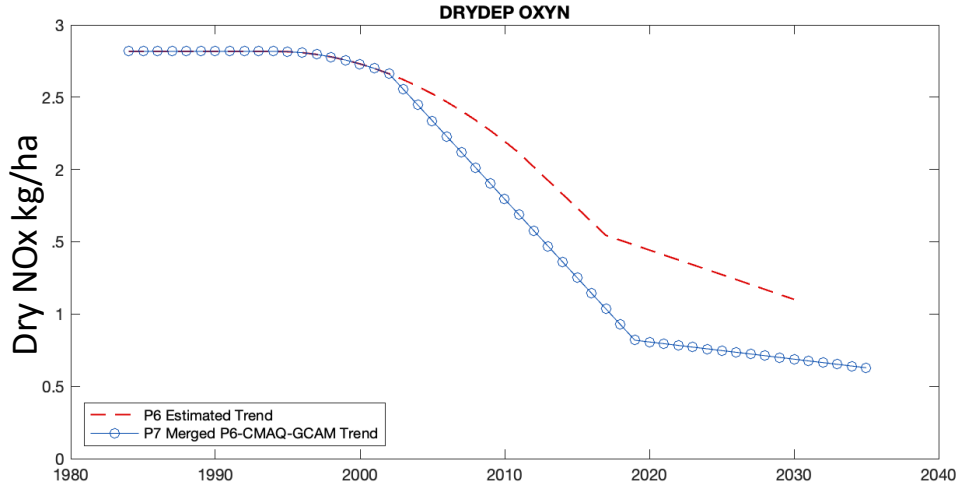
Phase 6 data at CMAQ grid cells

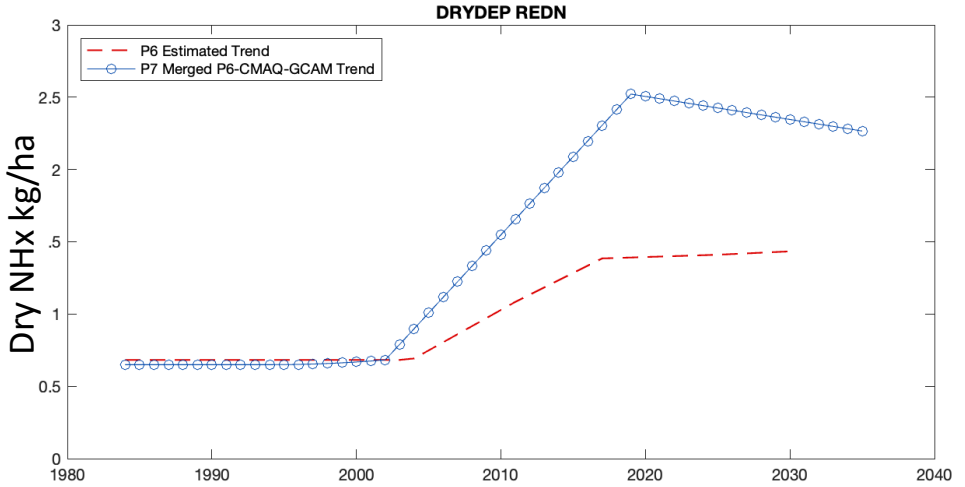
Method for merging Phase 6, CMAQ, and GCAM loads

TIDAL BAY – 55 CMAQ TIDAL WATER GRIDS



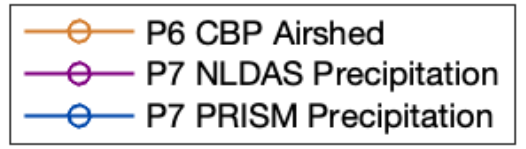


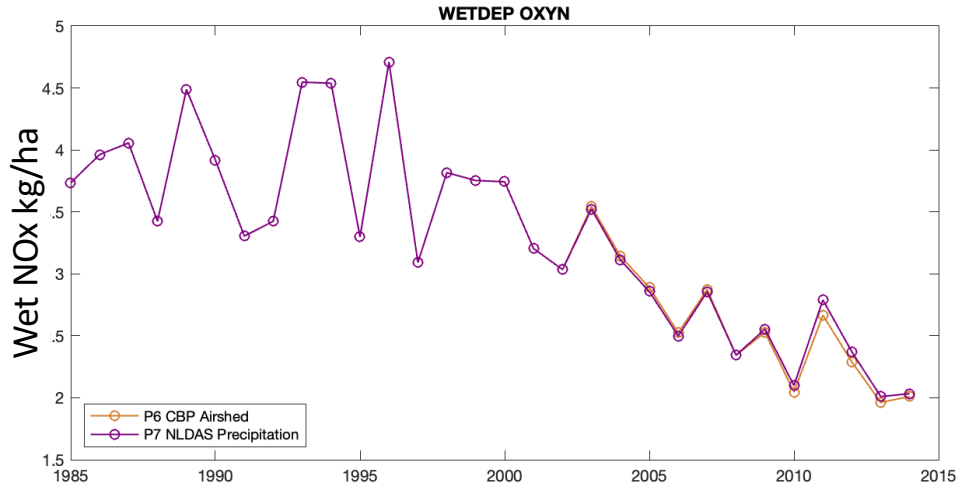


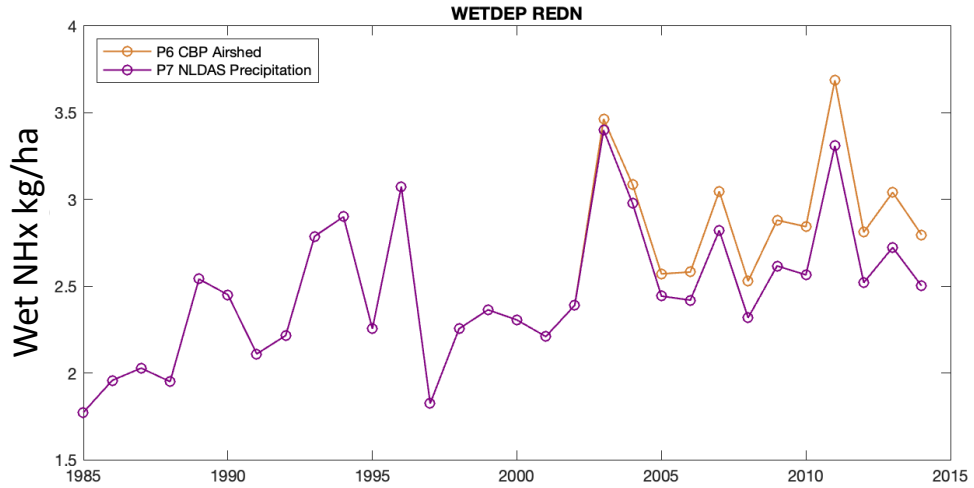


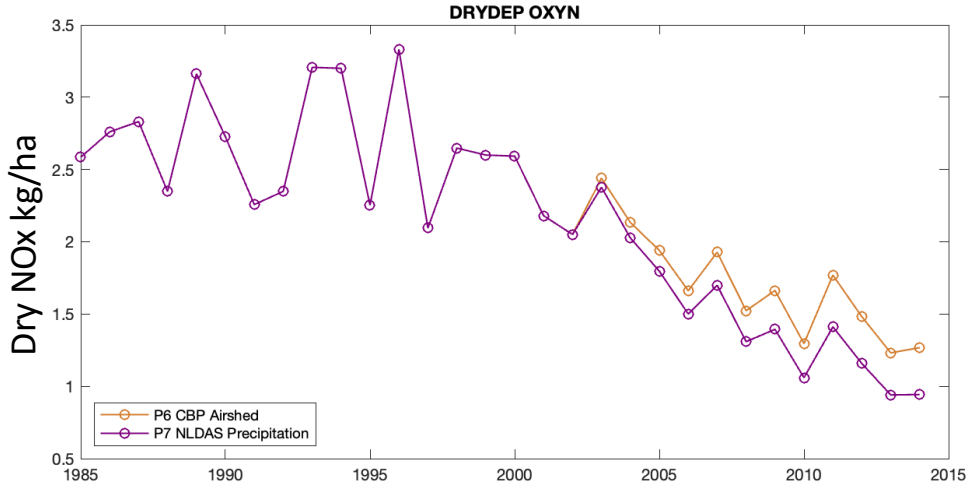
With variability in meteorology (and emissions)

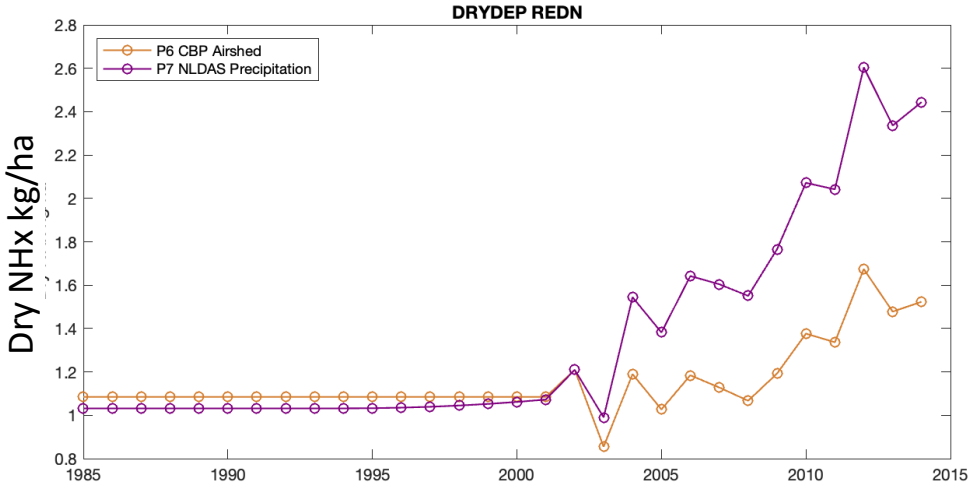
Grid 142x360 – CHESAPEAKE BAY











Summary

1. We have a method in place that uses Phase 6, CMAQ, and GCAM data for estimating Phase 7 atmospheric N deposition –

- N-deposition data for the calibration period (1985-2024)
- It has coverage for the both WSM and MBM domains
- Estimates for the past and future trends in loads

>> Next Steps for the atmospheric deposition

2. (a) estimate for direct N-deposition to the Bay based on PRISM precipitation; (b) process for generating data for Coastal Ocean; (c) additional analyses and QA QC; (d) linkage with the MBM and MTMs (i.e., NetCDF file format).

Appendices

- We received CMAQ data for 2016 along with the data for 2035 and 2050 under scenarios of **(a)** Inflation Reduction Act & Limited GHG Mitigation (**IRA LM**) and **(b)** Net Zero by 2050 with national scale implementations of state GHG reduction goals (**Net Zero**).