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Using Robust Decision Making to Address Climate Change Uncertainties in Water Quality Management

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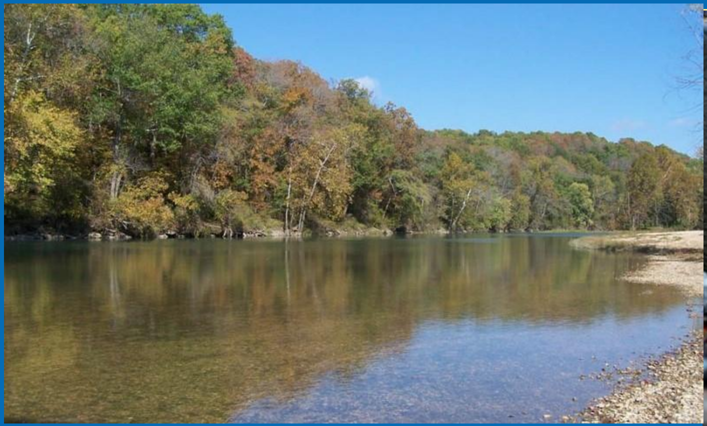


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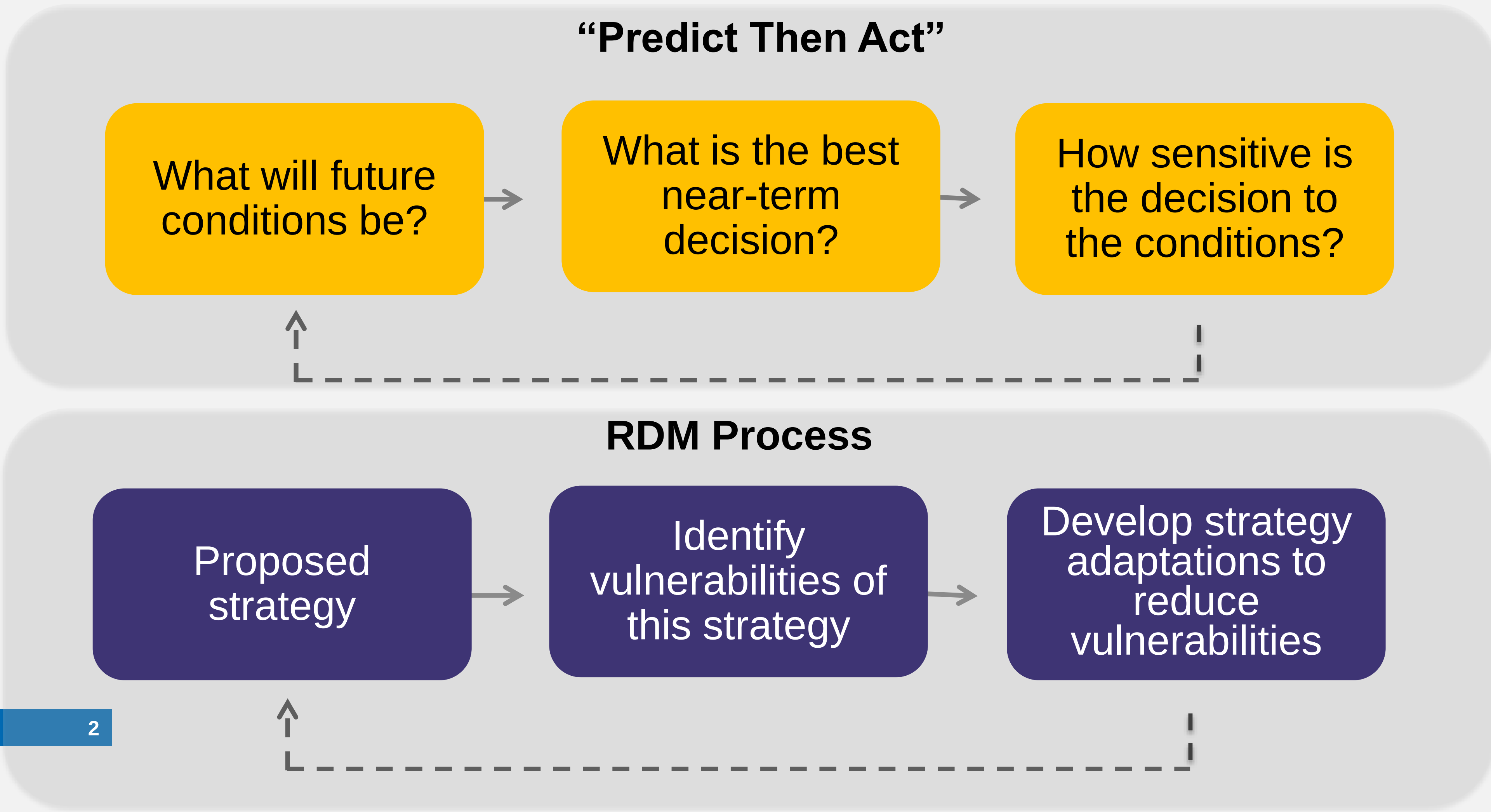
Robust Decision Making (RDM) works under deep uncertainty by running the analysis backwards



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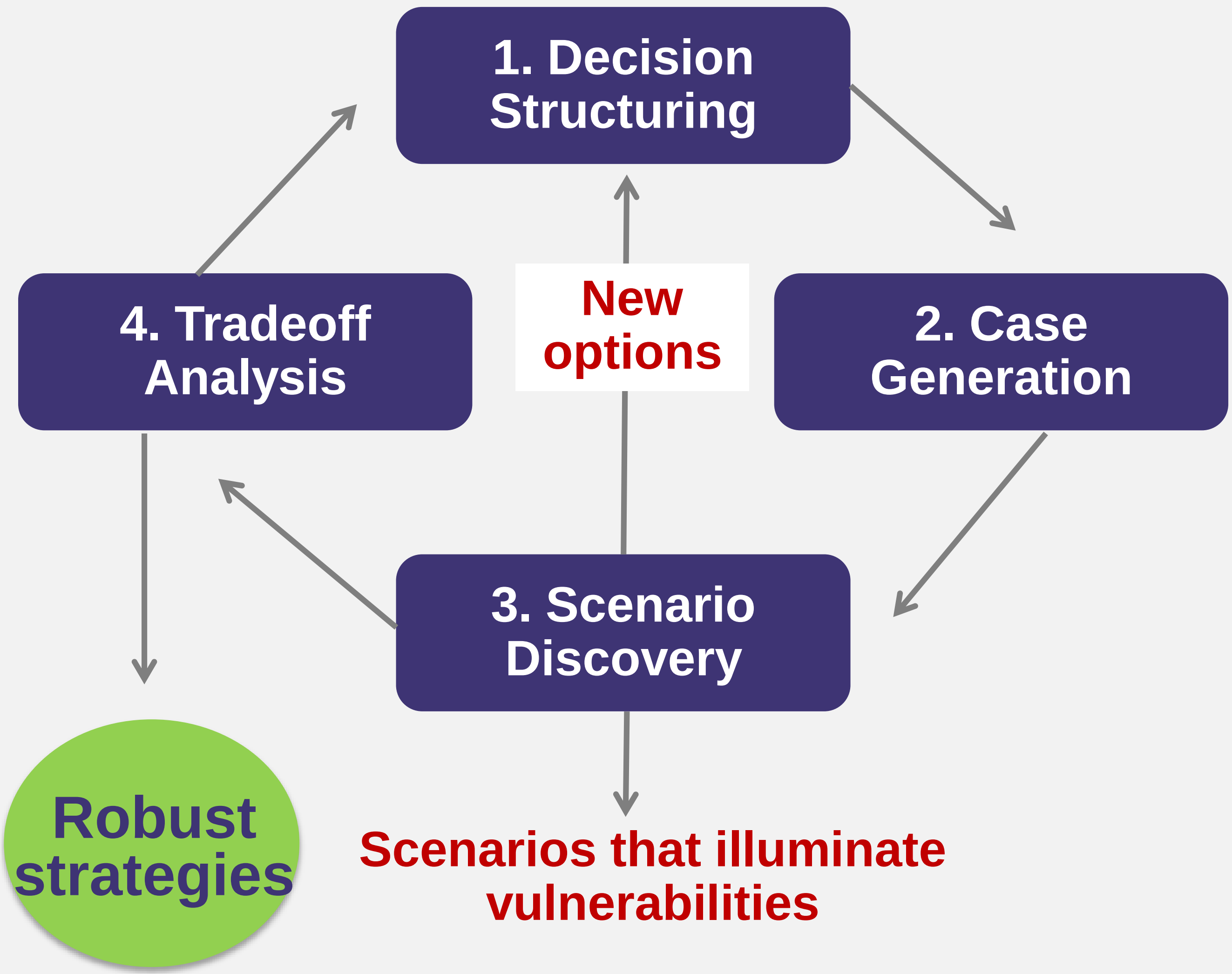
RDM uses analytics to facilitate new conversations between decisionmakers

RDM is *iterative*; analytics facilitate stakeholder deliberation



We applied RDM to stormwater management in the Patuxent River

- Focus: Urban stormwater
- Use Patuxent version of the Chesapeake Bay Watershed Model
- Scope the case study (land use change scenarios, measures of merit, BMPs to consider)
- Complete RDM analysis using the modeling results

We scoped the problem using the XLRM framework

Uncertain Factors (X)	Policy Levers (L)

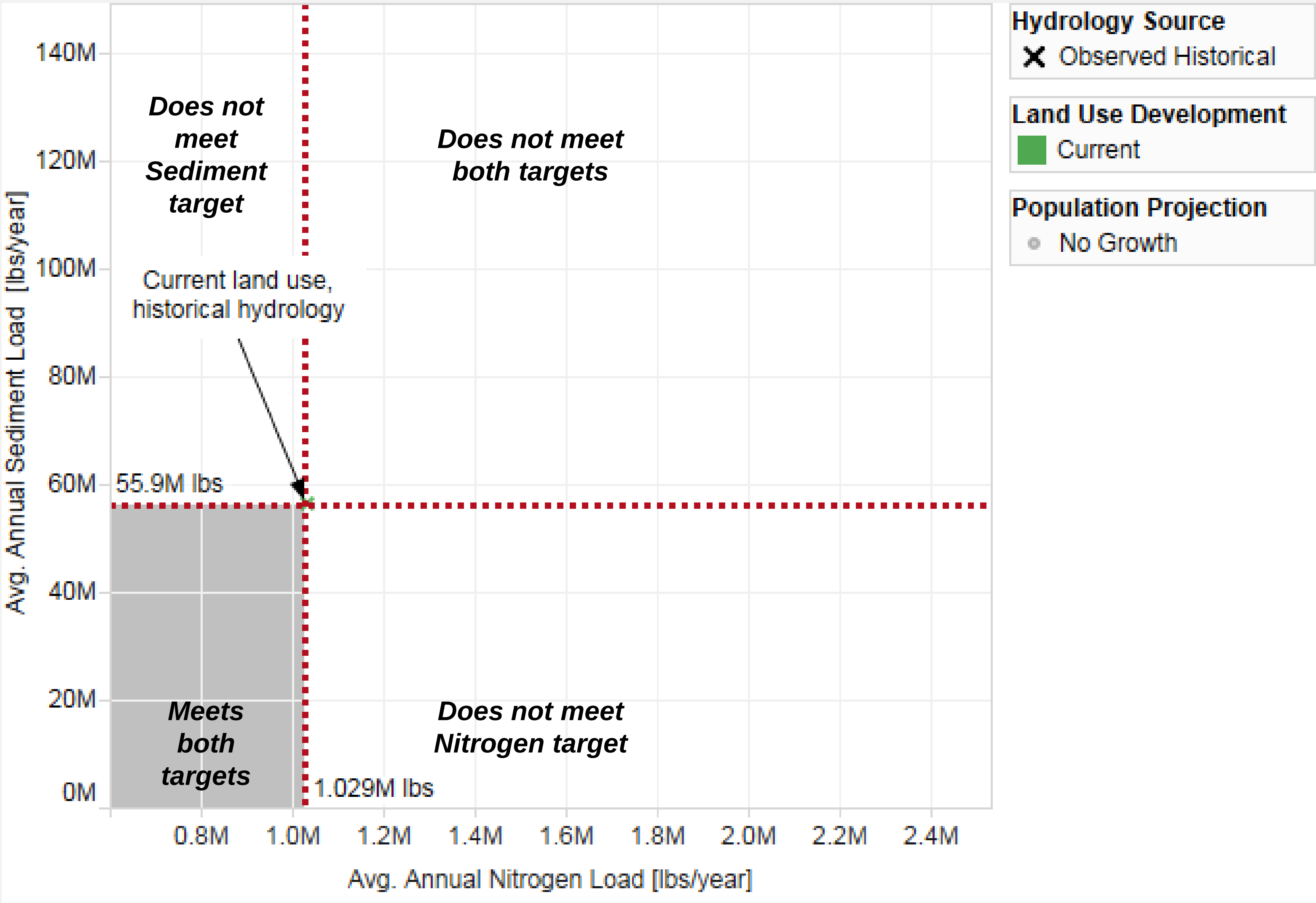
Hydrology and climate change
• Observed historical hydrology (1984-2005)
• Downscaled climate scenarios
  • 2035-2045
  • 2055-2065
Land use
• Population growth (2010-2050)
• Infill, sprawl, and forest conservation
BMP effectiveness
Evapotranspiration model parameters
	MDE Phase II Watershed Implementation Plan BMPs, including:
	• Stormwater management-filtering practices
	• Stormwater management-infiltration practices
	• Urban stream restoration
	• Urban forest buffers

System Model Relationships (R)	**Performance Metrics (M)**
Phase 5.3.2 Chesapeake Bay Watershed Model • Airshed model • Land use change model • Watershed model • Chesapeake	***Metrics*** Nitrogen delivered loads Phosphorus delivered loads Sediment delivered loads Implementation costs (extended analysis only) ***Targets:*** Phase I WIP TMDLs and Phase II WIP TMDLs (2017 interim; 2025 final)

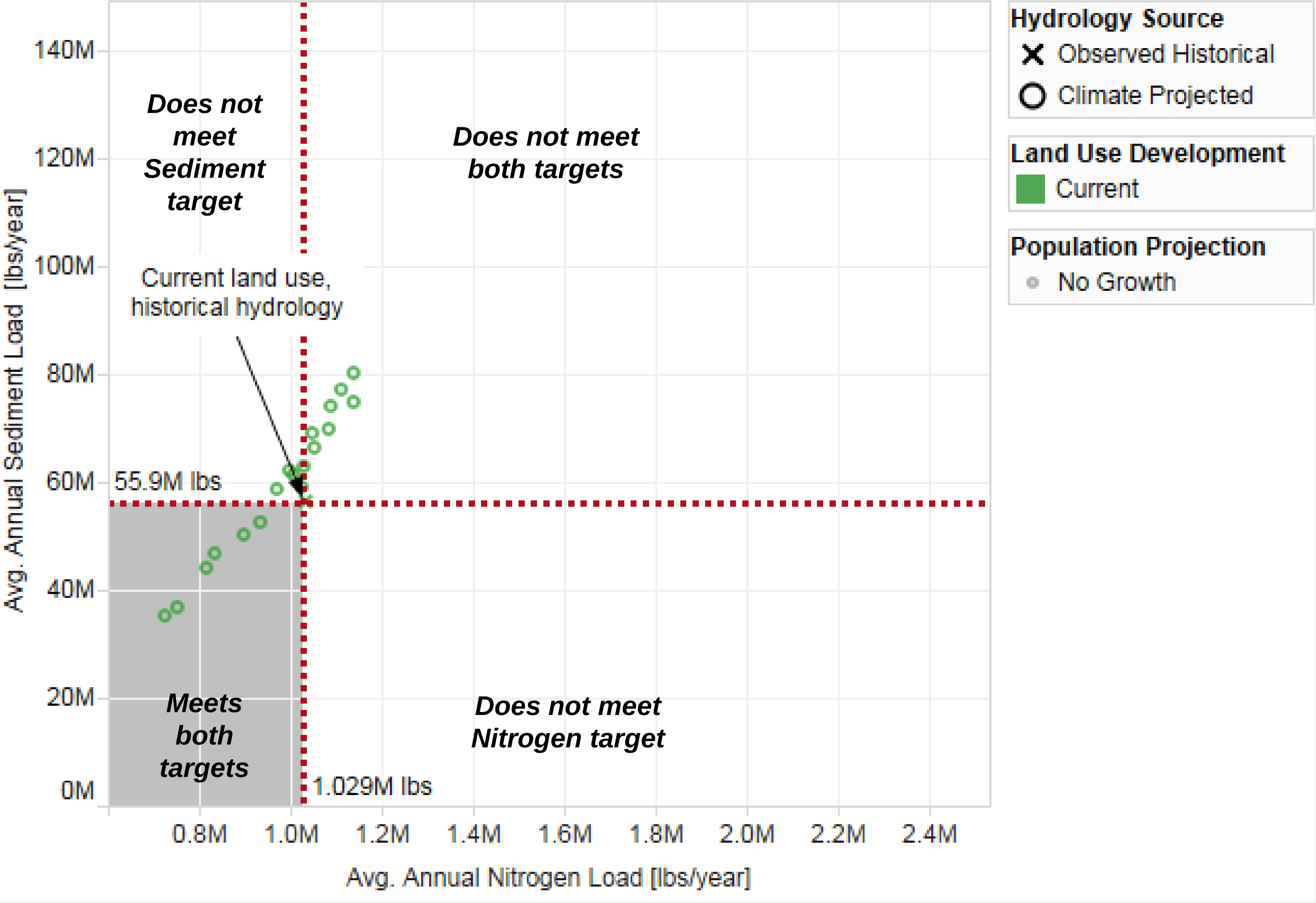
BMPs used in Patuxent Phase II Watershed Implementation Plan (WIP)

BMP Name	Unit	2012 Progress	2025 WIP	Change from 2012
Standard Stormwater Management (Gray Infrastructure)				
Dry Detention Ponds and Hydrodynamic Structures	Acres	4,857	2,885	-1,972
Erosion and Sediment Control	Acres	1,258	1,848	590
Stormwater Management Generic BMP	Acres	19,566	7,443	-12,123
Urban Nutrient Management	Acres	13,544	30,898	17,354
Urban Infiltration Practices	Acres	1,012	1,511	498
Mechanical Street Sweeping	lbs/year	-	568,089	568,089
Nature-Based Stormwater Management (Green Infrastructure)				
Bio Retention	Acres	-	2,131	2,131
Bioswales	Acres	-	1,654	1,654
Urban Forest Buffers	Acres	68	881	813
Urban Filtering Practices	Acres	1,482	9,480	7,997
Retrofit Stormwater Management	Acres	3,501	12,660	9,159
Vegetated Open Channels	Acres	-	595	595
Wet Ponds and Wetlands	Acres	4,850	7,839	2,989
Urban Stream Restoration	lbs/year	22,948	11,481,346	11,458,398

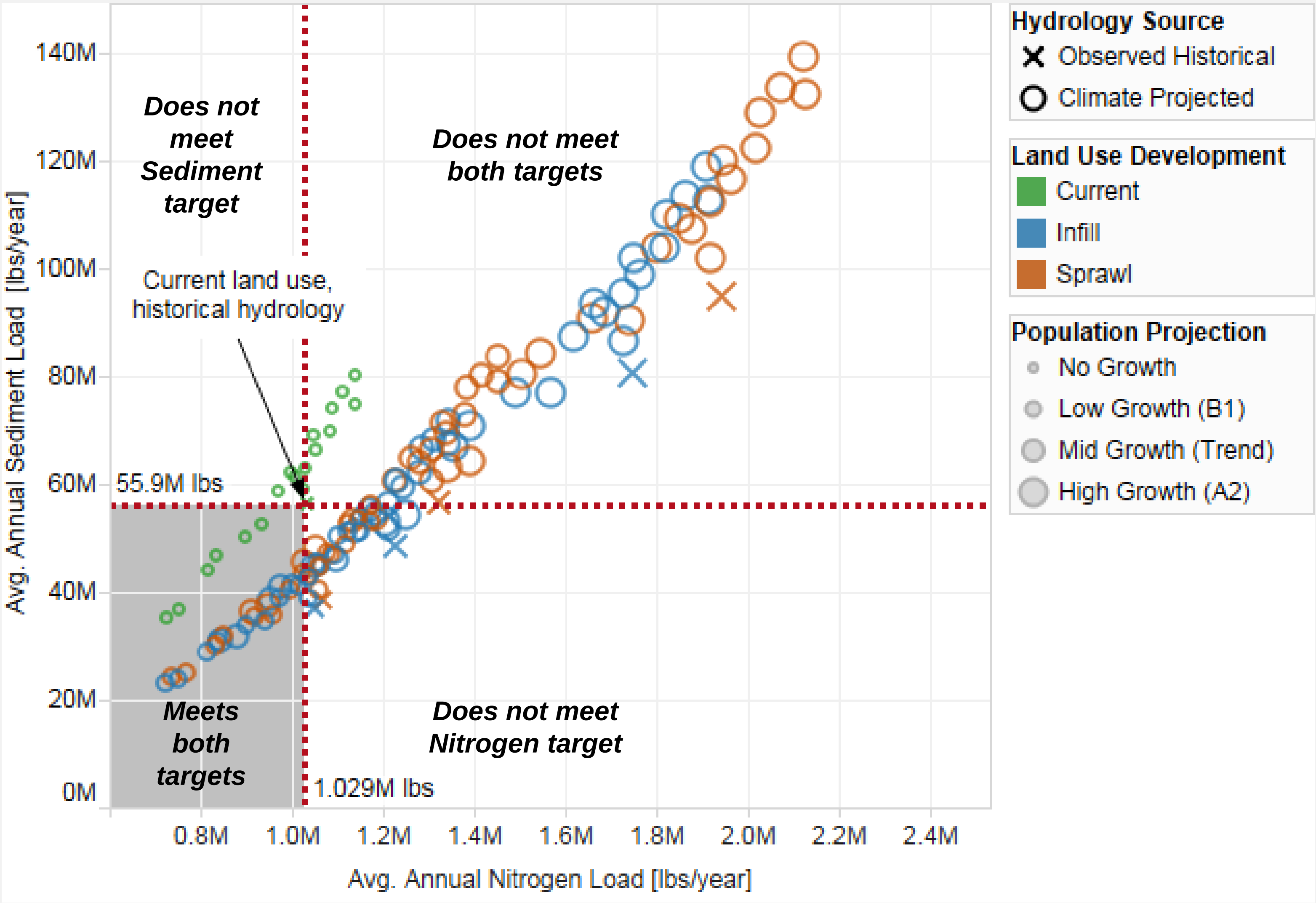
Phase II WIP Strategy Meets Intended Target In Current Conditions



Climate Projections Affect Attaining Targets in Some Futures (2035-2045)

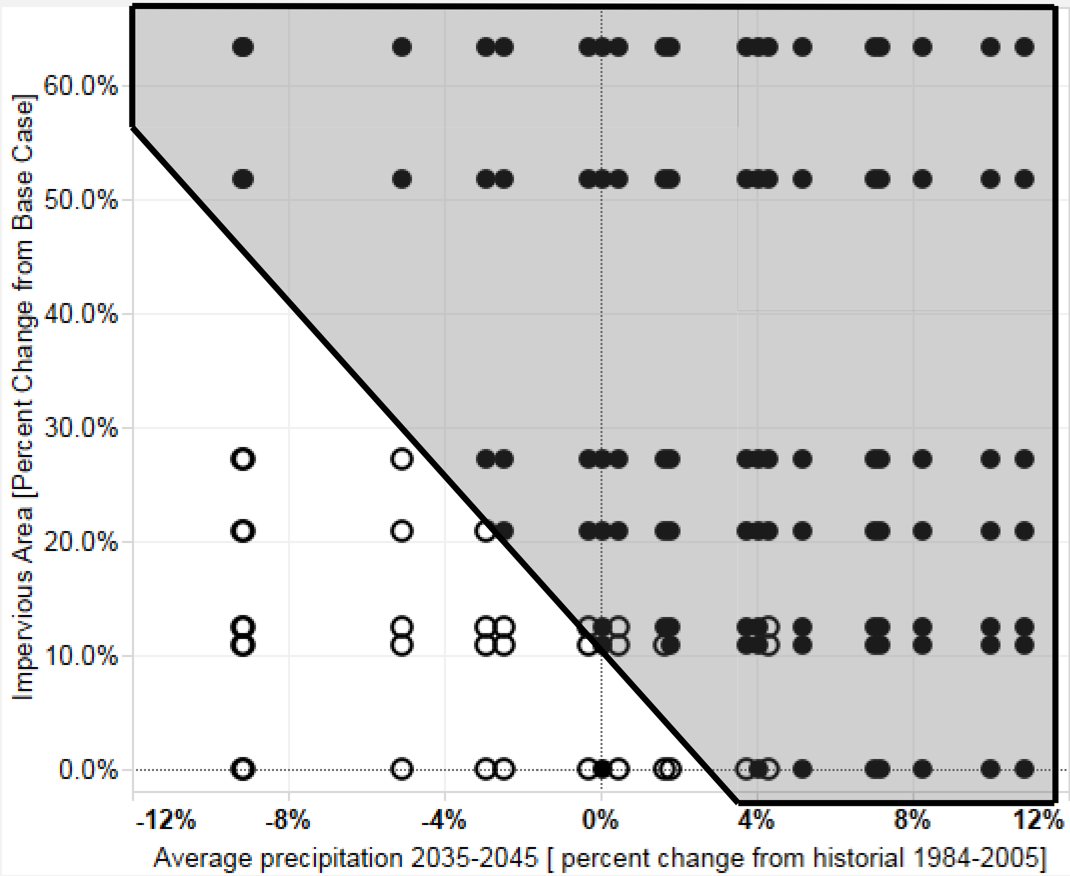


Climate and Land Use Together Lead to Many Stressing Futures (2035-2045)

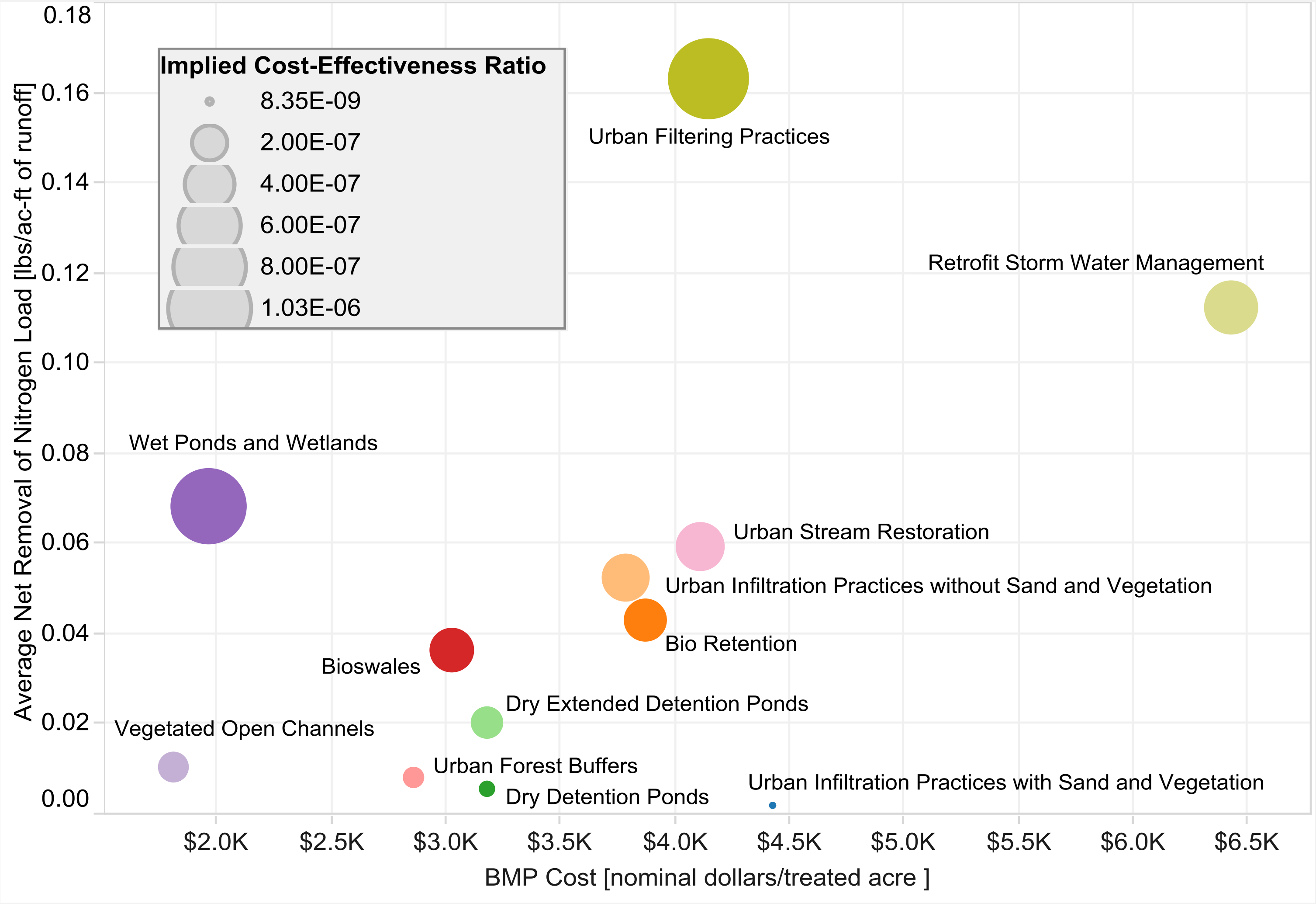


Most Vulnerability Explained by Increase in Impervious Runoff (2035-2045)

- Nitrogen's Vulnerability Region in MD's Phase II WIP:
  - Higher precipitation increases runoff, leads to higher nitrogen loads
  - Impervious area growth leads to missing target even if average precipitation declines
  - Combination leads to many vulnerable scenarios



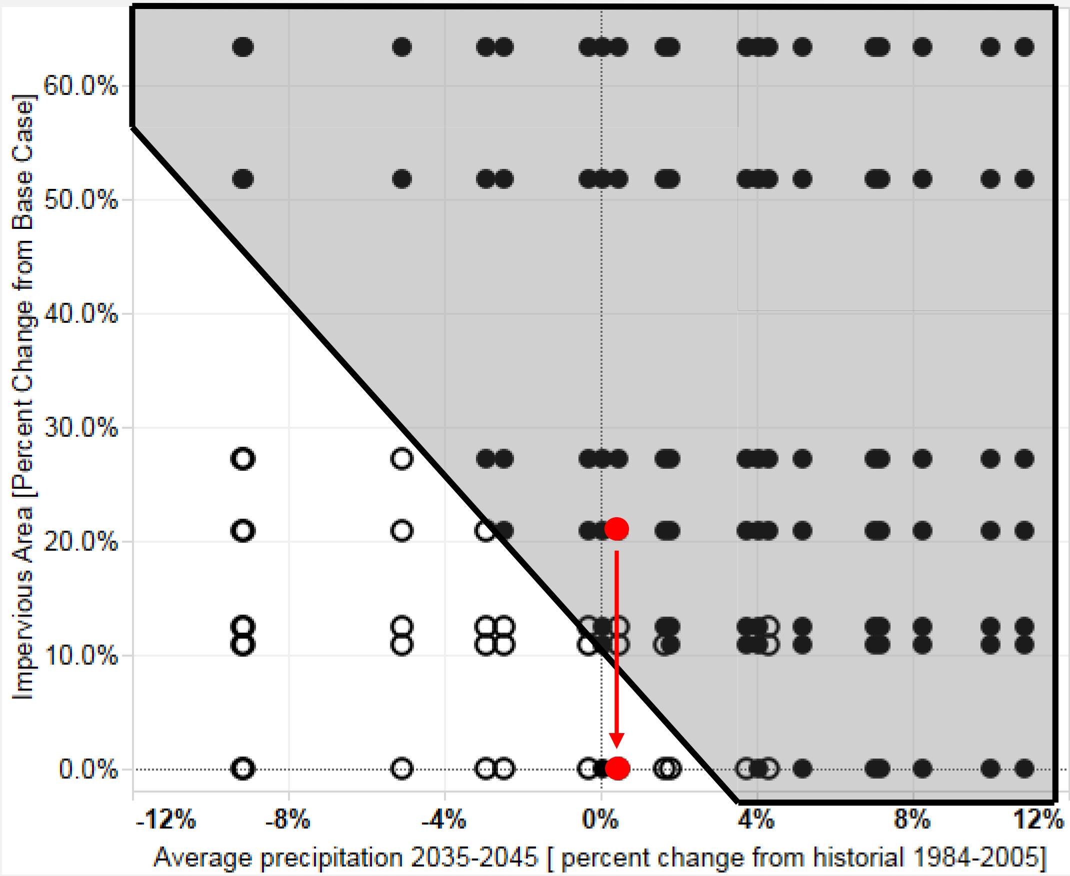
Nitrogen Removal Cost-Effectiveness for Impervious Land Use by BMP Type



Most Vulnerability Explained by Increase in Impervious Runoff (2035-2045)

Example Future:
Nitrogen load: 1.0M lbs
Average precip increase: 1.8%
Population projection: Low (ICLUS B1)
Development pattern: Infill

Mitigation Strategy:
1,985 additional acres of Wetponds and Wetlands
Cost: $8 million



Conclusions

- Under historic climate and no change in land uses, Maryland Phase II WIP meets TMDL targets
  - With future population growth or precipitation increases, targets are almost always missed
- Vulnerability is driven by increased runoff from impervious areas
  - Precip increases over historic average
  - Impervious land cover increases
  - Both precip and impervious cover increase
- Consider cost-effective options to hedge against future changes
  - For example, greater investments in wetland BMPs or urban filtering practices
- Next steps
  - Monitor BMPs; test additional BMPs; adaptively manage; revisit targets

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Thank you!

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