2019 Climate Change Assessment – Watershed Modeling Progress Update

Modeling Workgroup Quarterly Meeting – April 2019

Gopal Bhatt[1] and Lewis Linker[2]

[1] Penn State, [2] US EPA – Chesapeake Bay Program Office

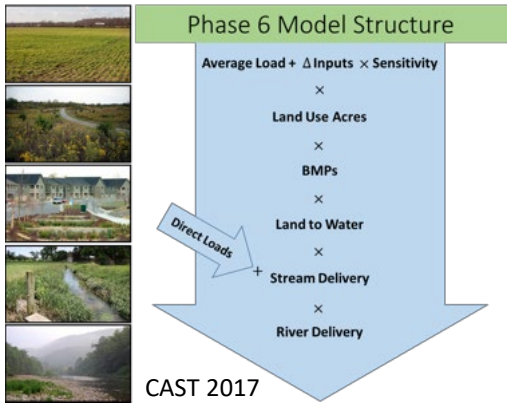
Presentation outline

1. How the load reduction effectiveness of best management practices (BMPs) are calculated for climate change scenarios.
2. How rainfall volume delta change is estimated for climate change scenarios beyond Year 2025.
3. Evaluation of land cover land use change impacts on climate change assessment.

- Brief overview, inputs, model results, summary.
- Climate change assessments for 2025, 2035, 2045 and 2055 are shown.

1. Load reduction effectiveness of best management practices (BMPs)

- In prior climate change assessments, BMP effectiveness data of corresponding baseline scenario were used (e.g., 2010 WIP2 with Climate Change used effectiveness data of 2010 WIP2).



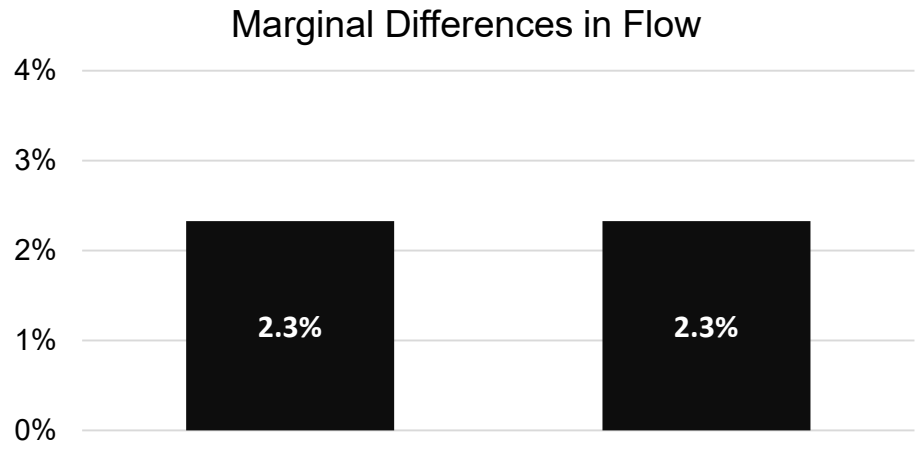
CAST 2017

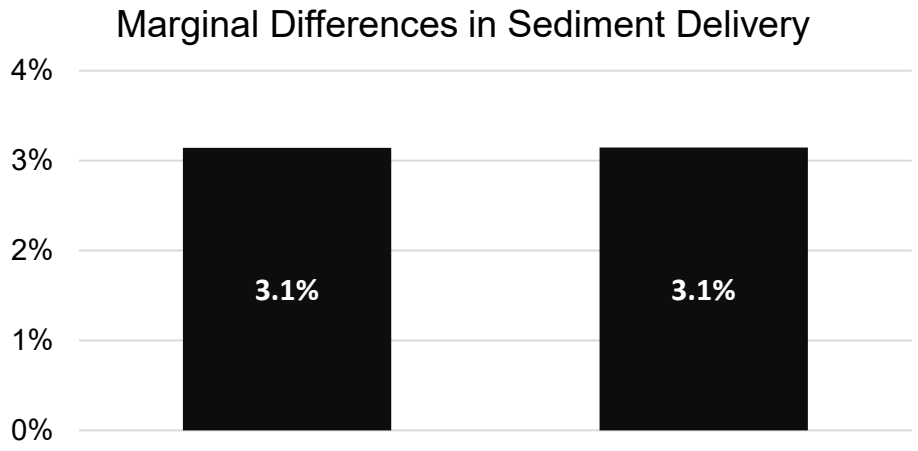
- A potential improvement would be to perform BMP effectiveness calculations in CAST for a better accounting of their effects with changes in loads due to climate change.

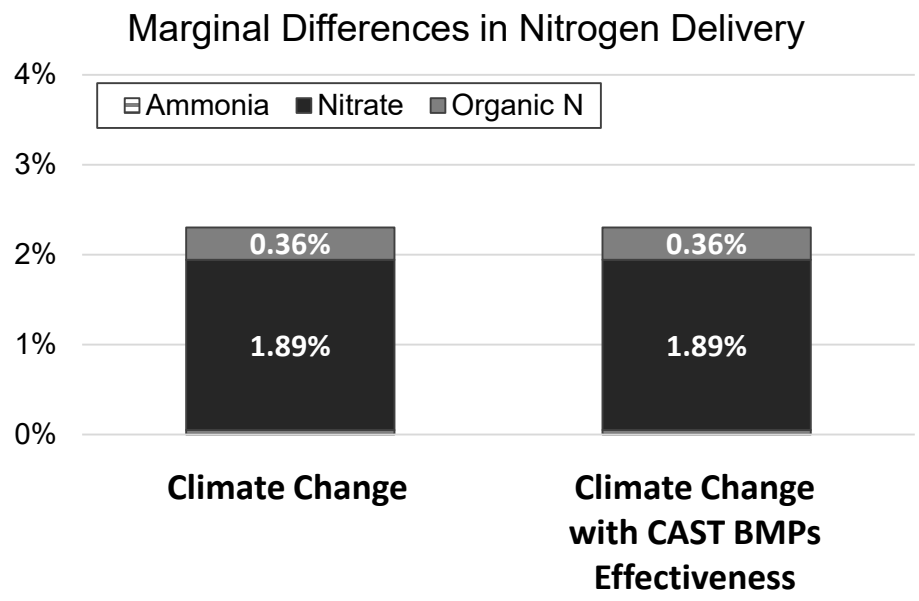
Different from potential changes in BMP effectiveness with Climate Change.

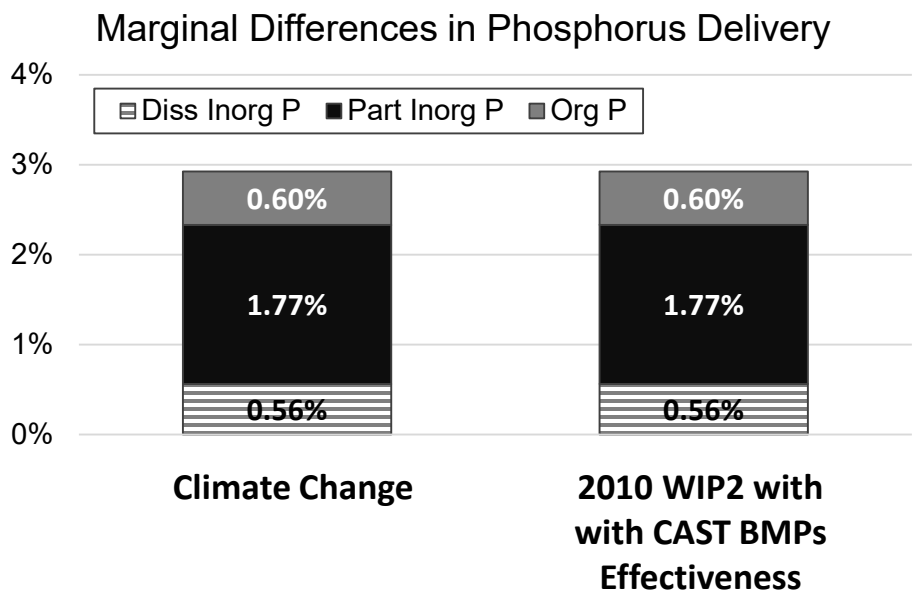
Chesapeake Bay Program, 2017. Chesapeake Assessment and Scenario Tool (CAST) Version 2017d. Chesapeake Bay Program Office, Last accessed [March, 2019].

BMPs effectiveness calculated in CAST *Rigelman, J.*





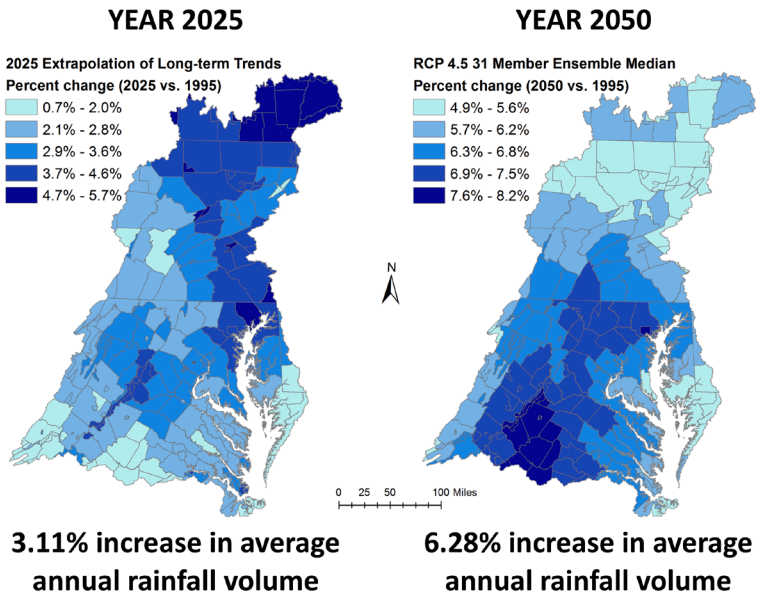


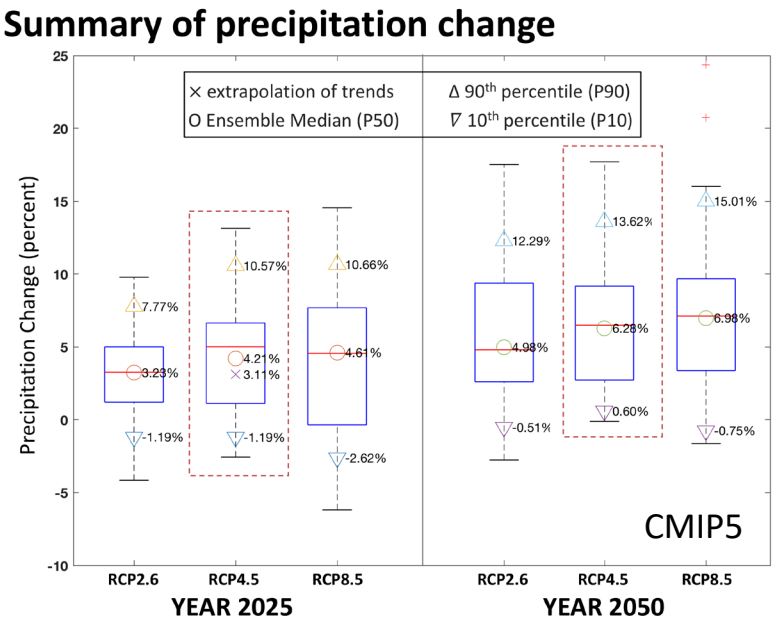


Differences are shown with respect to WIP2 Scenario on 2010 land use

2. How rainfall volume delta change is estimated for climate change scenarios beyond Year 2025

- As per STAC (2016)[1] and CBP Climate Resiliency Workgroup recommendations long-term trends were used for 2025 rainfall projections, and an ensemble of GCMs for 2050 and beyond.

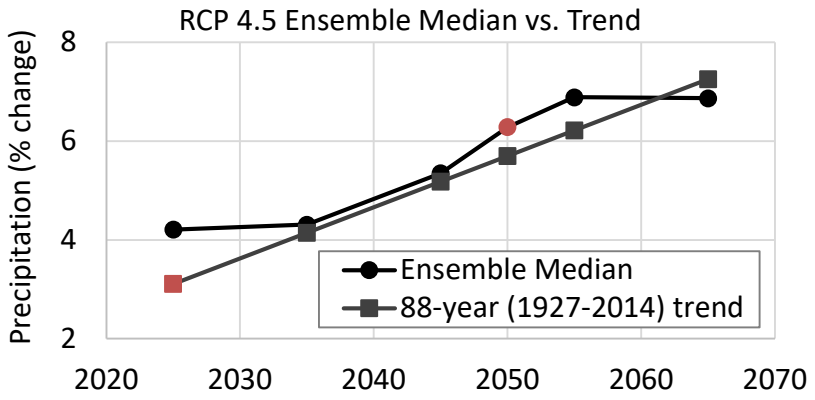


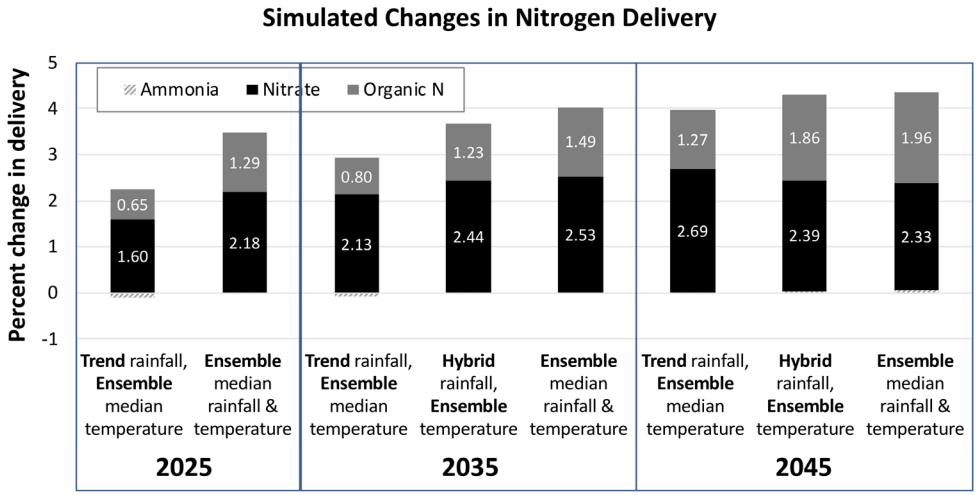


[1] Johnson et al., 2016 STAC Workshop Report – http://www.chesapeake.org/pubs/360_Johnson2016.pdf
[2] https://www.chesapeakebay.net/channel_files/25923/20181016_-_bhatt_-_mwqm_-_application_of_phase_6_watershed_model_to_climate_change_assessment.pdf

2. How rainfall volume delta change is estimated for climate change scenarios beyond Year 2025

- They form a source of discontinuity. Modeling workgroup in September 2018[1] recommended combining two data sources using weighted averages for the periods between 2025 and 2050.
- Model results were presented in October 2018[2].





***Trend**: projection of extrapolation of long-term trends*
***Ensemble**: 31-member ensemble of RCP4.5 GCMs*
***Hybrid**: weighted average of trend and ensemble*

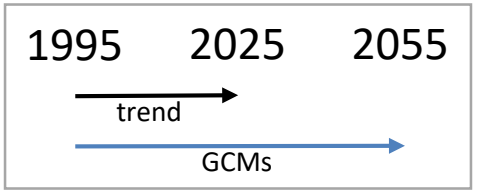
[1] https://www.chesapeakebay.net/channel_files/26032/20180911b_-_bhatt_-_mwcc_-_application_of_phase_6_watershed_model_to_climate_change_assessment.pdf
[2] https://www.chesapeakebay.net/channel_files/25923/20181016_-_bhatt_-_mwqm_-_application_of_phase_6_watershed_model_to_climate_change_assessment.pdf

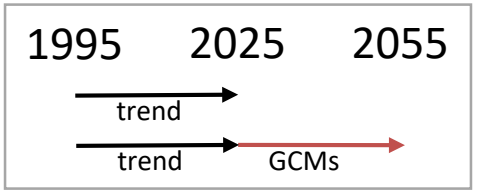
2. How rainfall volume delta change is estimated for climate change scenarios beyond Year 2025

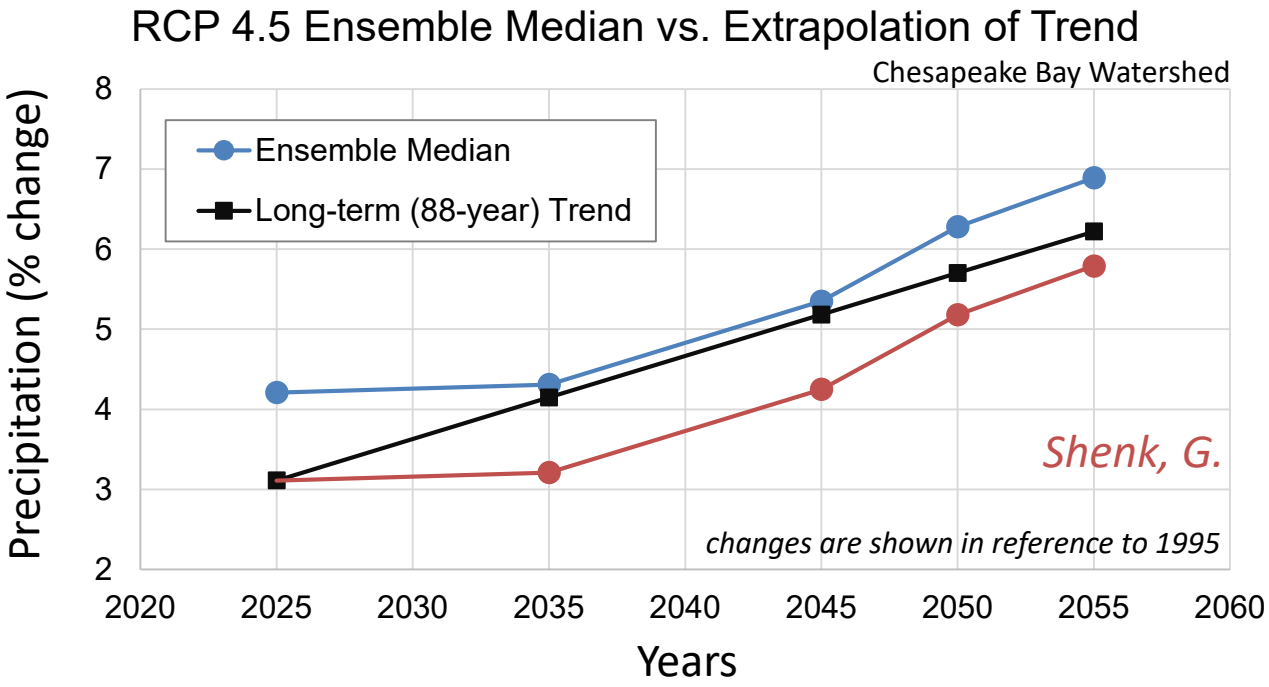
- An alternative would be to estimate delta change for the periods beyond 2025 by adding GCM delta for a future year and 2025 to the trend-based delta for 2025.

Hybrid vs. **Proposed**

(delta change for GCMs *wrt* 2025)

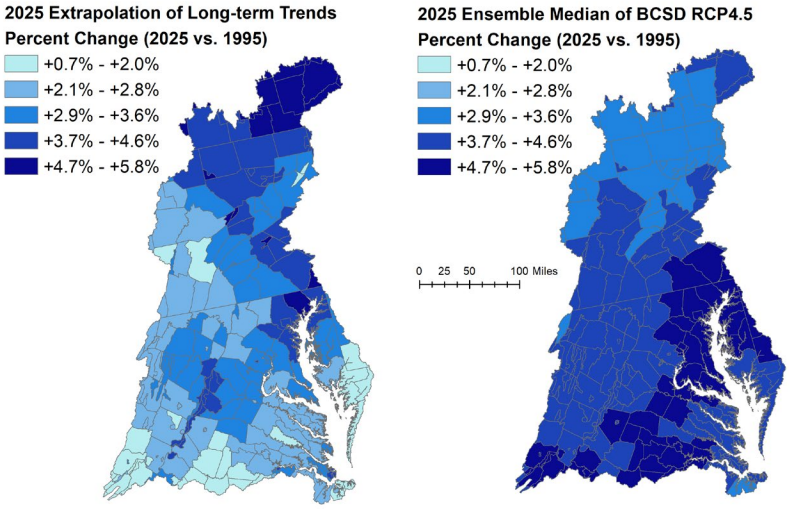


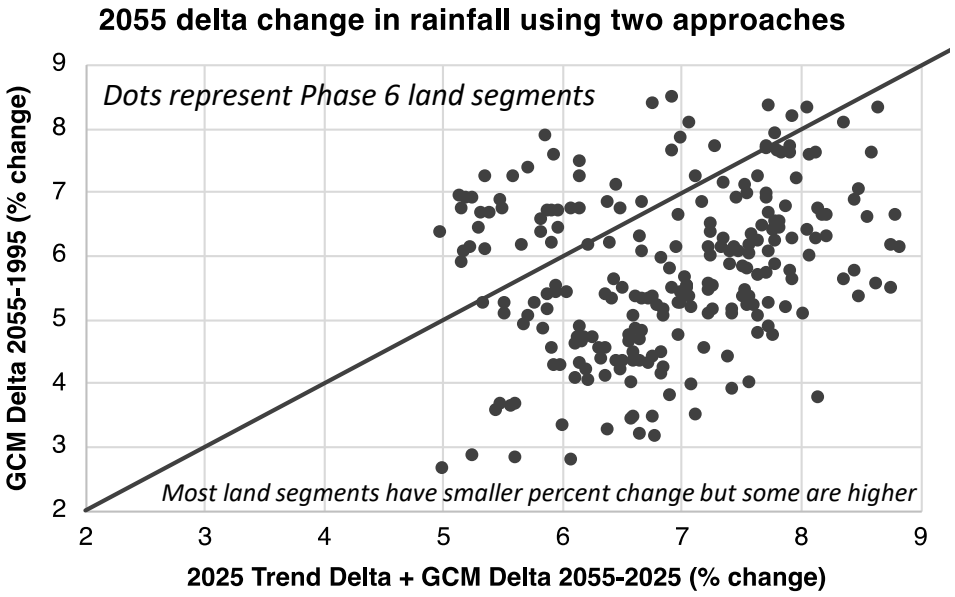


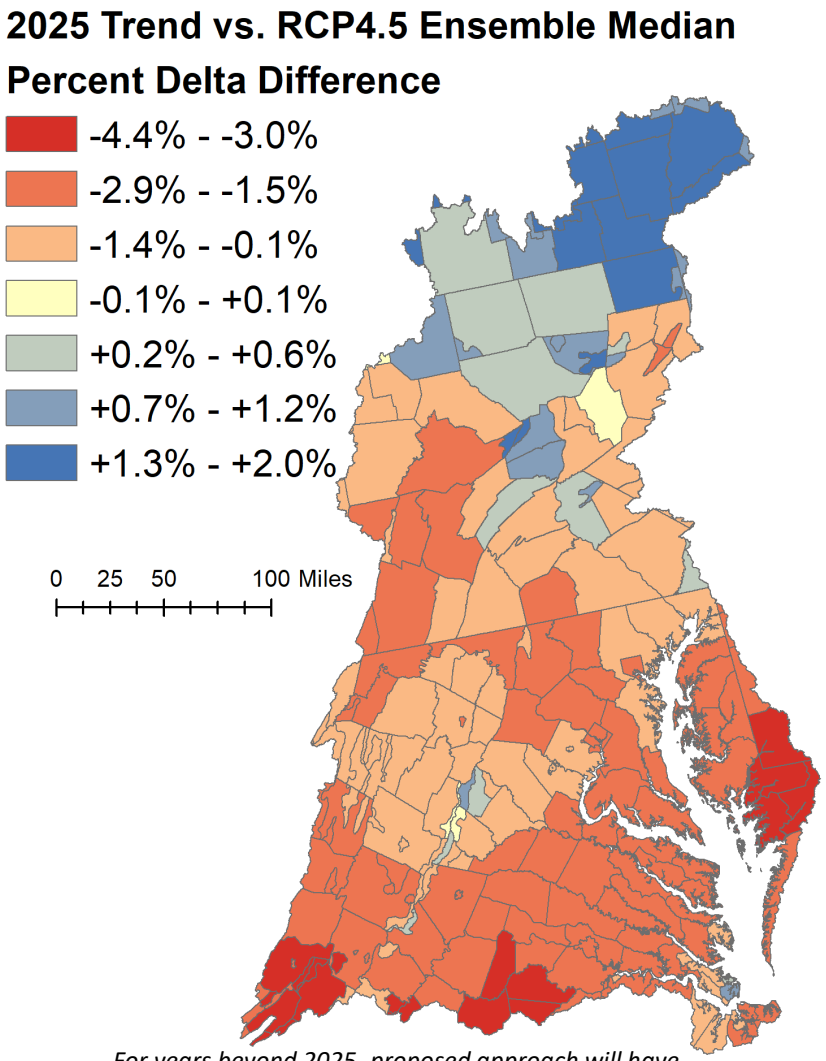


***Ensemble**: 31-member ensemble of RCP4.5 GCMs; **Trend**: extrapolation of long-term (1927-2014) trends;*

E.g., Rainfall volume delta change for Year 2055







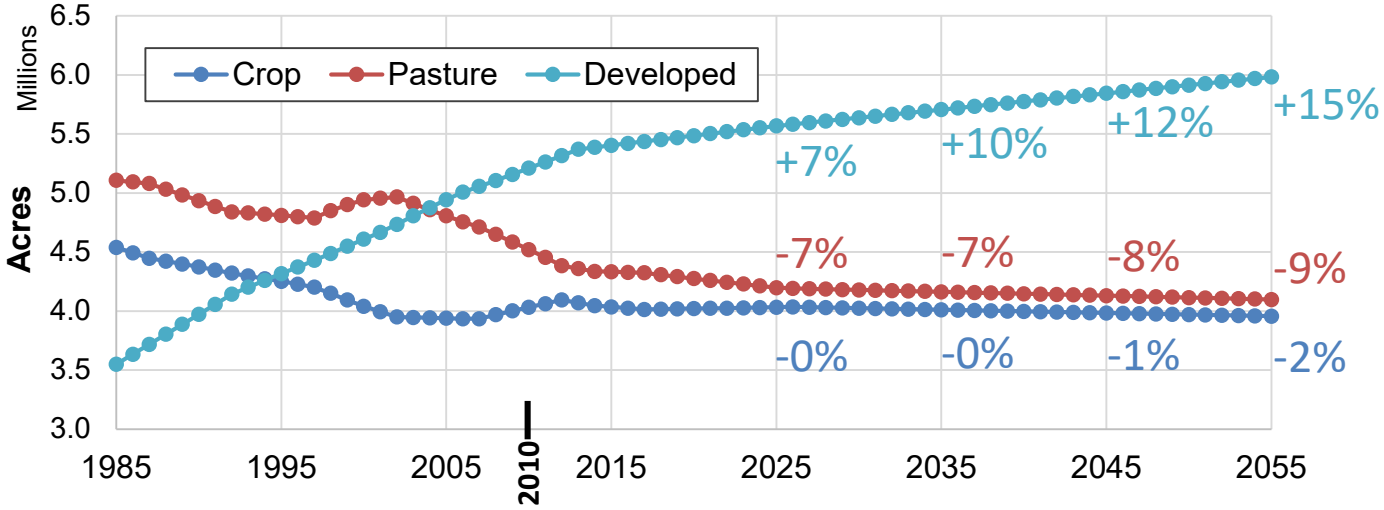
For years beyond 2025, proposed approach will have lower rainfall for the land segments shown in red

3. Evaluation of land cover land use change impacts on climate change assessment

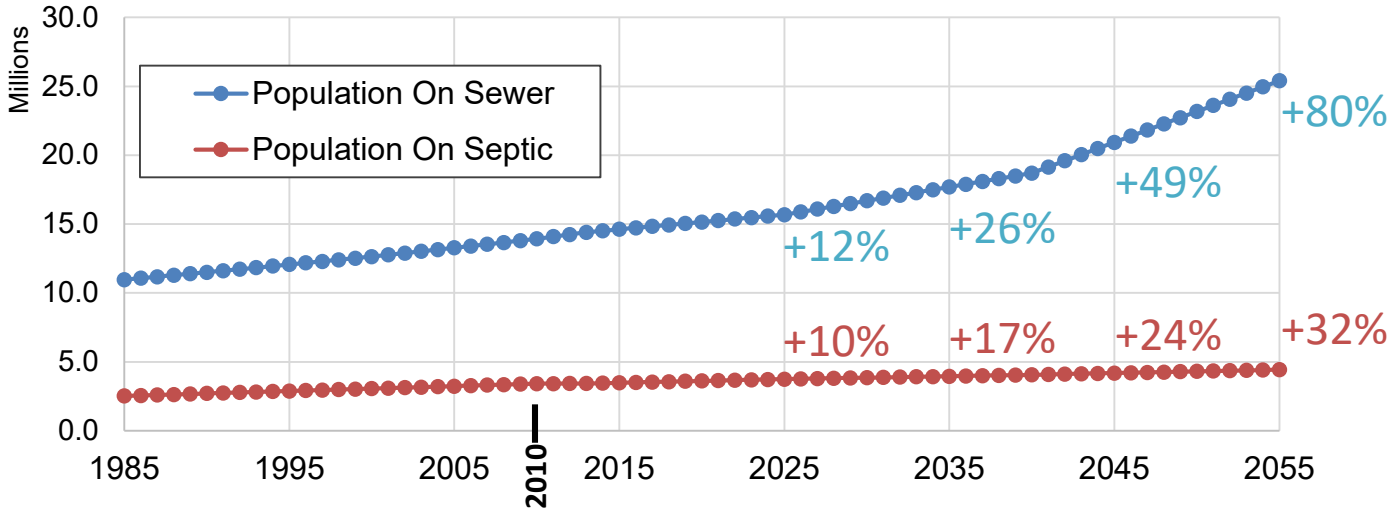
- Land use effects the baseline nutrients and sediment loads, and therefore the marginal differences in loads with climate change.
- The future projections of land use and populations on sewer and septic systems were estimated using Chesapeake Bay Land Change Model (CBLCM Version 4 – *Claggett, P., et al.*)

County-level demographic population projections for 2020, 2030, and 2040 were downloaded from each jurisdiction's official projection provider. Projections beyond 2040 were developed by the CBPO through linearly extrapolating trends from 2010 – 2040.

Land use acres - Chesapeake Bay Watershed

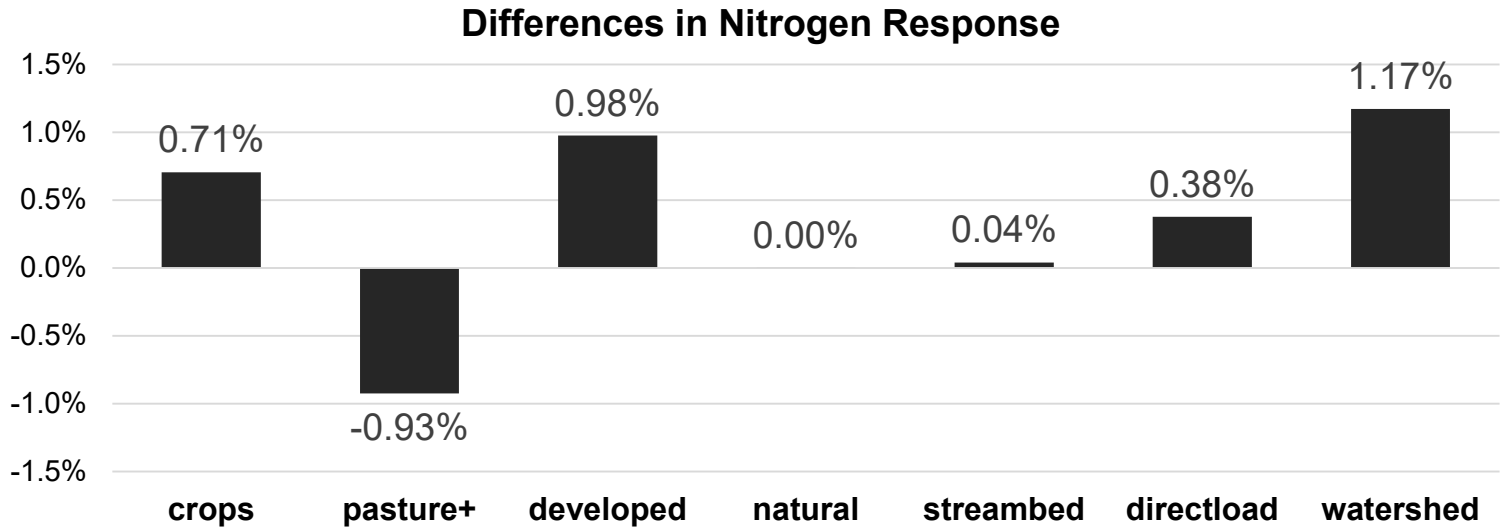


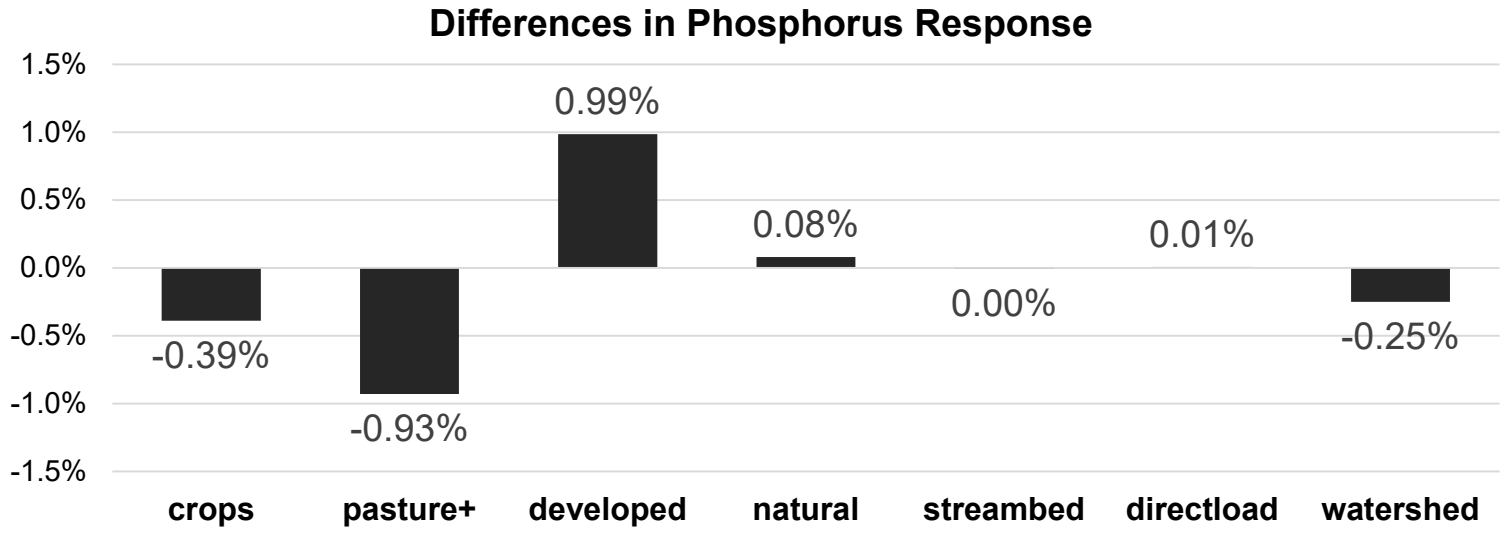
Population - Chesapeake Bay Watershed



Pre-BMP land use acres are shown.
Percent changes are shown with respect to 2010 (with WIP2 level of effort)

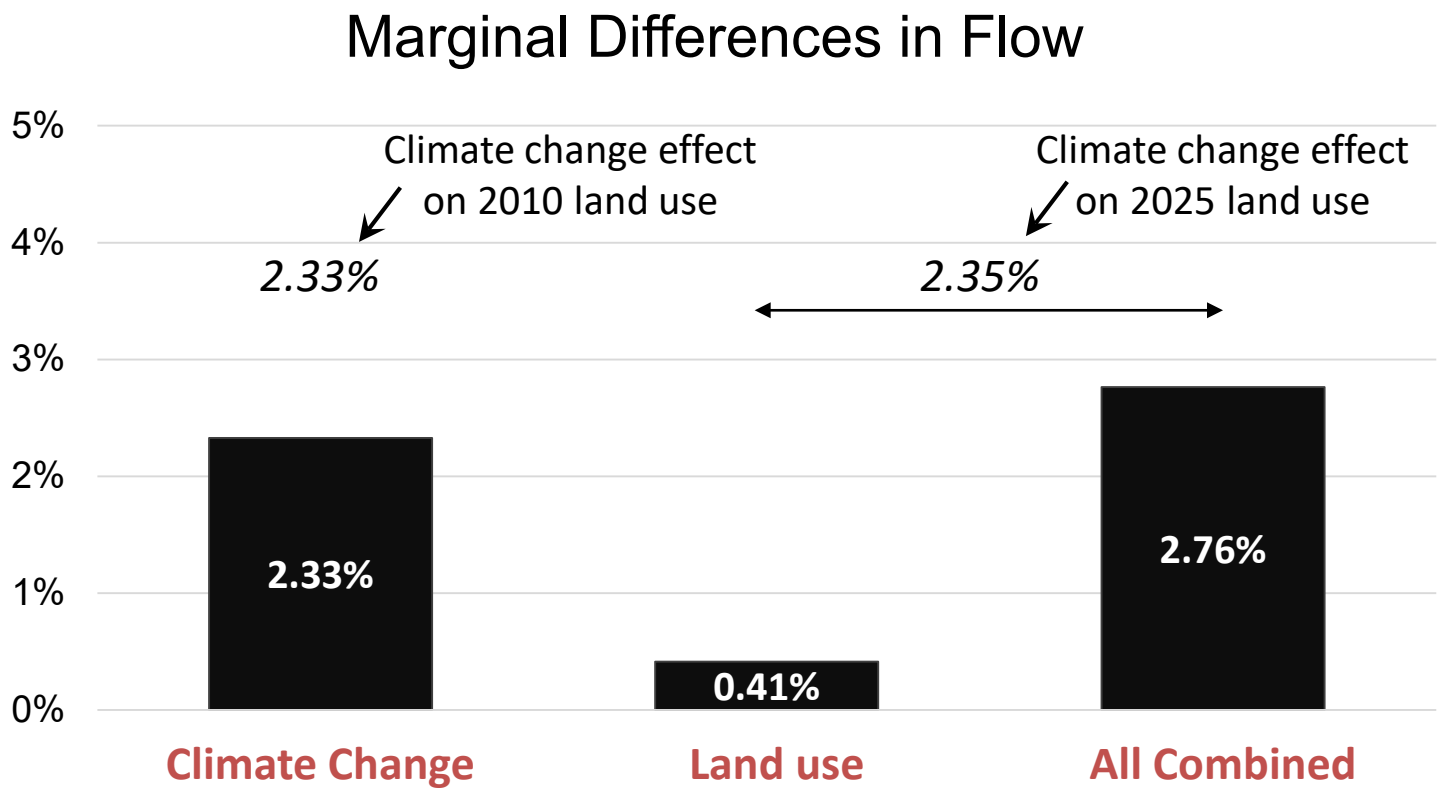
WIP2 level of effort on 2025 vs. 2010 land use





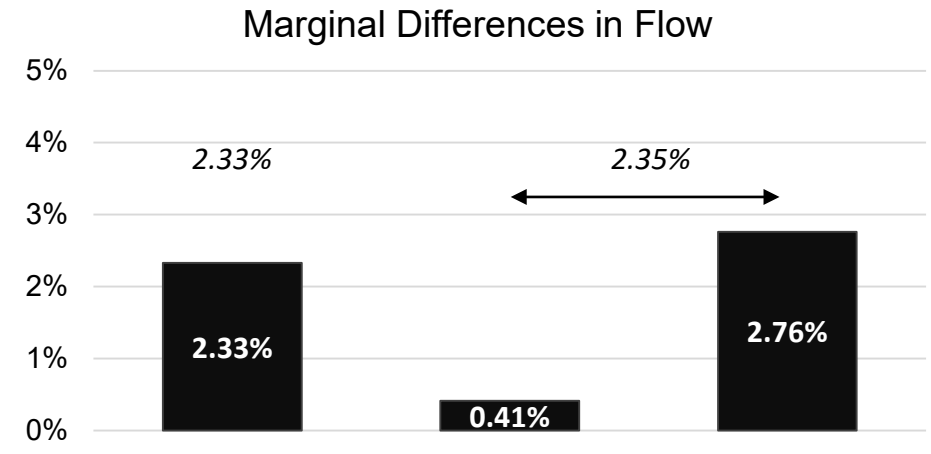
Figures show load sources contributing to the differences in nitrogen and phosphorus loads with changes in land use

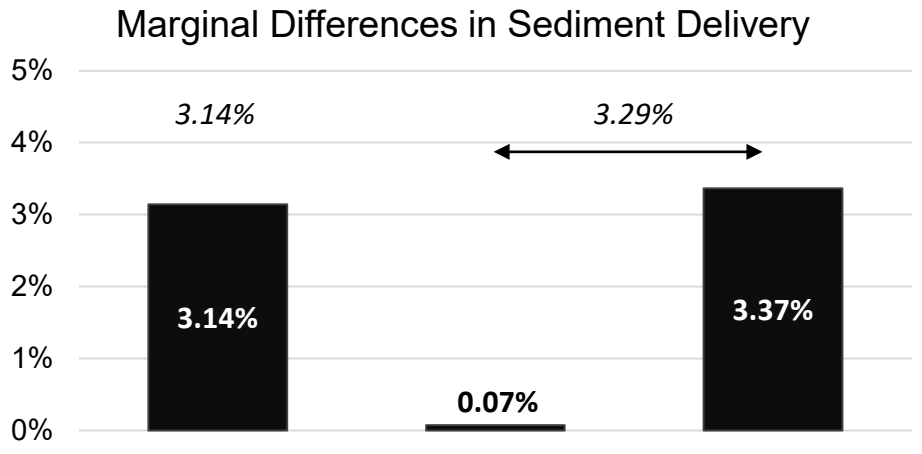
2025 sensitivity scenarios

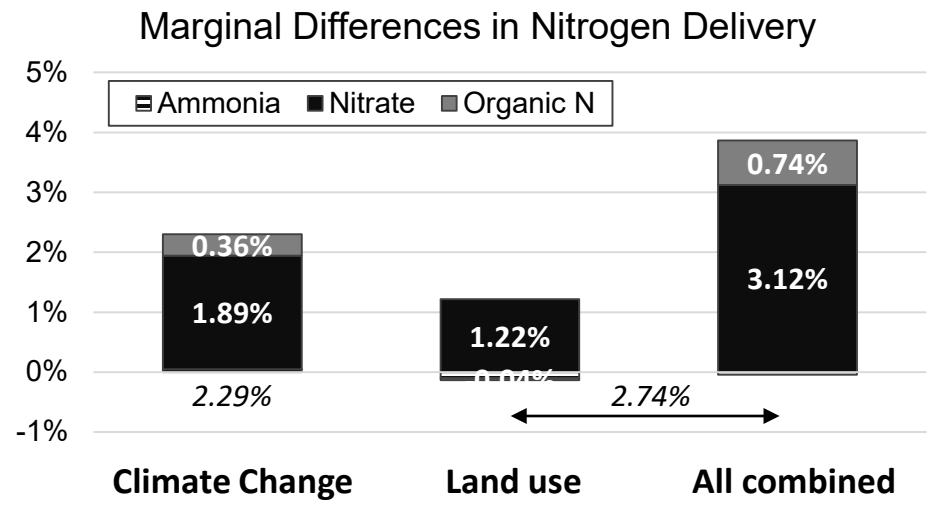


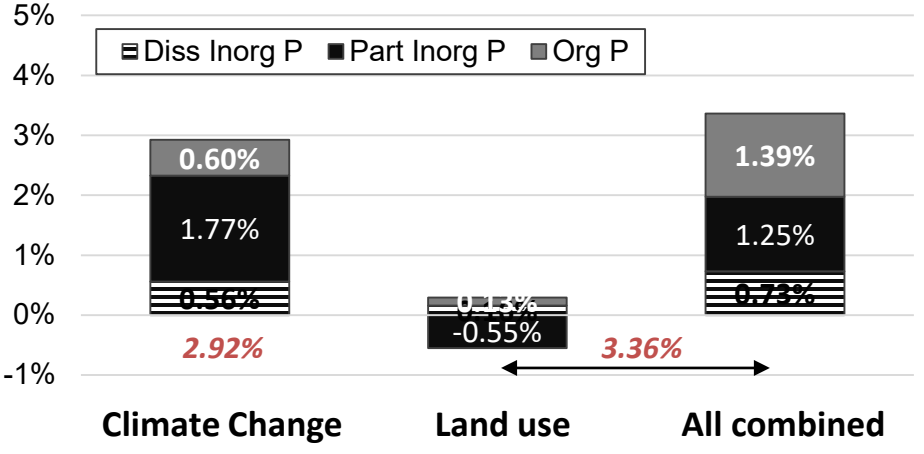
Differences are shown with respect to WIP2 on 2010 land use

2025 sensitivity scenarios





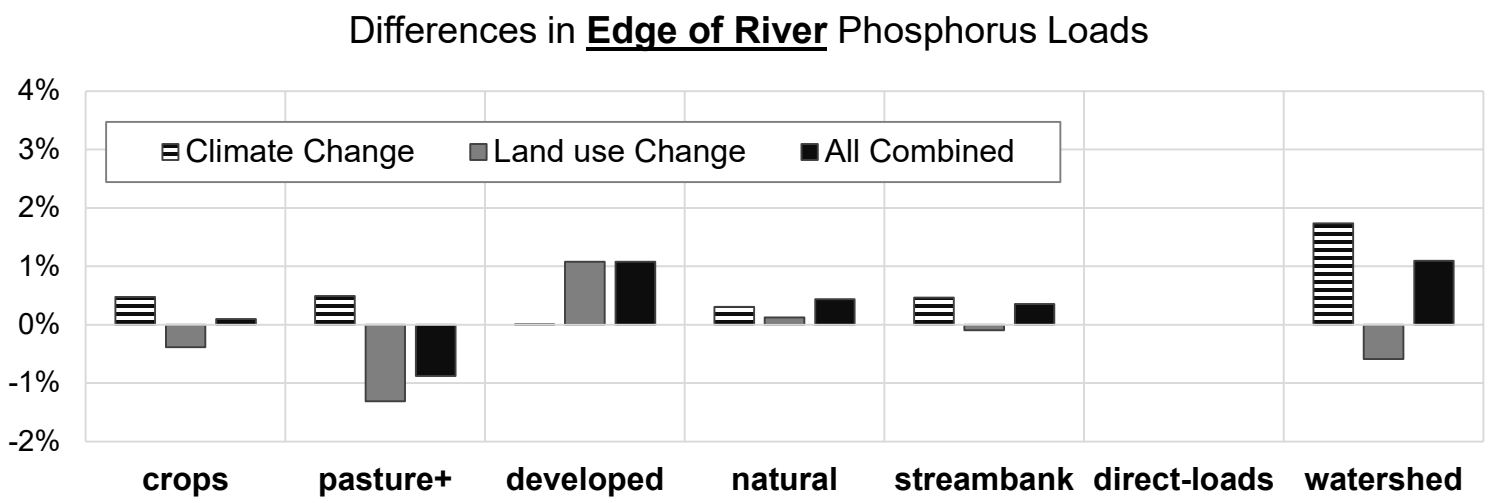


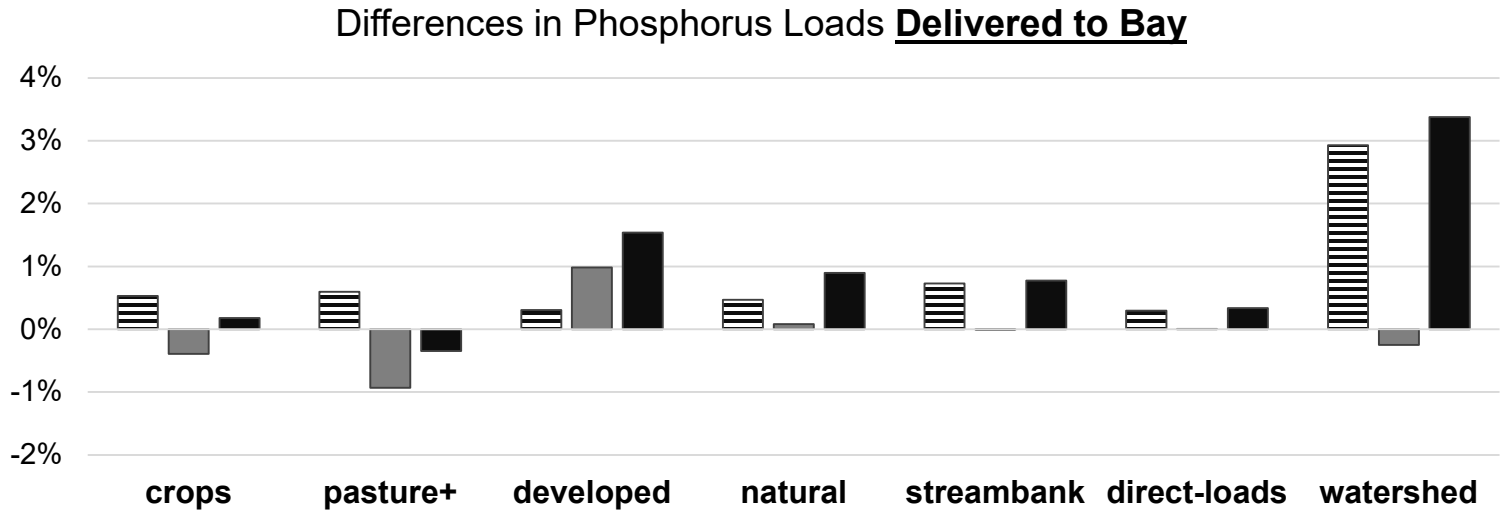


Going forward use WIP2 on 2025 land use for climate change assessments until WIP3 is available.

Differences are shown with respect to WIP2 delivery on 2010 land use

Phosphorus delivery

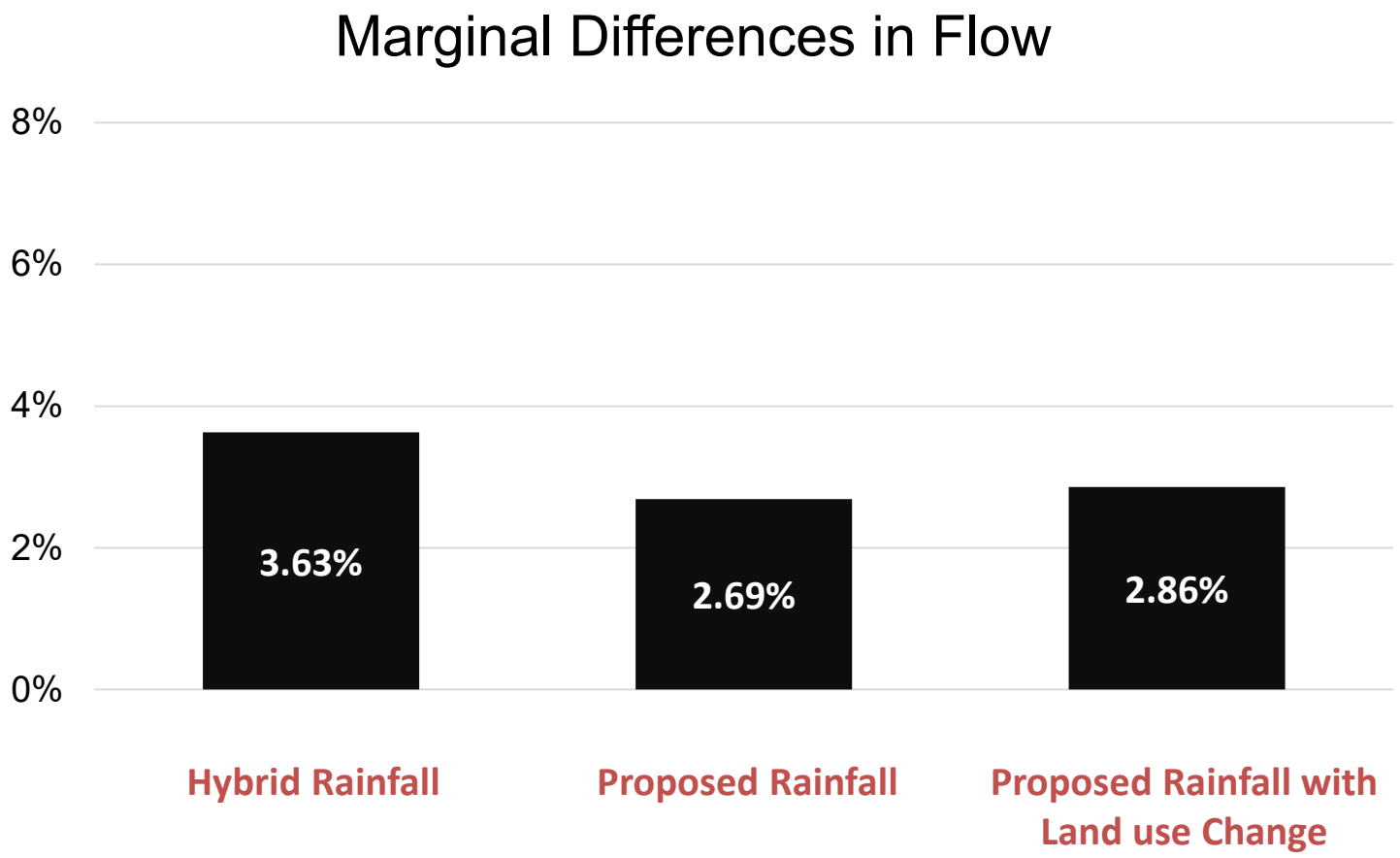




Climate change on 2025 land use had higher riverine response, particularly due to larger developed footprint.

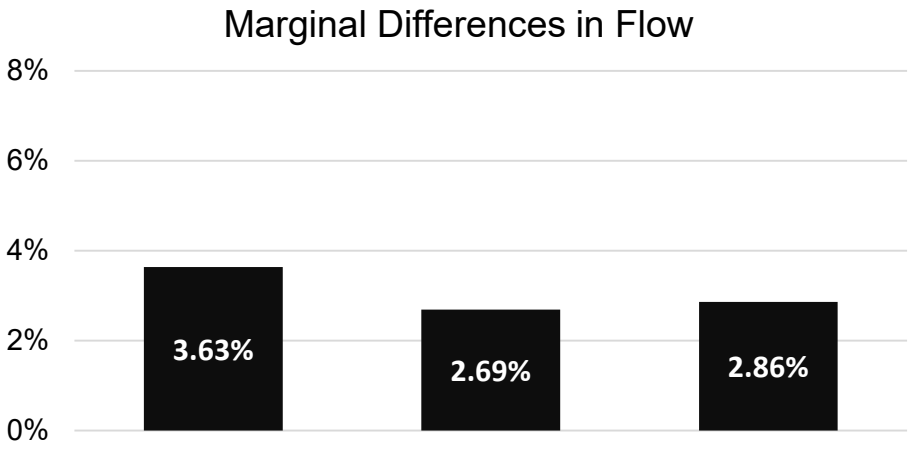
Differences are shown with respect to WIP2 on 2025 land use

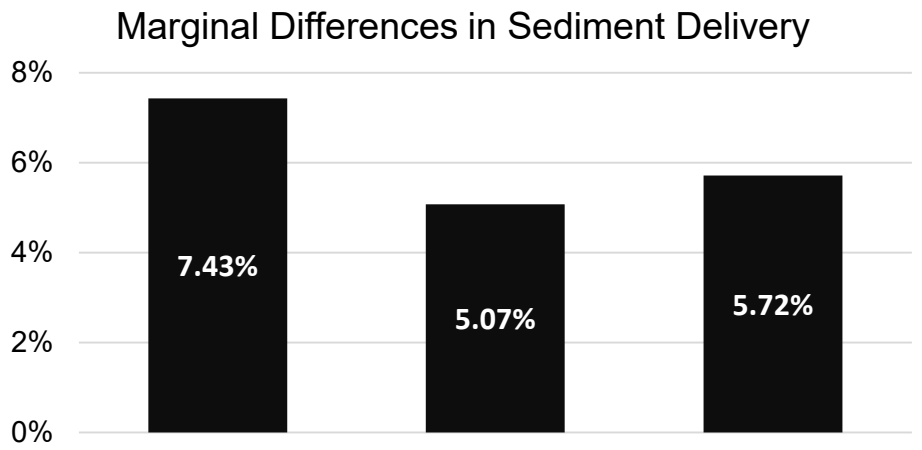
2035 sensitivity scenarios

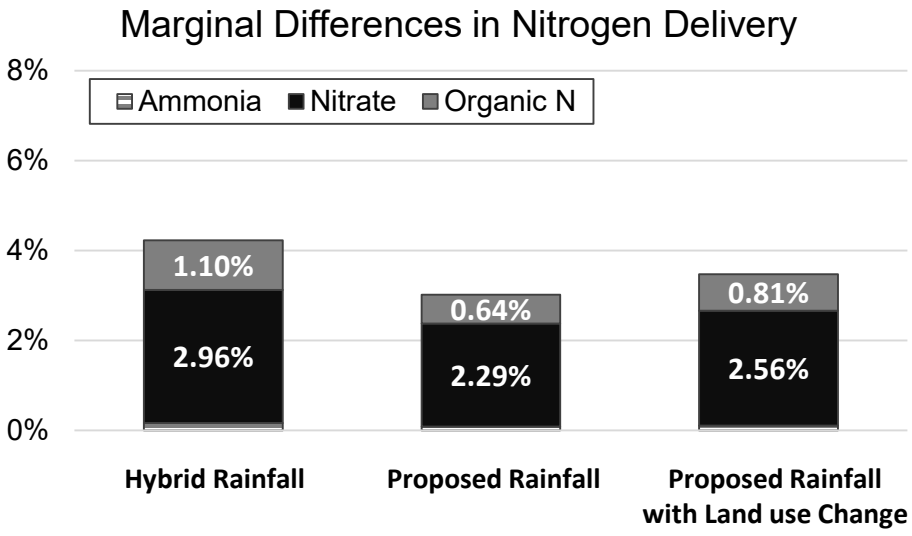


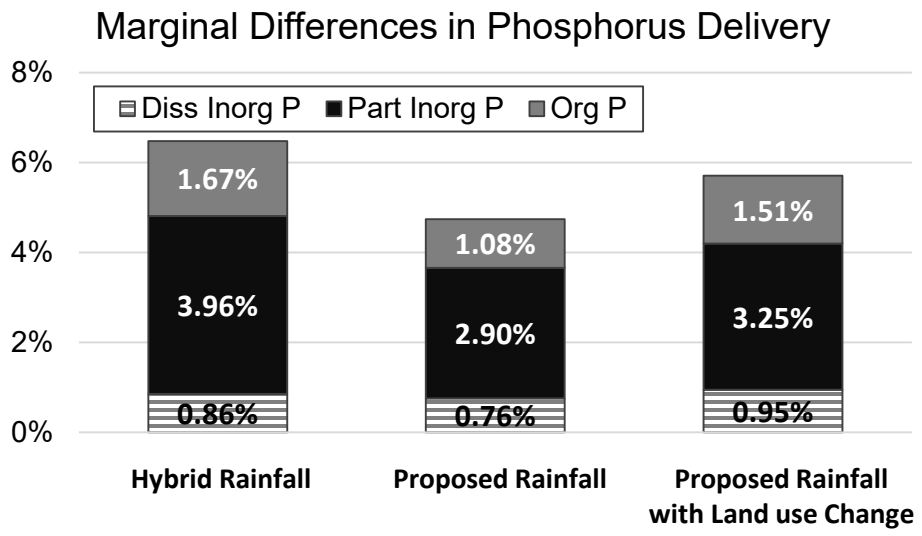
Differences are shown with respect to WIP2 on 2025 land use

2035 sensitivity scenarios



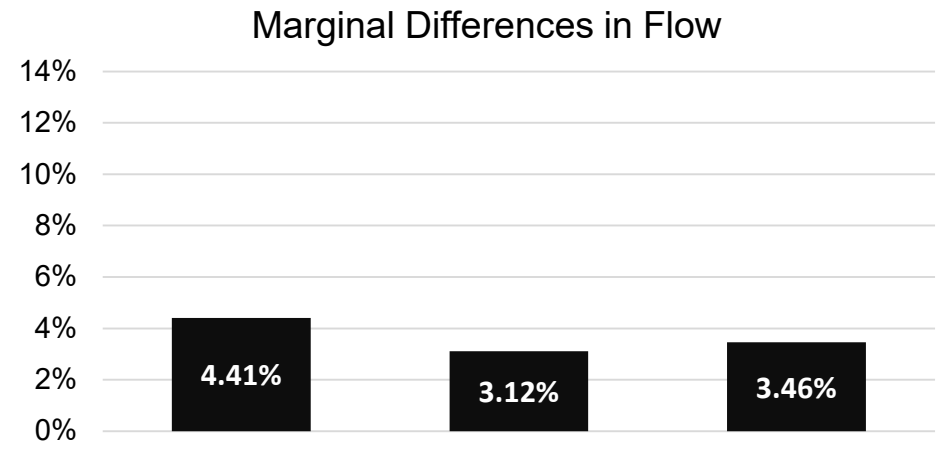


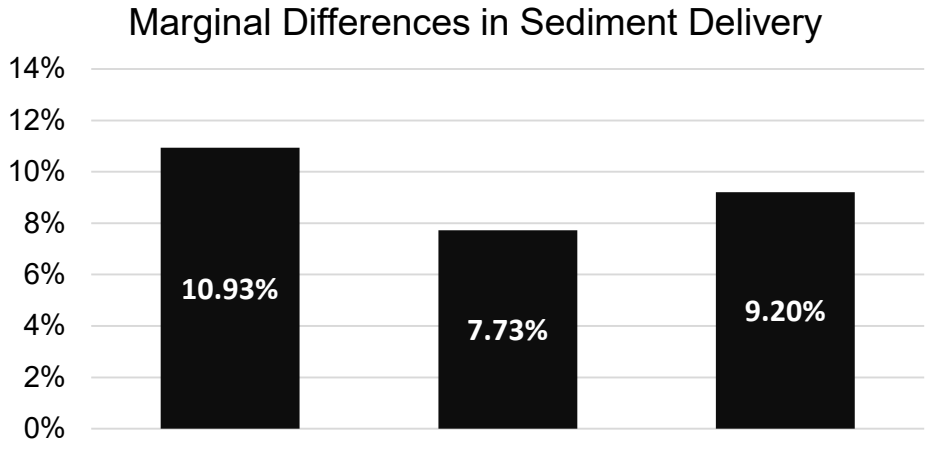


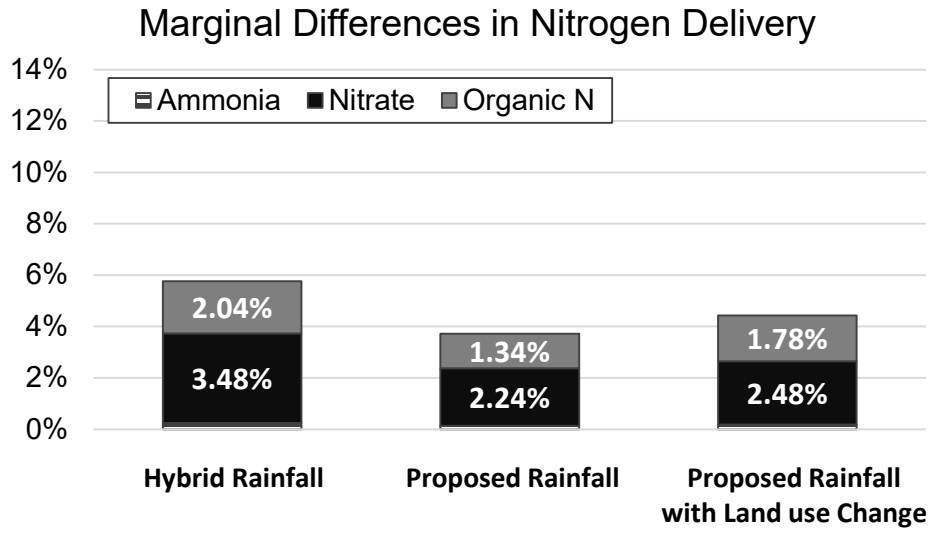


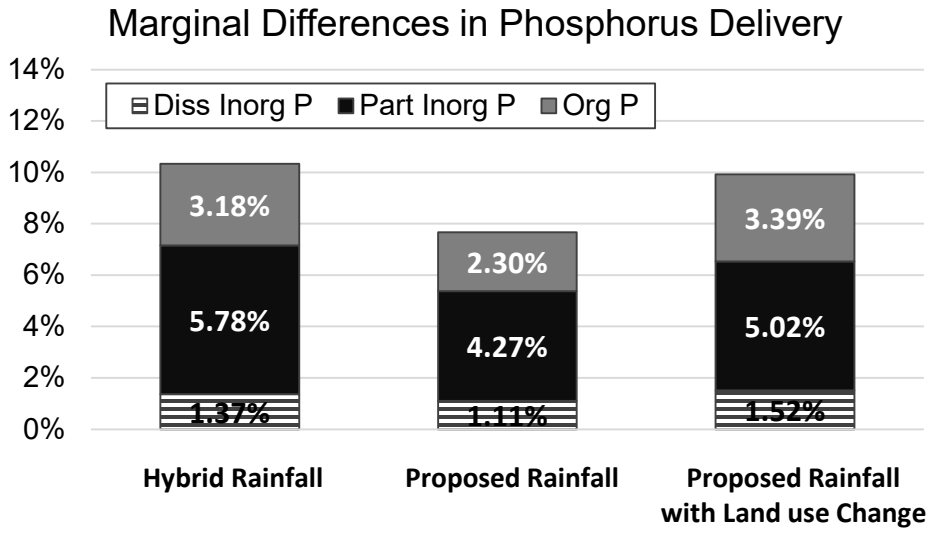
Differences are shown with respect to WIP2 on 2025 land use

2045 sensitivity scenarios



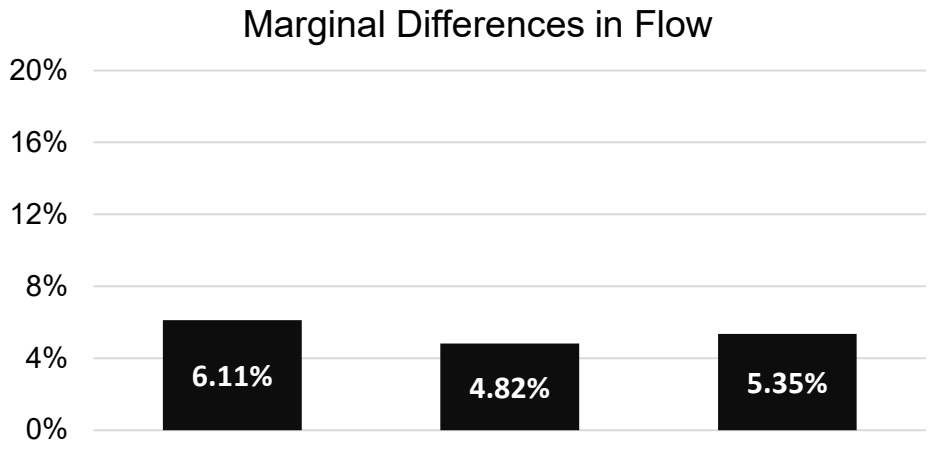


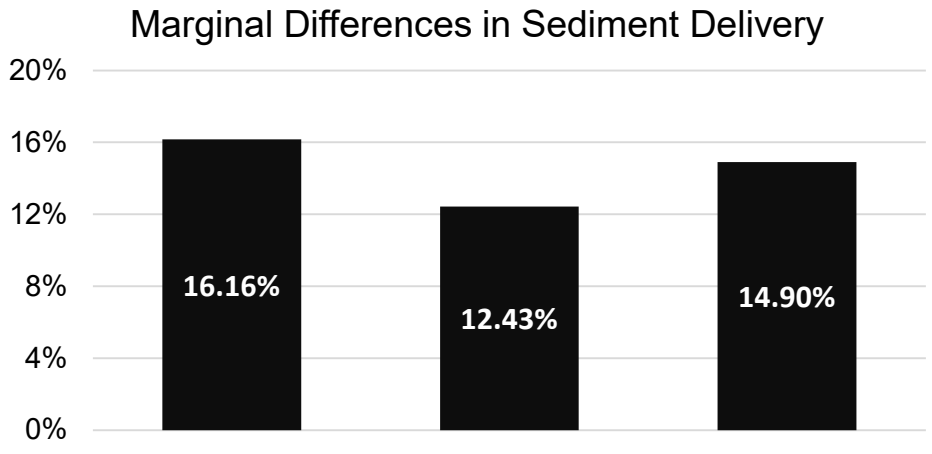


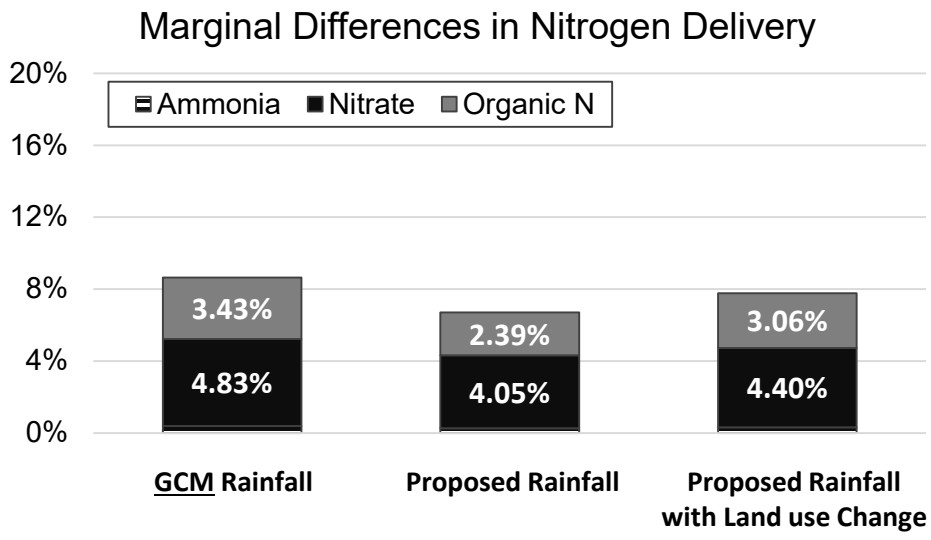


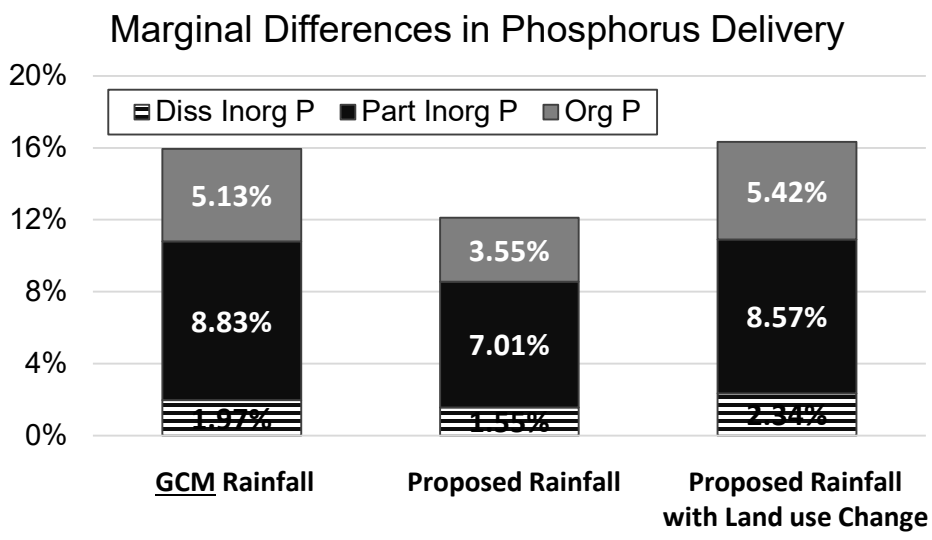
Differences are shown with respect to WIP2 on 2025 land use

2055 sensitivity scenarios



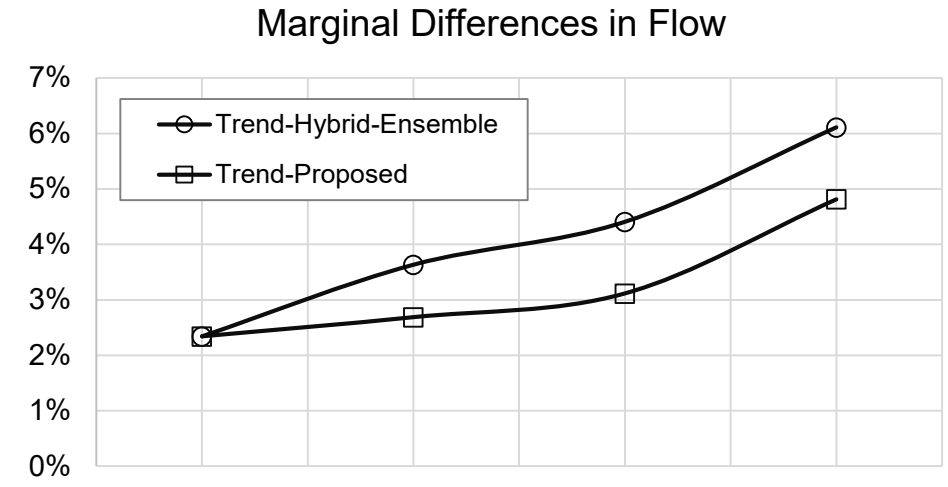


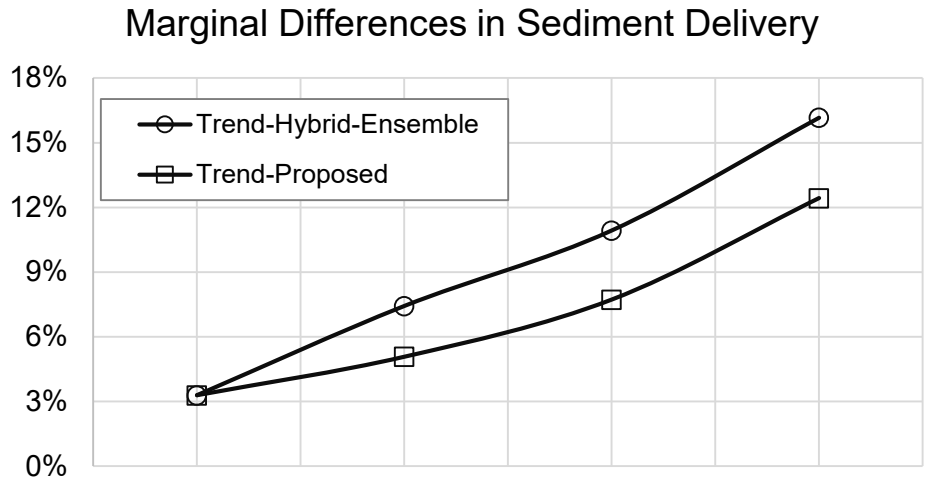


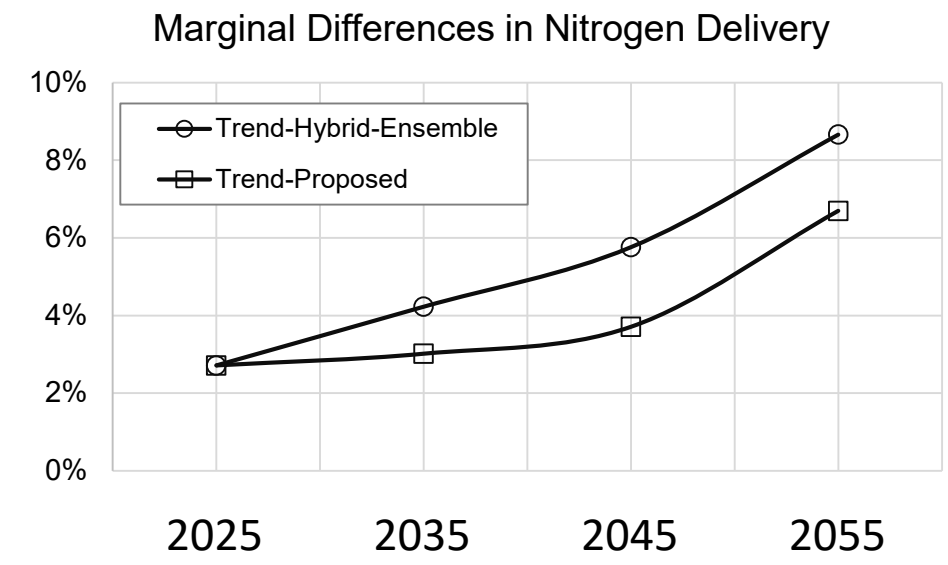


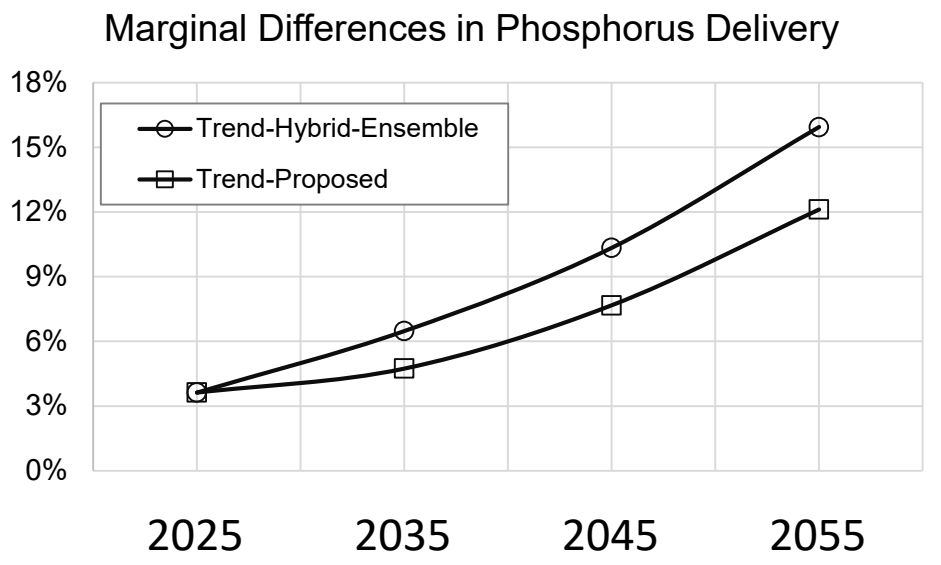
Differences are shown with respect to WIP2 on 2025 land use

2025, 2035, 2045, & 2055 Summary









'Proposed' rainfall for 2035, 2045, and 2055 offer better continuity with extrapolation of long-term trends for 2025 rainfall

Summary and Conclusions

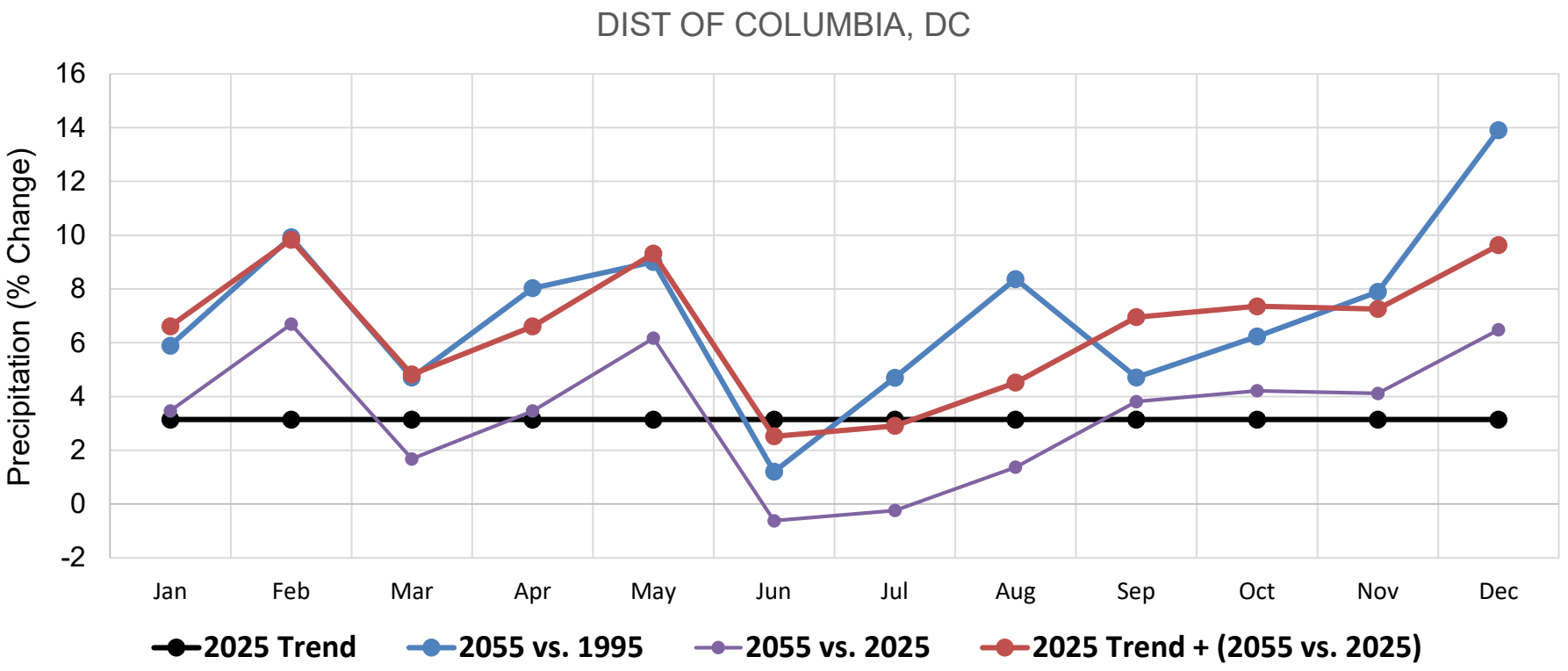
- Results of climate change assessments for 2025, 2035, 2045, and 2055 were shown.
- Climate change simulations were updated to improve: (a) how BMP effectiveness are calculated, (b) how the delta change in rainfall volume is estimated for periods beyond 2025, (c) examine the effect of land use change projections.
- BMP effectiveness calculation in CAST improves consistency between time-averaged and dynamical models.
- Proposed change for rainfall provides a better blend between trend based projections and ensemble of GCMs.
- Land use change projections slightly compounds the climate change effects.

- Trend-based rainfall projections (estimated from annual rainfall data) did not have any monthly/seasonal component.
- Analysis did not include changes in socio-economic responses, crop yields, growing degree days, atmospheric deposition, and best management practices (BMPs) etc.

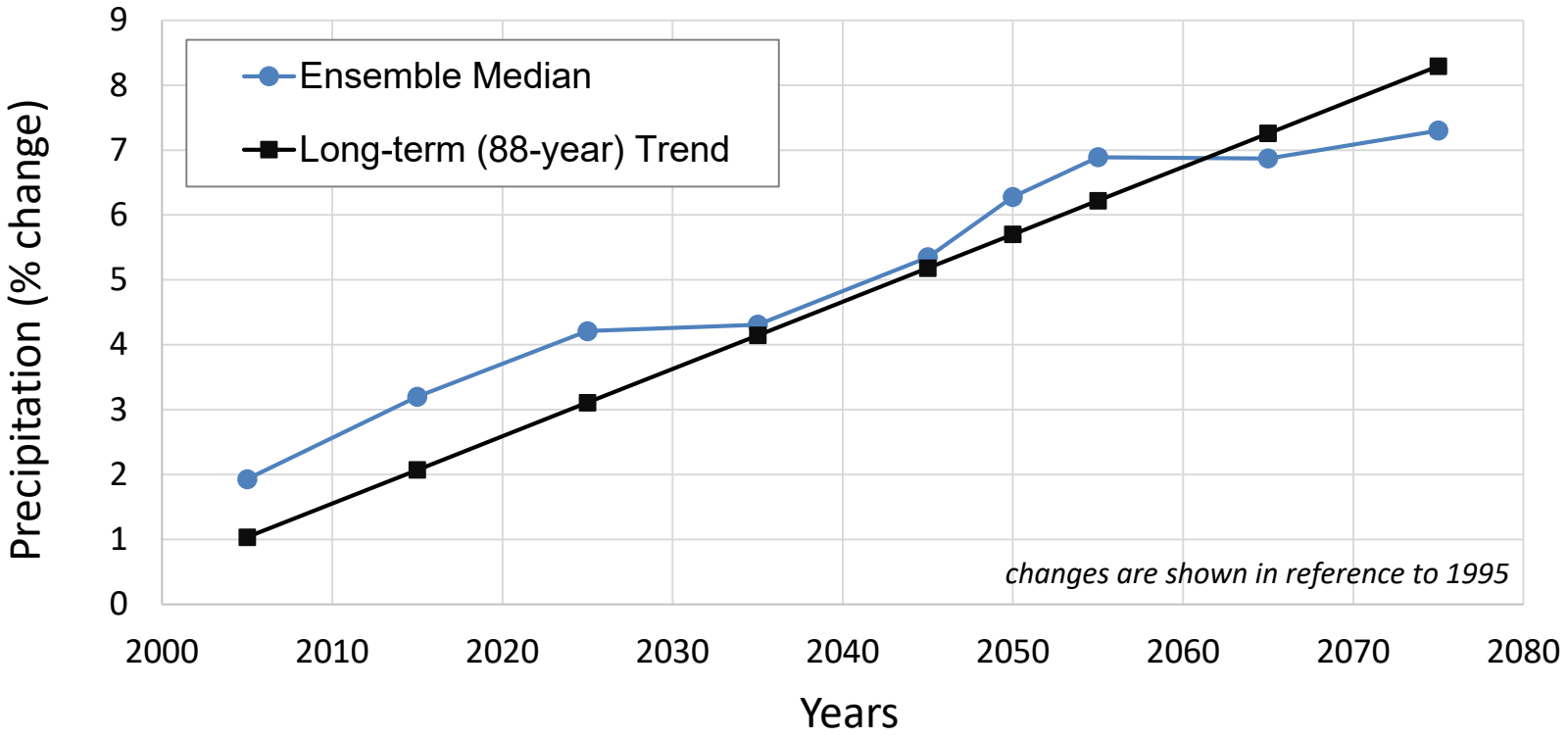
Next Steps

- Potential sources for changes in loads may include:
  - Changes in climate forcing – e.g., downscaling
  - Nitrogen response (or sensitivity) to flow changes – either overall or land use specific
  - Phosphorus response – e.g., developed land use sensitivity
  - Changes in nutrient speciation with climate (or flow)
  - CSO response with changes in rainfall volume and intensity
  - Process responses – e.g., riverine scour of organic nutrients
  - Changes in BMP effectiveness response with climate change

E.g., Rainfall volume delta change for Year 2055



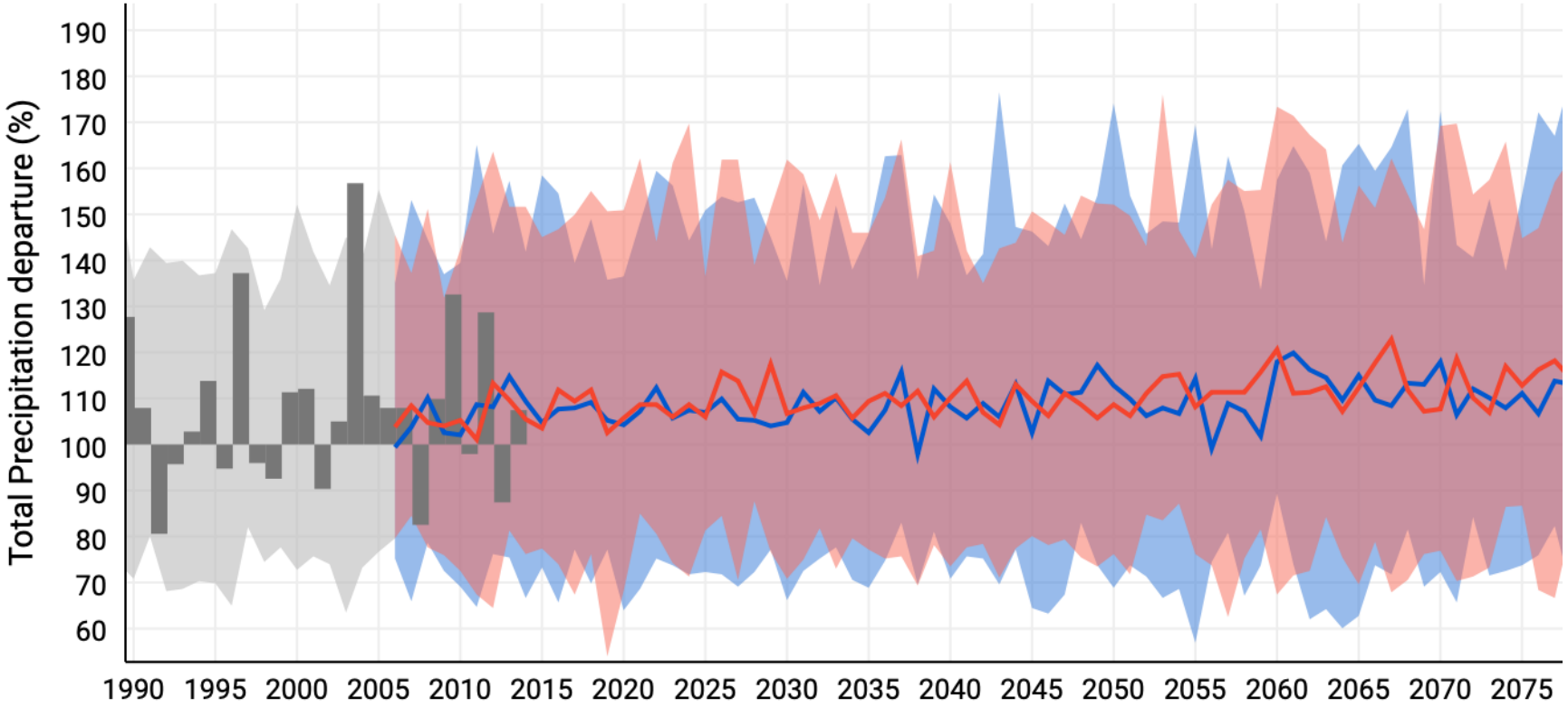
RCP 4.5 Ensemble Median vs. Extrapolation of Trends



***Ensemble**: 31-member ensemble of RCP4.5 GCMs; **Trend**: extrapolation of long-term (1927-2014) trends;*

Expanded analysis period include data points for 2005, 2015, 2065, and 2075.
A number of years are common in the 2005 (1991-2020 – 1981-2010) and 2015 (2001-2030 – 1981-2010) delta change calculations.

Anne Arundel County – Annual Total Precipitation (anomaly)



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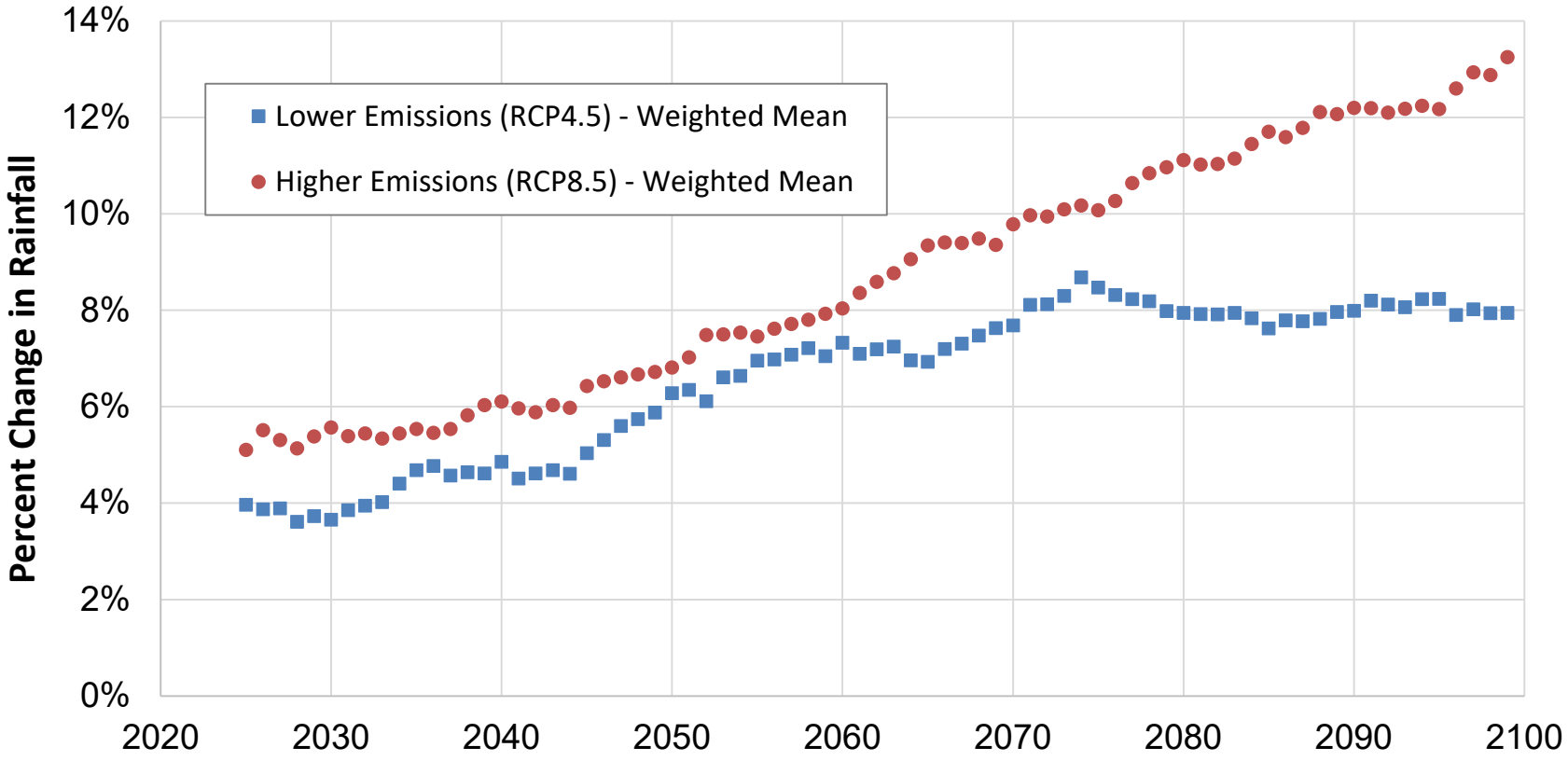

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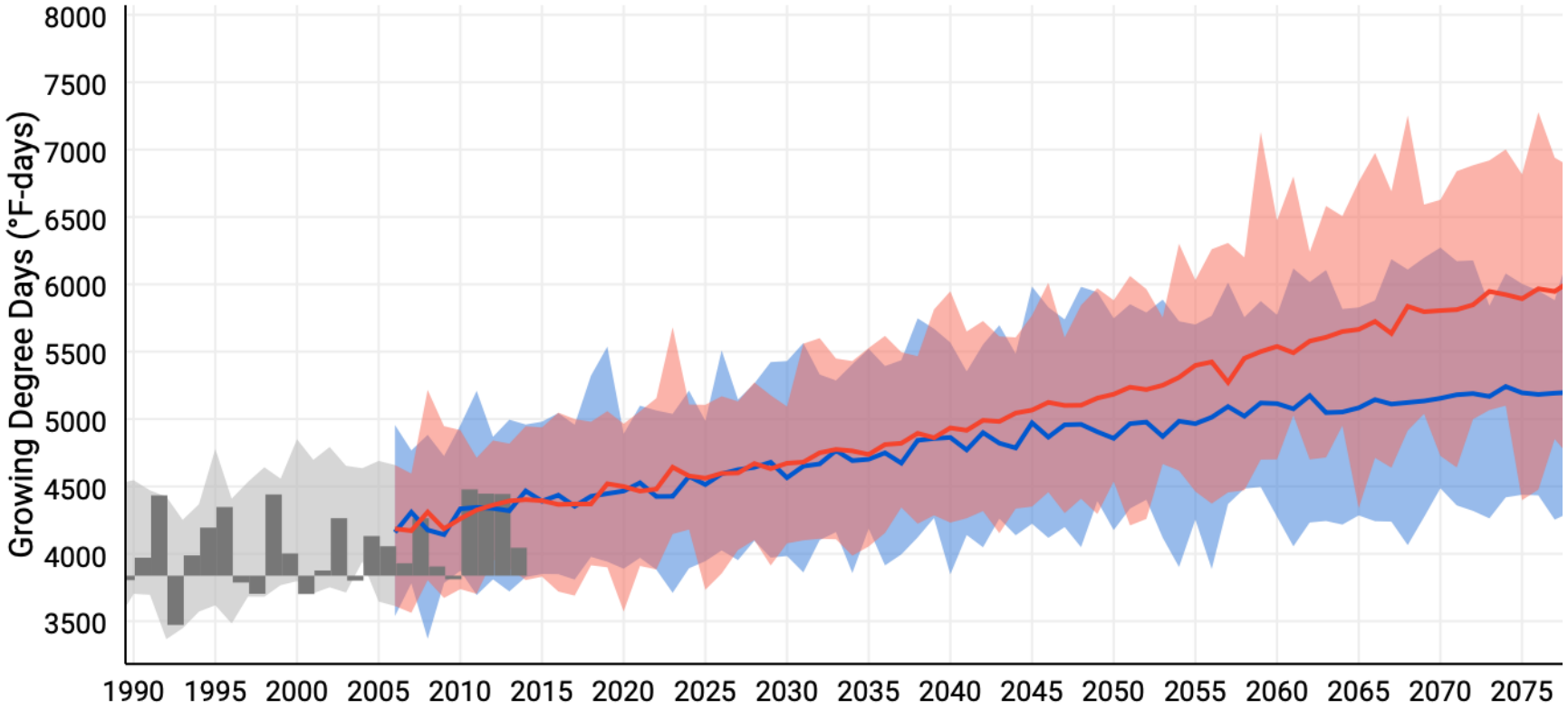
Anne Arundel County – Growing Degree Days (actual)



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