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Future Climate Impacts on CBW BMP Efficiencies

A Modeling Sensitivity Study for Agricultural BMPs

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Project Overview

Goal: Quantify the performance of agricultural BMPs in the Chesapeake Bay watershed under current and future climate scenarios

Tools: APEX for agricultural, SWMM for urban

Output: N, P, and TSS removal efficiencies for BMPs under varying hydrologic scenarios

Watershed Settings

Hydrologic Regimes

- Baseline: 1990-2000
- Future(s): TBD

Physiographic Region (PR)	Land Use (LU): Soybeans (Row Crops)	Corn (Row Crops)	Wheat (Row Crops)	Alfalfa (Hay Land)
Ridge & Valley	LU1 PR1	LU2 PR1	LU3 PR1	LU4 PR1
Appalachia	LU1 PR2	LU2 PR2	LU3 PR2	LU4 PR2
Coastal Plain	LU1 PR3	LU2 PR3	LU3 PR3	LU4 PR3
Piedmont	LU1 PR4	LU2 PR4	LU3 PR4	LU4 PR4

BMPs

- Cover crops
- No till
- Manure Incorporation
- Nutrient Management*
- Grass Buffers*

**in development*

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Experimental Approach - BMPs

CBP Most Effective BMPs + CBP Most Implemented BMPs + APEX feasibility =

	BMP	Soy	Corn	Wheat	Alfalfa
Modeled ✓	Cover crops	✓	✓	✓	-
	No till	✓	✓	✓	✓
	Manure Incorporation	✓	✓	✓	✓
In development	Nutrient Management	✓	✓	✓	✓
	Grass Buffers*	✓	✓	✓	✓

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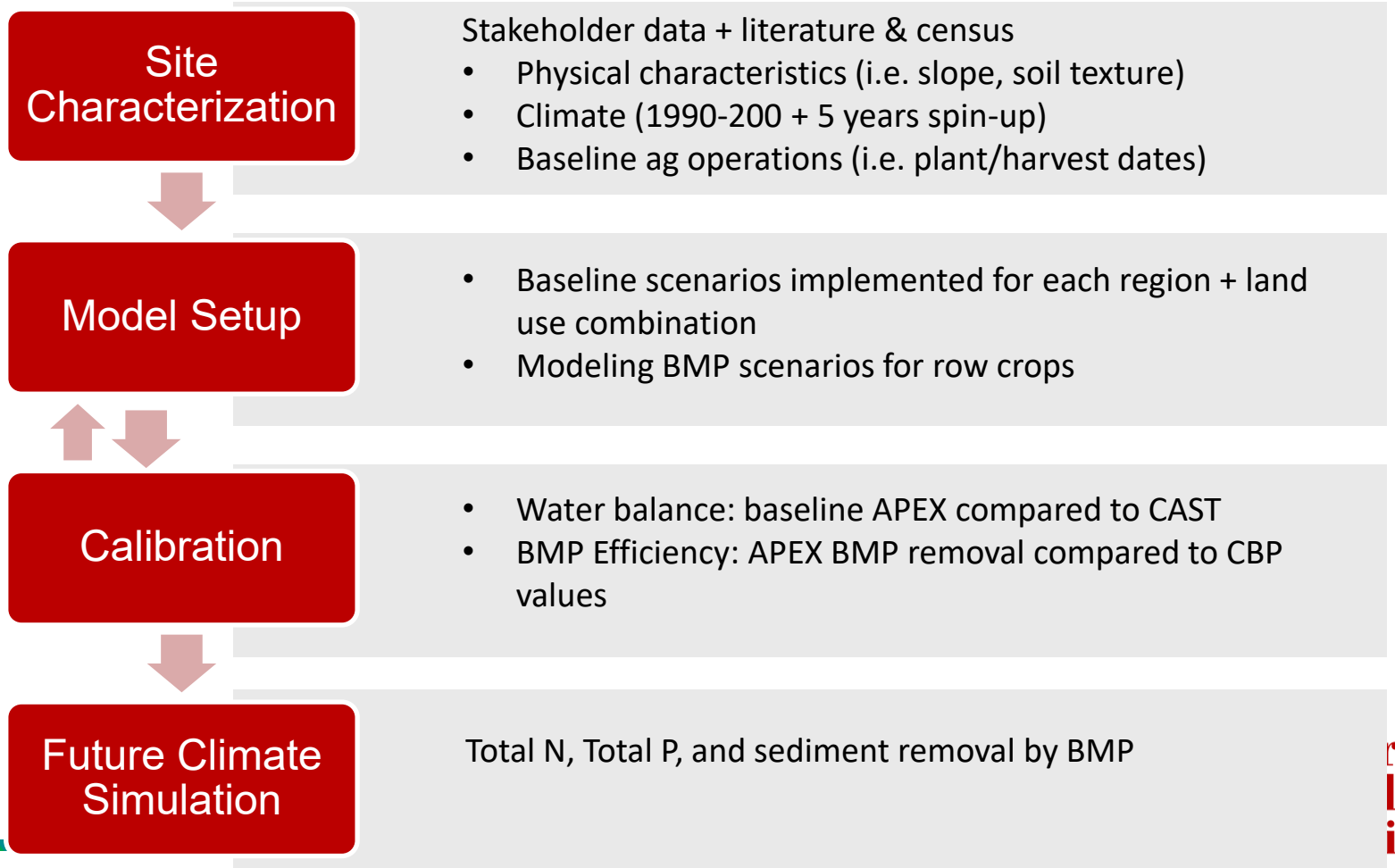

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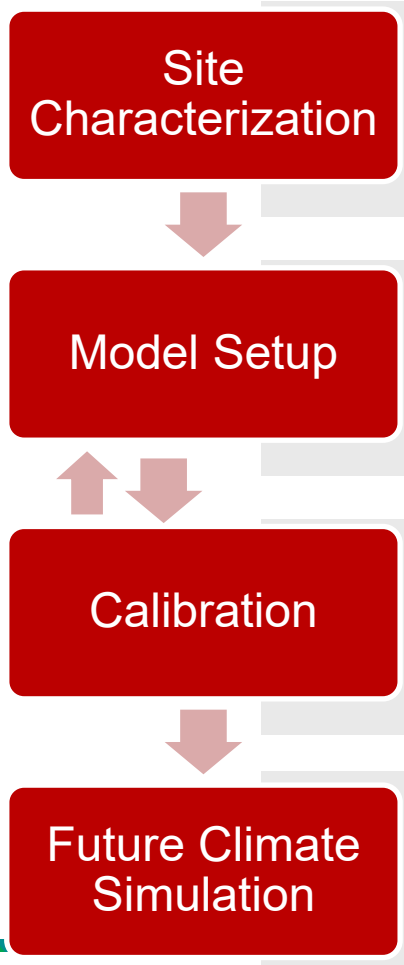

Stakeholder data + literature & census

- Physical characteristics (i.e. slope, soil texture)
- Climate (1990-200 + 5 years spin-up)
- Baseline ag operations (i.e. plant/harvest dates)

- Baseline scenarios implemented for each region + land use combination
- Modeling BMP scenarios for row crops

- Water balance: baseline APEX compared to CAST
- BMP Efficiency: APEX BMP removal compared to CBP values

Total N, Total P, and sediment removal by BMP

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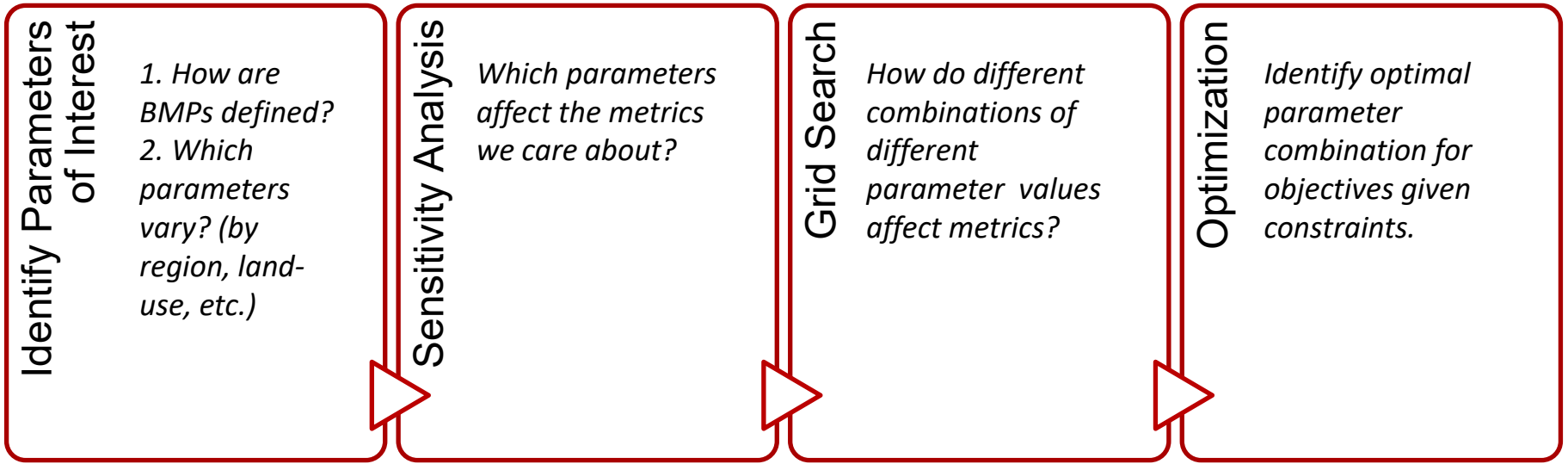
Calibration Framework



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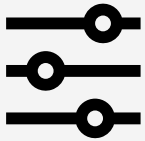
Multi-Objective Optimization



Model Inputs Adjusted

within each land-use-region combination

- Baseline N & P Fertilizer
- Crop PHU
- BMP-specific parameters
  - *BMP N & P fertilizer*
  - *Erosion control factor*
  - *Manure application*
  - *Surface crop residue*

Objectives

within each land-use-region combination

- % ET
- % Total runoff
- Removal Efficiencies
  - *N, P, TSS*
- Crop yield
- Water balance residual

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Planned Climate Data Approach

CBP

CMU

Climate Inputs

- CMIP5 monthly deltas
- RCP 4.5 & RCP 8.5
- Precipitation (%), Temperature (Δ)
- Ensemble medians & members

Delta Method

(Bhatt et al, 2023)

- 30-year centered change factors
- Applied to 1991-2000 reference climate

Data Processing

- Apply monthly deltas to representative baseline climates:
  - Appalachia
  - Piedmont
  - Valley & Ridge
  - Coastal Plain

APEX Climate Inputs

- Scenario-specific climate forcing
- Consistent with CBP Phase 6 methods

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Baseline APEX Scenarios Calibrated to CAST

ex: Appalachia Soy

BMP	TSS Removal Efficiency (%)			TN Removal Efficiency (%)			TP Removal Efficiency (%)		
	CAST	APEX	|diff|	CAST	APEX	|diff|	CAST	APEX	|diff|
Cover Crops	0	19.6	**19.6**	22-29	21	**1**	0	11.1	**11.1**
Manure Incorporation	0	2.7	**2.7**	8	11.8	**3.8**	12-24	35	**10**
No Till	41	39.7	**1.3**	10	19.2	**9.2**	17-27	17.8	**0**

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Preliminary Results

Mean Change from 1995 to 2050 RCP 4.5 (Bhatt, 2023):

Precipitation = +6.28%

Temperature = +2.03℃

BMP	TSS Removal Efficiency (%)			TN Removal Efficiency (%)			TP Removal Efficiency (%)		
	1990-2000	P & T Perturbation	diff	1990-2000	P & T Perturbation	diff	1990-2000	P & T Perturbation	diff
Cover Crops	0.2	-22.8	**-22.6**	23.5	27.5	**+4.5**	19.7	15.1	**-4.6**
Manure Incorporation	8.4	-29.6	**-21.2**	8.5	8.9	**+0.4**	22	22.1	**+0.1**
No Till	31.9	16.9	**-15**	17	19.6	**+2.6**	23.6	23.5	**-0.1**

Current Phase

- Completing BMP modeling for all baseline region + land-use combinations
  - Troubleshooting grass buffer bug

Next Steps

- Future weather climate modeling