Geosyntec consultants

DES PLAINS RIVER WATERSHED WORKGROUP (DRWW)

NUTRIENT ASSESSMENT REDUCTION PLAN (NARP) UPDATE

February 16, 2023

DES PLAINES RIVER WATERSHED WORKGROUP

AGENDA

NARP Overview

Modeling Background

DRWW Model Setup and Calibration

Watershed Management Scenarios

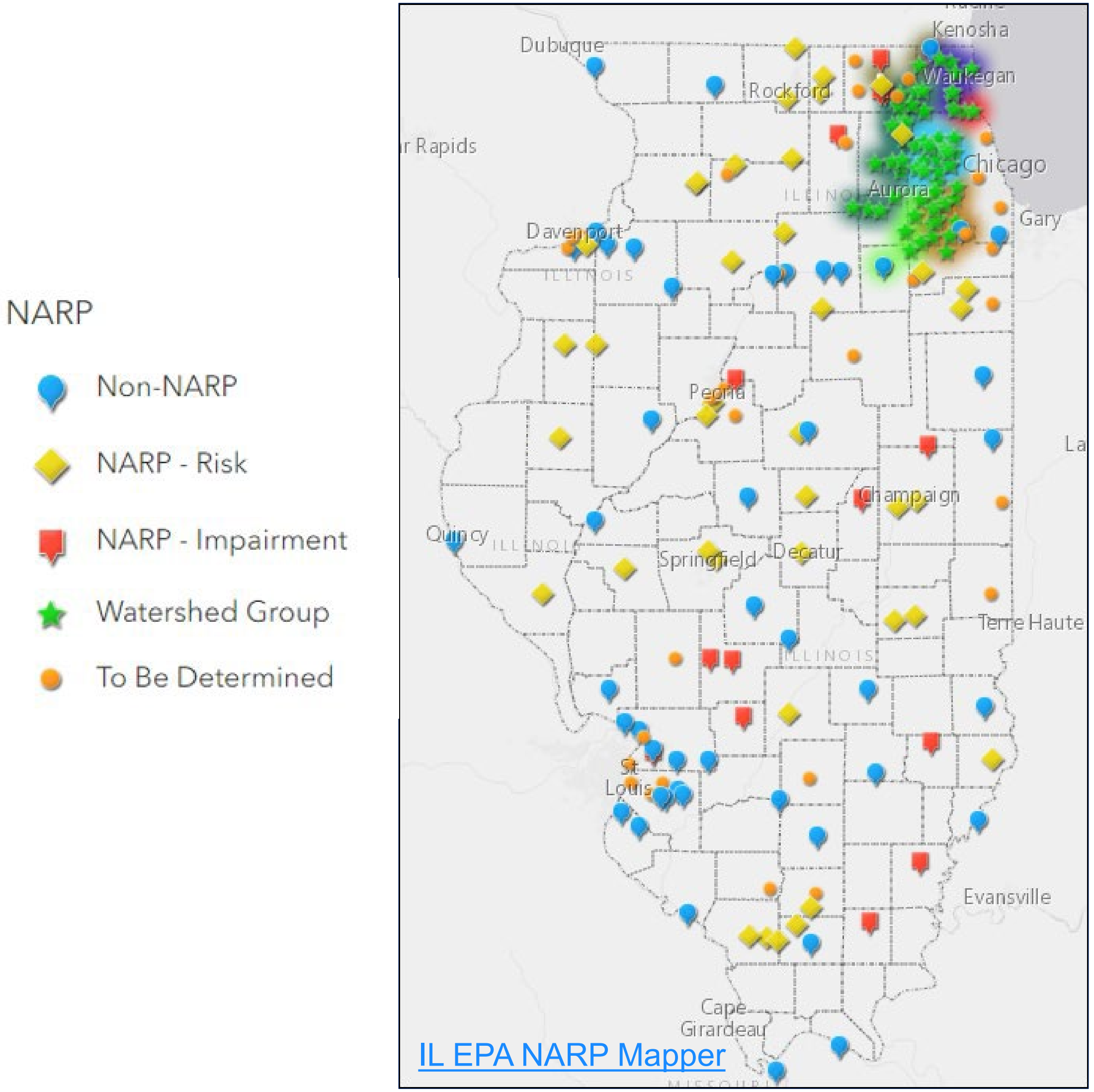
Next Steps

DRWW NARP

Overview and Schedule

NARP – Overview

- ## What's a NARP?
  - Nutrient Assessment Reduction Plan
  - Negotiated special conditions in NPDES permits to address phosphorus-related impairments*
    - Dissolved oxygen (DO)
    - Nuisance algae
- ## Who gets a NARP?
  - Dischargers to a 303 (d) listed stream due to a phosphorus-related impairment
  - Dischargers upstream of station at "Risk of Eutrophication"
- ## When is NARP Due?
  - December 31, 2023, or 2024

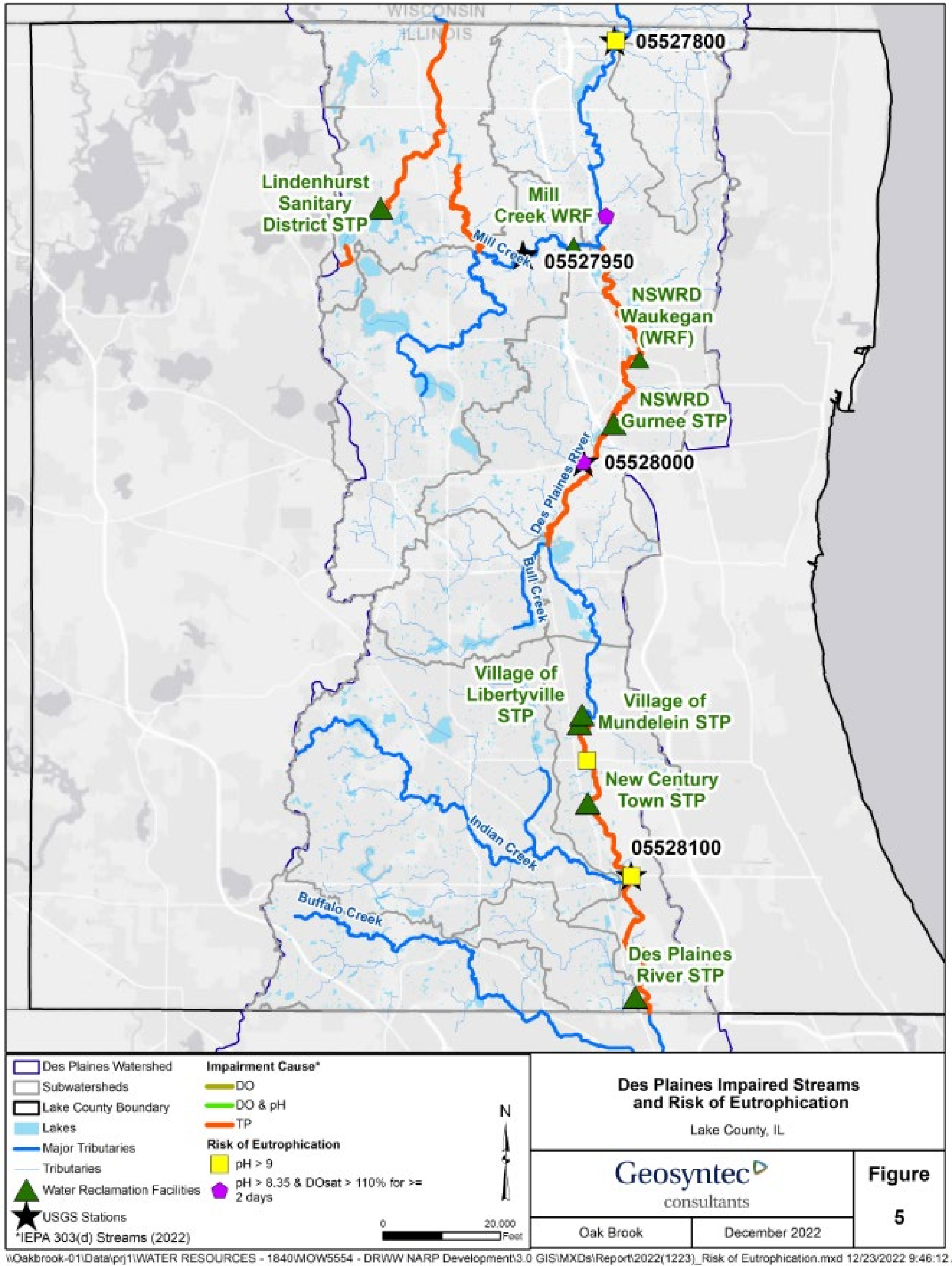


* Major (>1 MGD) publicly owned treatment works (POTWs)

DRWW NARP – Overview

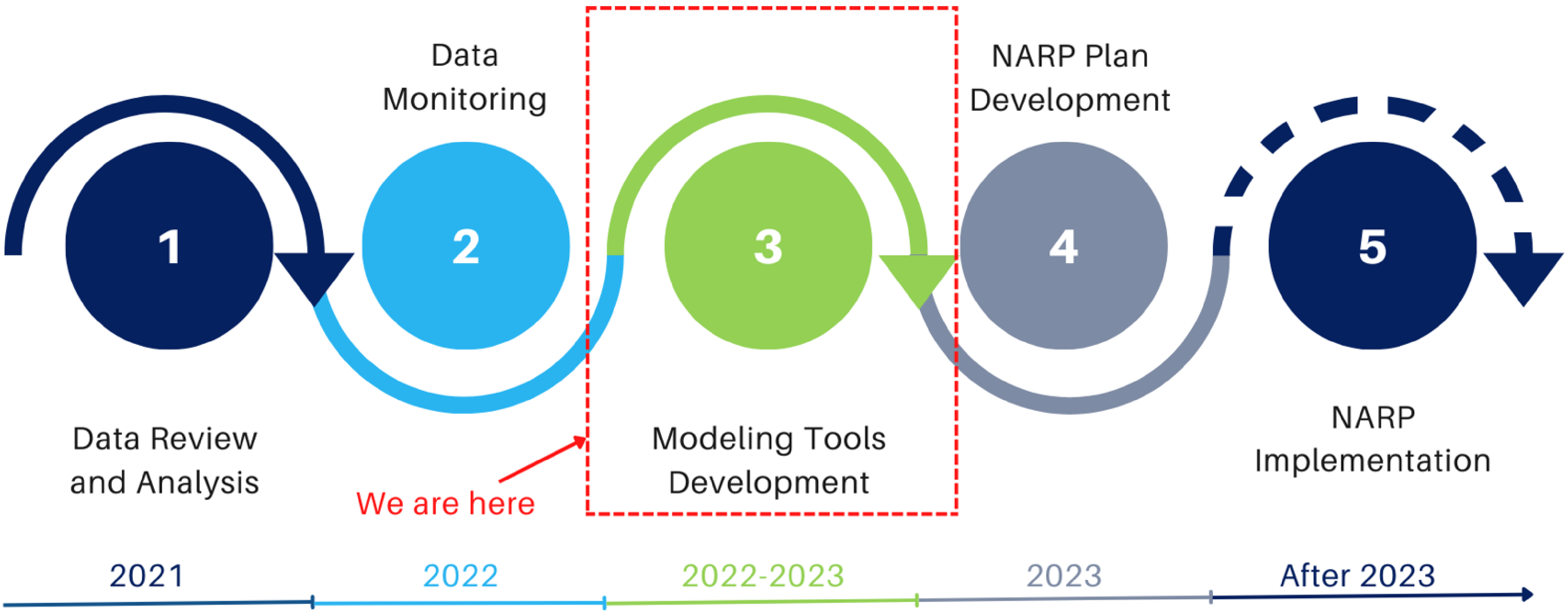
- POTWs discharging to
  - Des Plaines River mainstem (6)
  - Mill Creek (1)
  - Hastings Creek (1)

- The upstream station is at risk of eutrophication



DRWW NARP – Schedule

NARP is due December 31, 2023



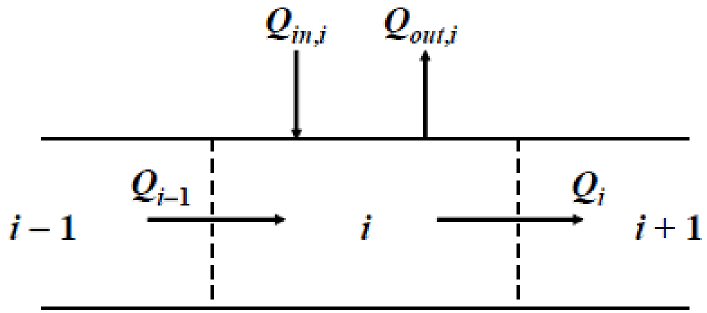
Modeling Background

Overview, Framework, and Input/Output

Modeling Background – Overview

What's a model?

- A model is a mathematical representation of the physical, chemical, and biological processes in a waterbody.



$$\frac{dc_i}{dt} = \frac{Q_{i-1}}{V_i} c_{i-1} - \frac{Q_i}{V_i} c_i - \frac{Q_{out,i}}{V_i} c_i + \frac{E'_{i-1}}{V_i}(c_{i-1} - c_i) + \frac{E'_i}{V_i}(c_{i+1} - c_i) + \frac{W_i}{V_i} + S_i$$

Why are models useful?

- Fill the gaps in observed data
- Have a predictive capability
- Help with evaluation of management strategies
- Identify causes of water quality problems

Modeling Background – Overview

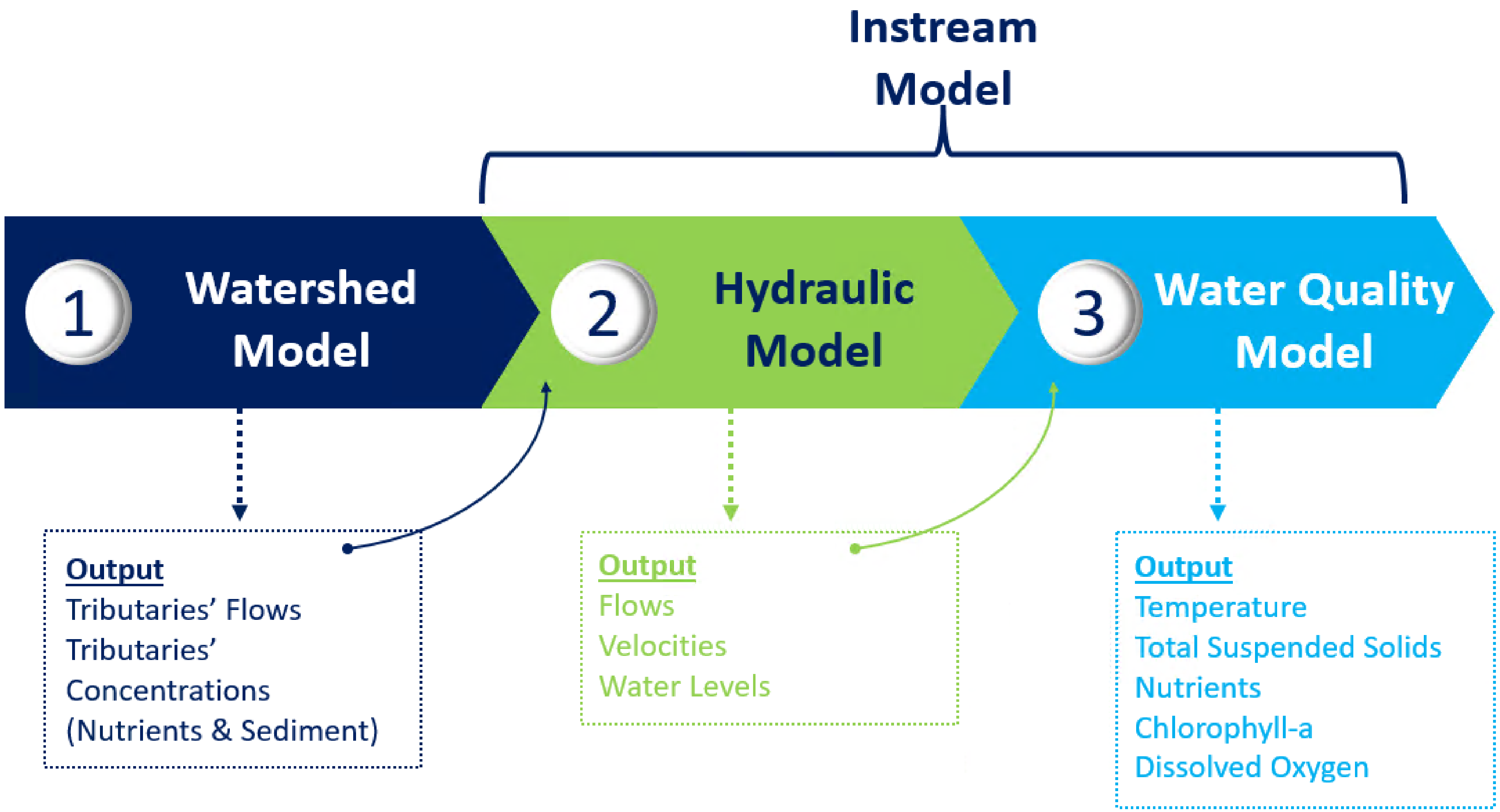
Watershed Model

- Simulates the response of water quantity and quality to hydrologic processes

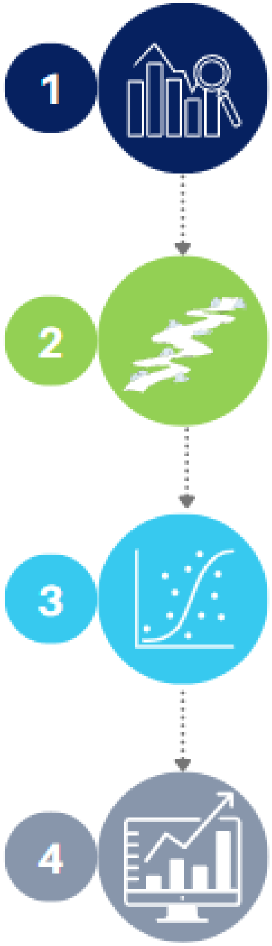
Instream Model

- Simulates hydraulics and water quality condition within a stream or river
- Hydraulic and water quality models

Modeling Background – Framework



Modeling Process



Data Analysis and Review

Model Development

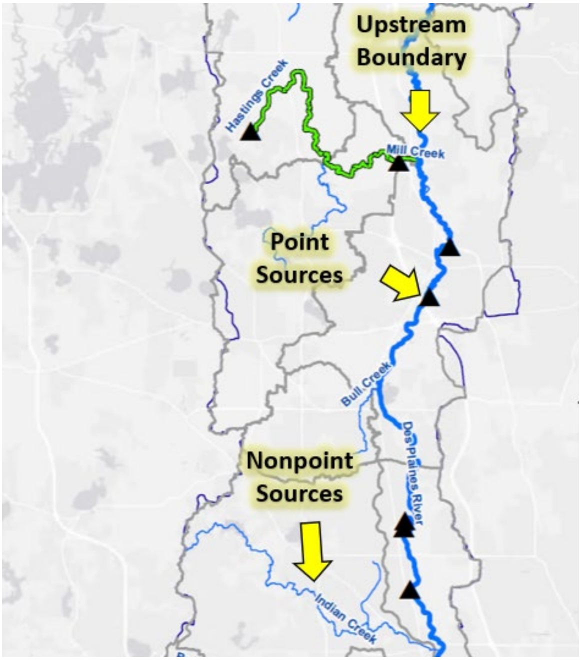
Model Calibration

Model Sensitivity Analysis

Modeling Process

1. *Data Analysis and Review*
2. *Model Development*
3. *Model Calibration*
4. *Model Sensitivity Analysis*

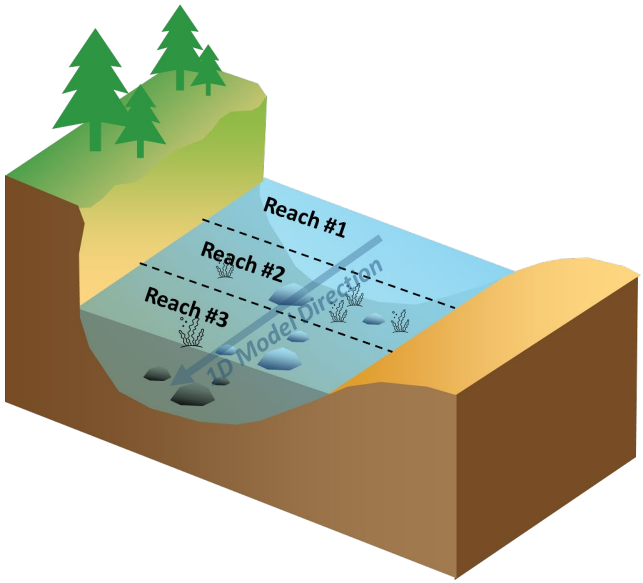
- ✓ Review existing data
- ✓ Identify data gaps
- ✓ Develop and execute a sampling program
- ✓ Determine model spatial and temporal extent



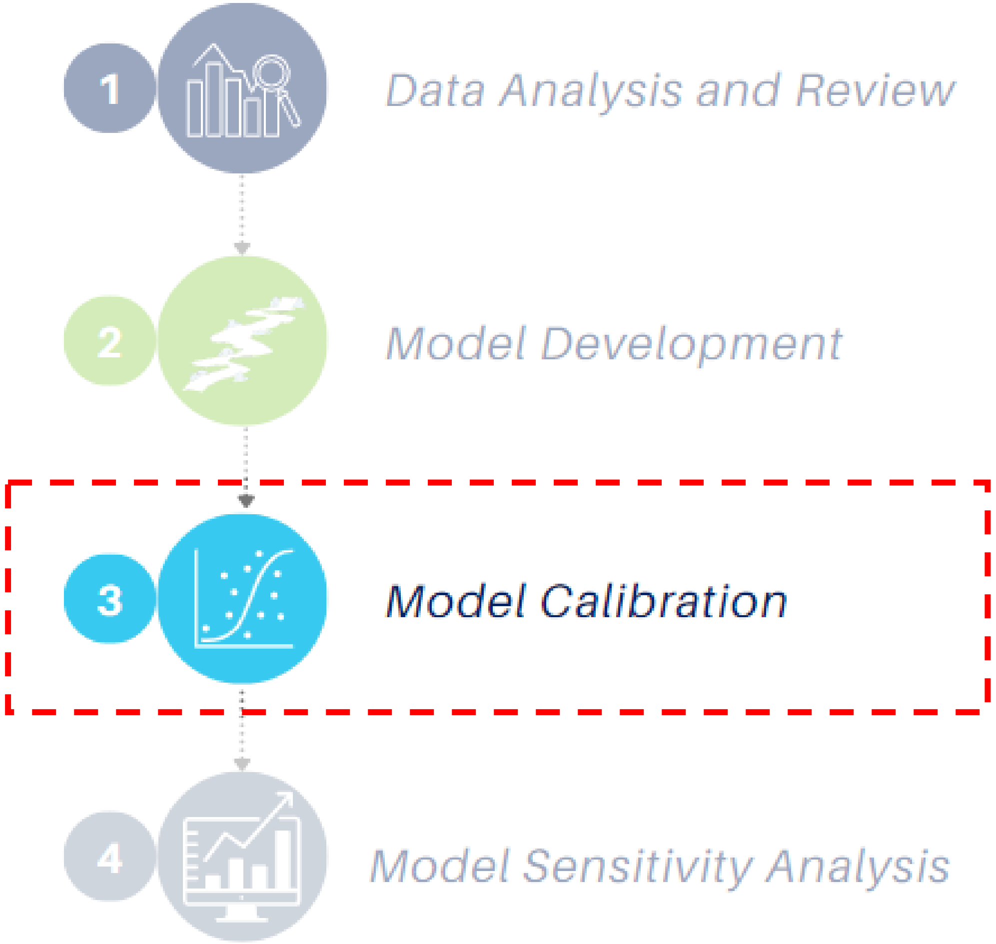
Modeling Process

1. *Data Analysis and Review*
2. *Model Development*
3. *Model Calibration*
4. *Model Sensitivity Analysis*

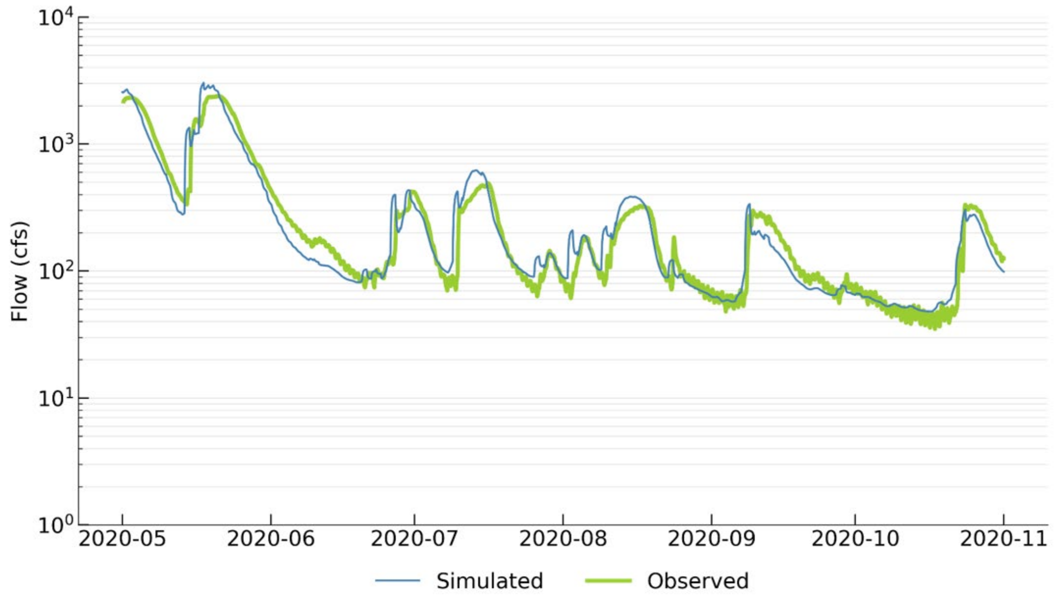
- ✓ Segment the river
- ✓ Preprocess input data
- ✓ Select model parameters
  - Biochemical oxygen demand, algae growth rate, etc.



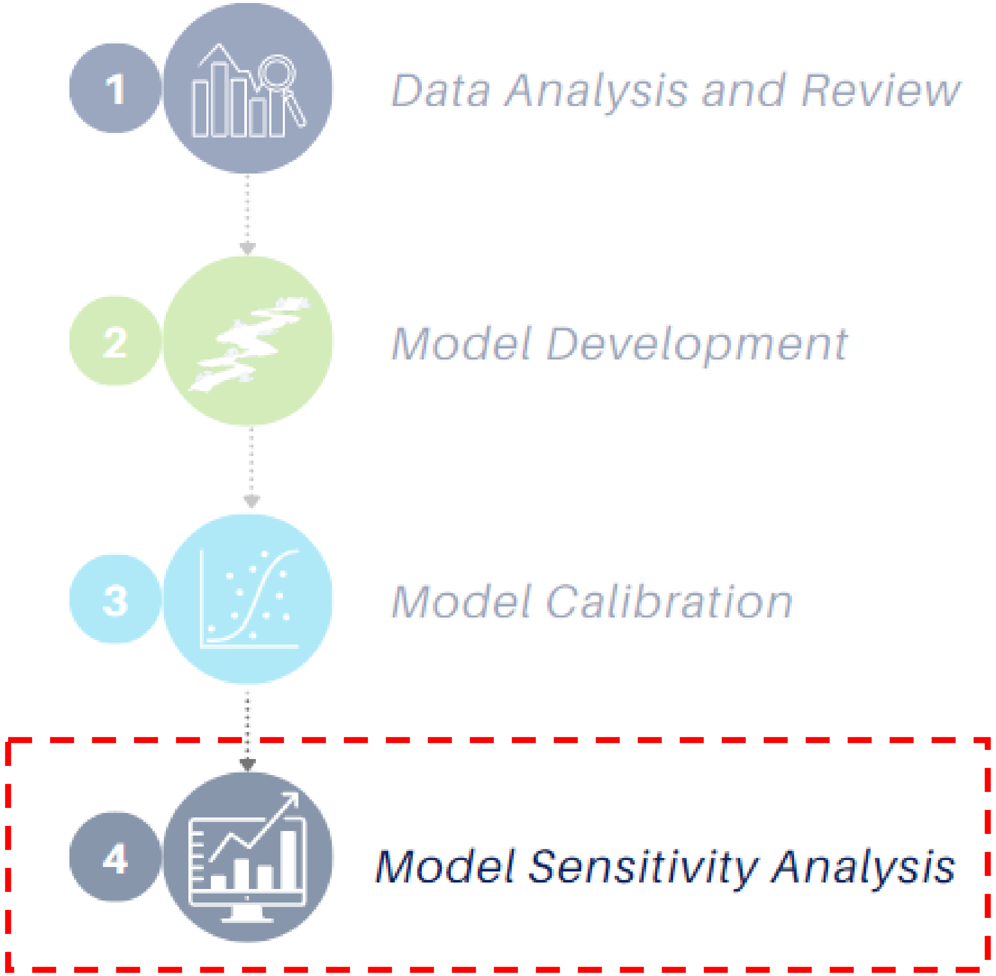
Modeling Process



- ✓ Troubleshoot the model simulation
- ✓ Adjust parameters to match simulated and observed data
  - Use measured data, literature values, or best professional judgement



Modeling Process



✓ Identify the most sensitive model parameters

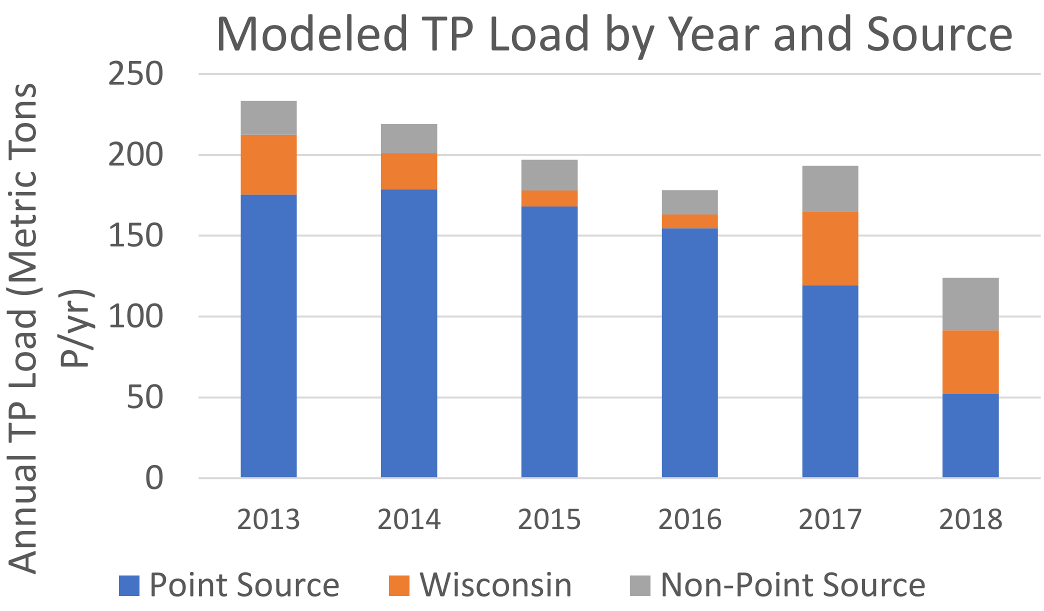
- Inform the management scenarios choices
- Identify the importance of data gaps

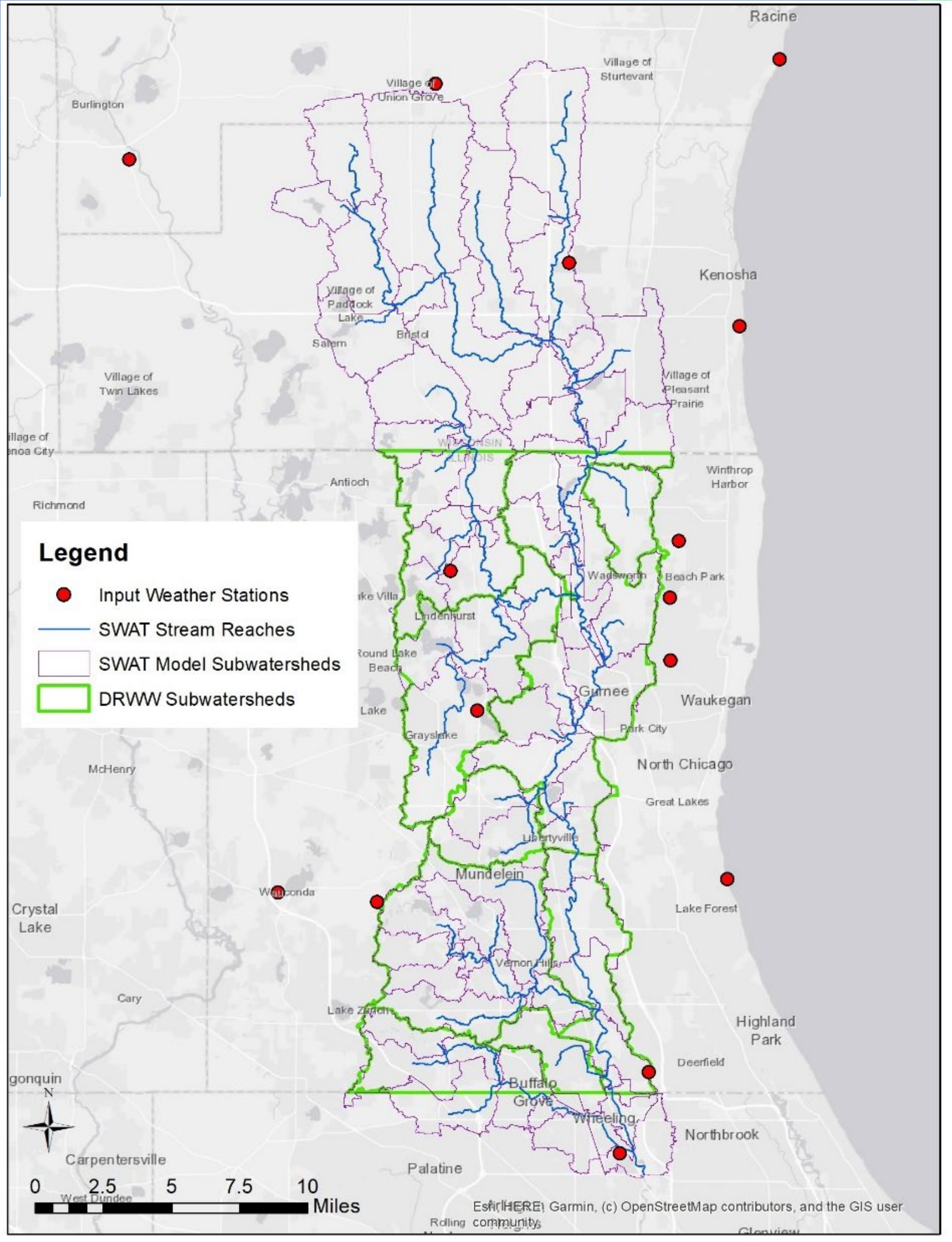
DRWW NARP Model

Setup and Calibration

Watershed Model

- Development and calibration presented at the DRWW General Membership meeting on Feb. 17, 2022

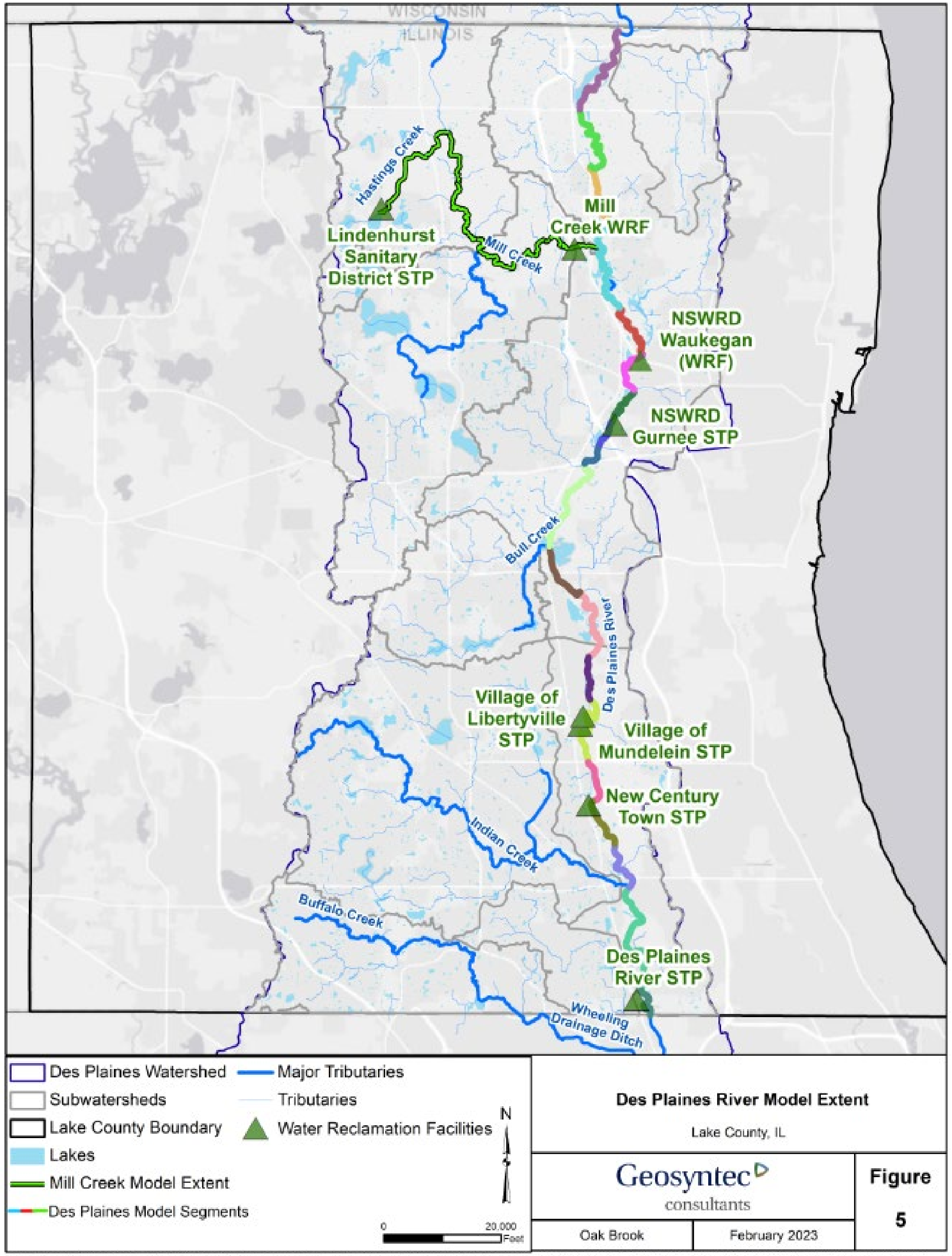




Instream Model – Setup

- ## Model Domain
  - Mainstem Model
    - Russell Road to the confluence of the Des Plaines River and the Wheeling Drainage Ditch
  - Tributary Model
    - Hastings Lake to the confluence of Mill Creek and the Des Plaines River

- ## Simulation Period
  - 2020 Growing season (May – October)
  - Lowest flow period with the maximum data availability

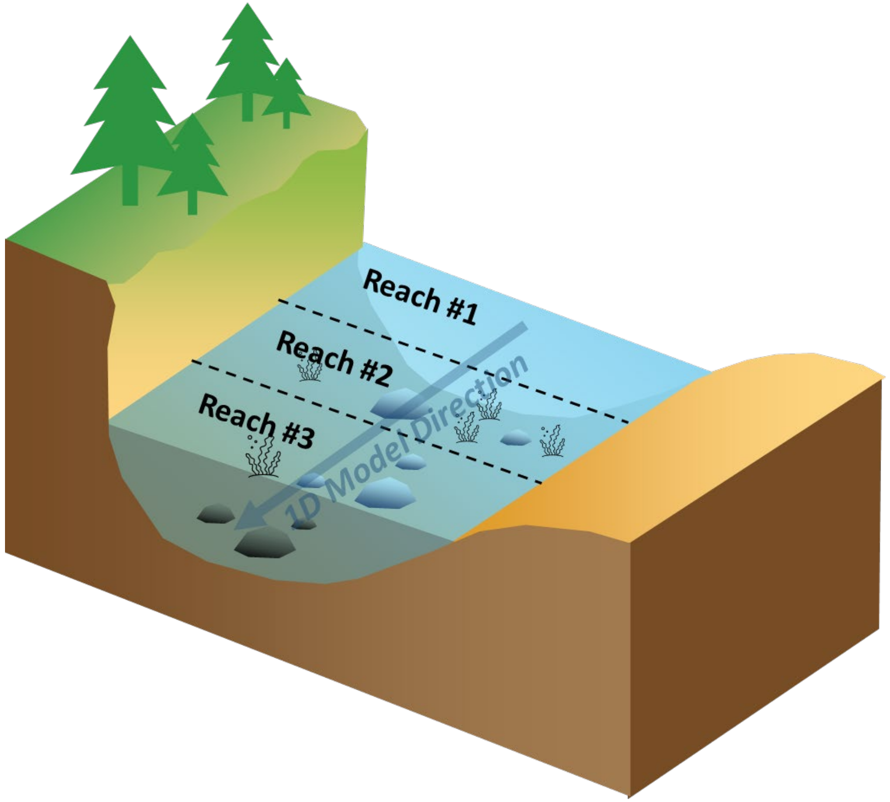


Water Quality Calibration Results

Selected Reaches

Instream Model – Qual2kw

- Qual2kw is a one-dimensional model
  - Qual2kw 1D model represents a river as a series of reaches with constant hydraulic and water quality characteristics
  - In reality, factors influencing water quality might change in the 2D or even 3D
  - Model simulations might not capture all variations in observed data
  - Observed data depends on where the sondes were exactly deployed within each reach



Model Calibration Error Statistics

Relative Root Mean Square Error (RRMSE)*

- RRMSE < 10% → Excellent
- 10% < RRMSE < 20% → Good
- 20% < RRMSE < 30% → Fair
- RRMSE > 30% → Poor

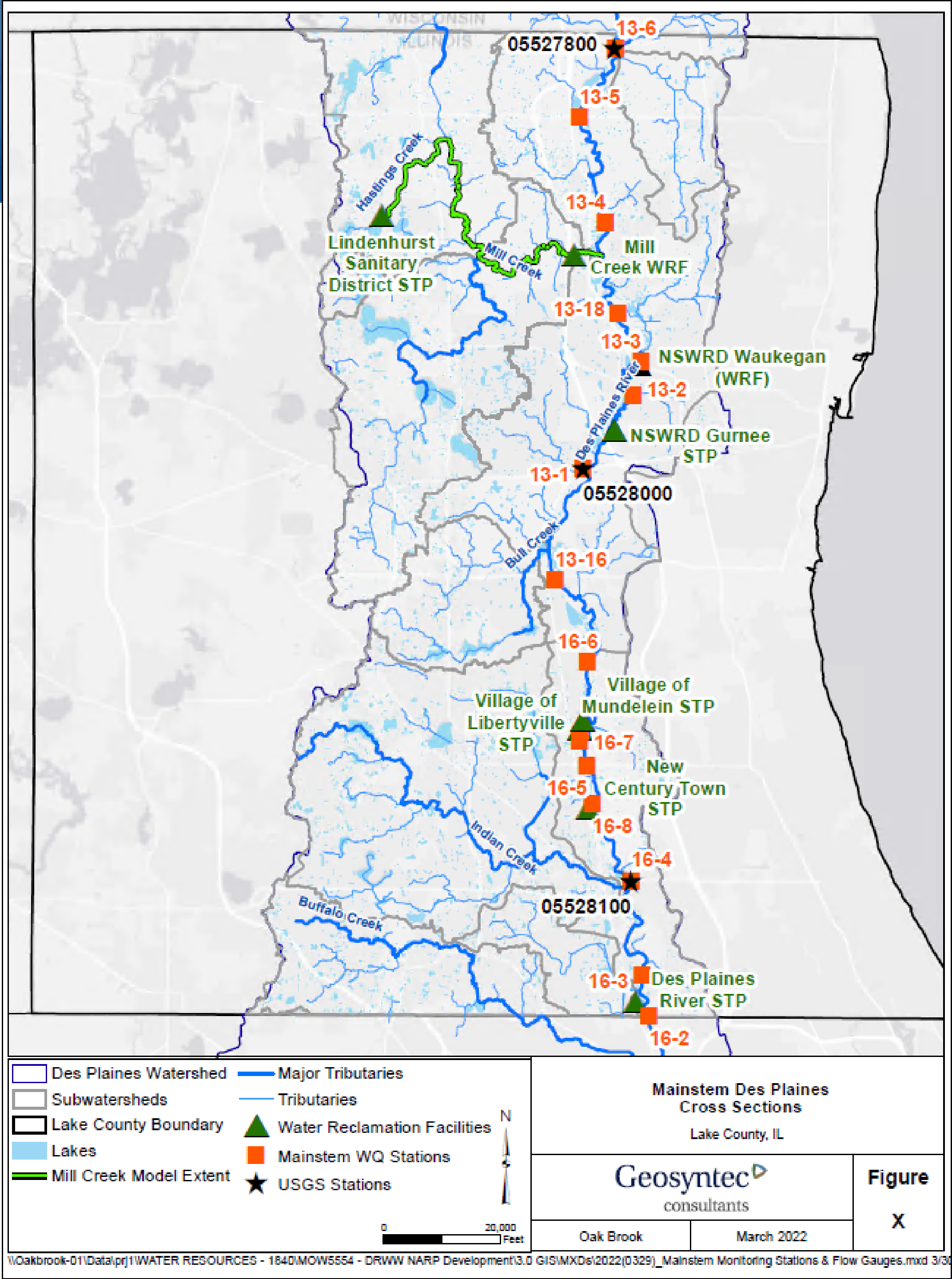
$$\text{RRMSE} = \sqrt{\frac{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(\hat{y}_i)^2}}$$

*Evaluation Metric for Regression Models - Analytics Vidhya

Calibration Stations

14 water quality stations on the mainstem

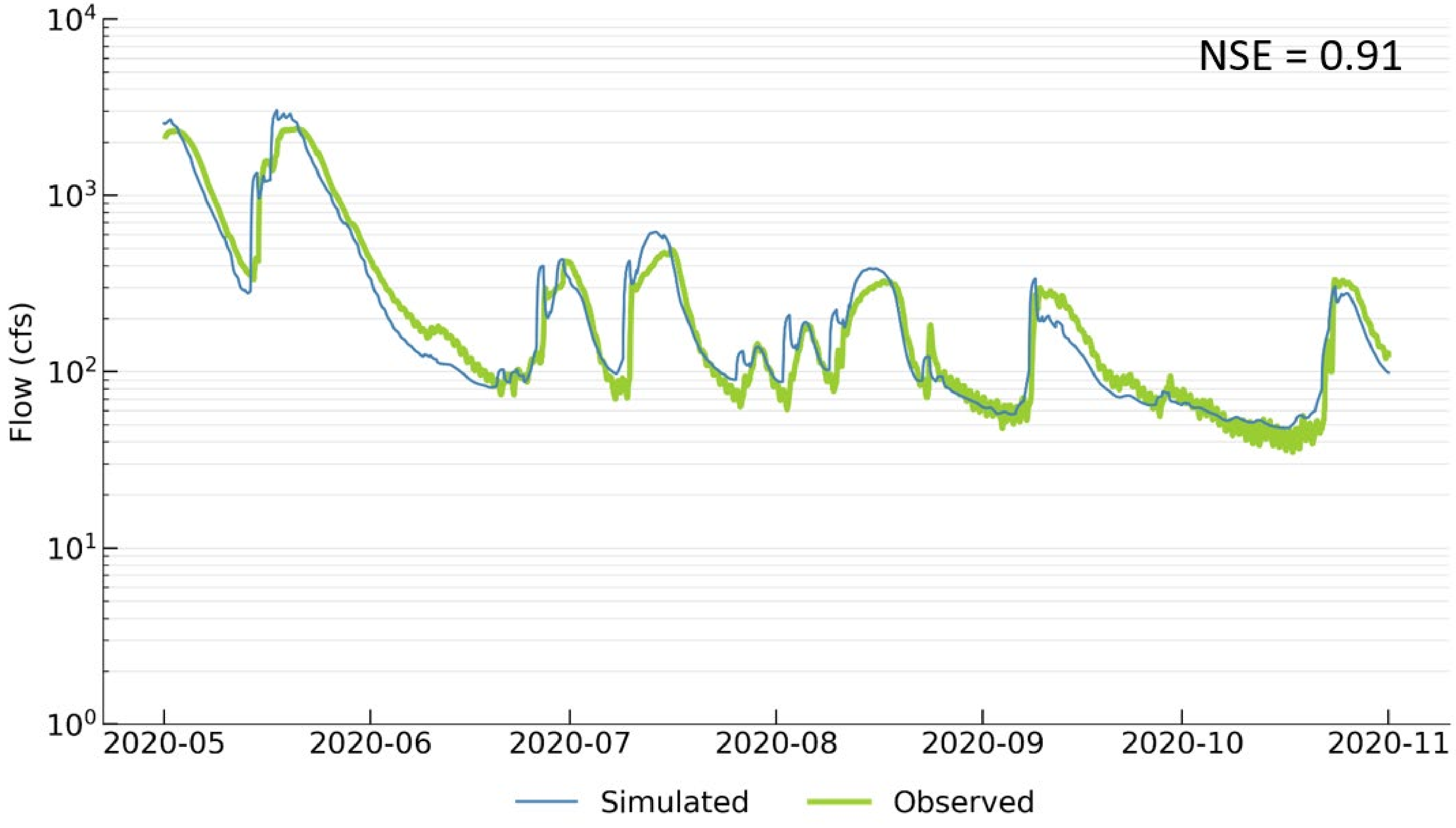
- 2 continuous
- 11 discrete



Flow Calibration

USGS 05528000 Des Plaines River near Gurnee, IL

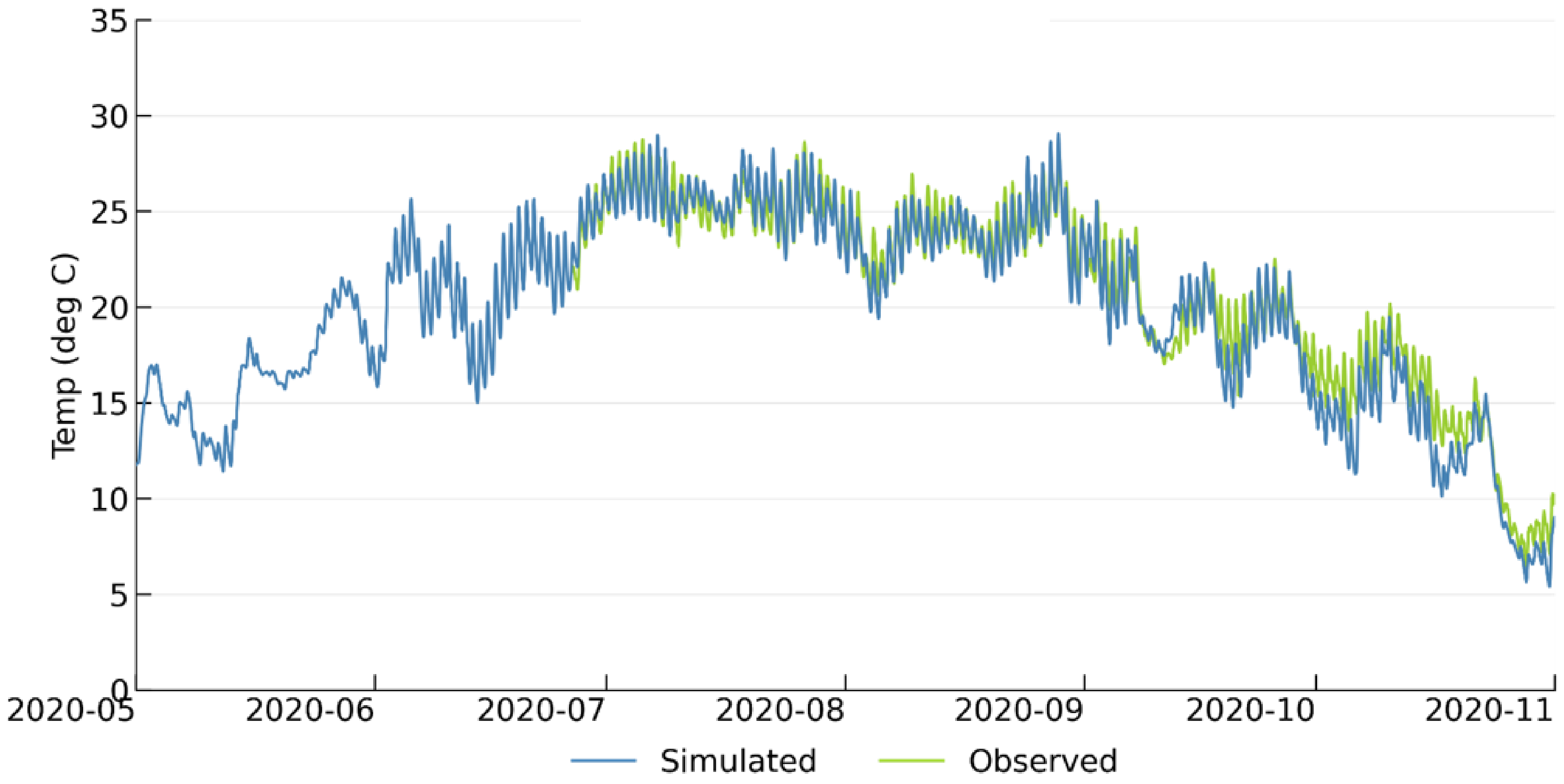
(River Mile 20.8)



Temperature Calibration

Des Plaines River at HWY 120

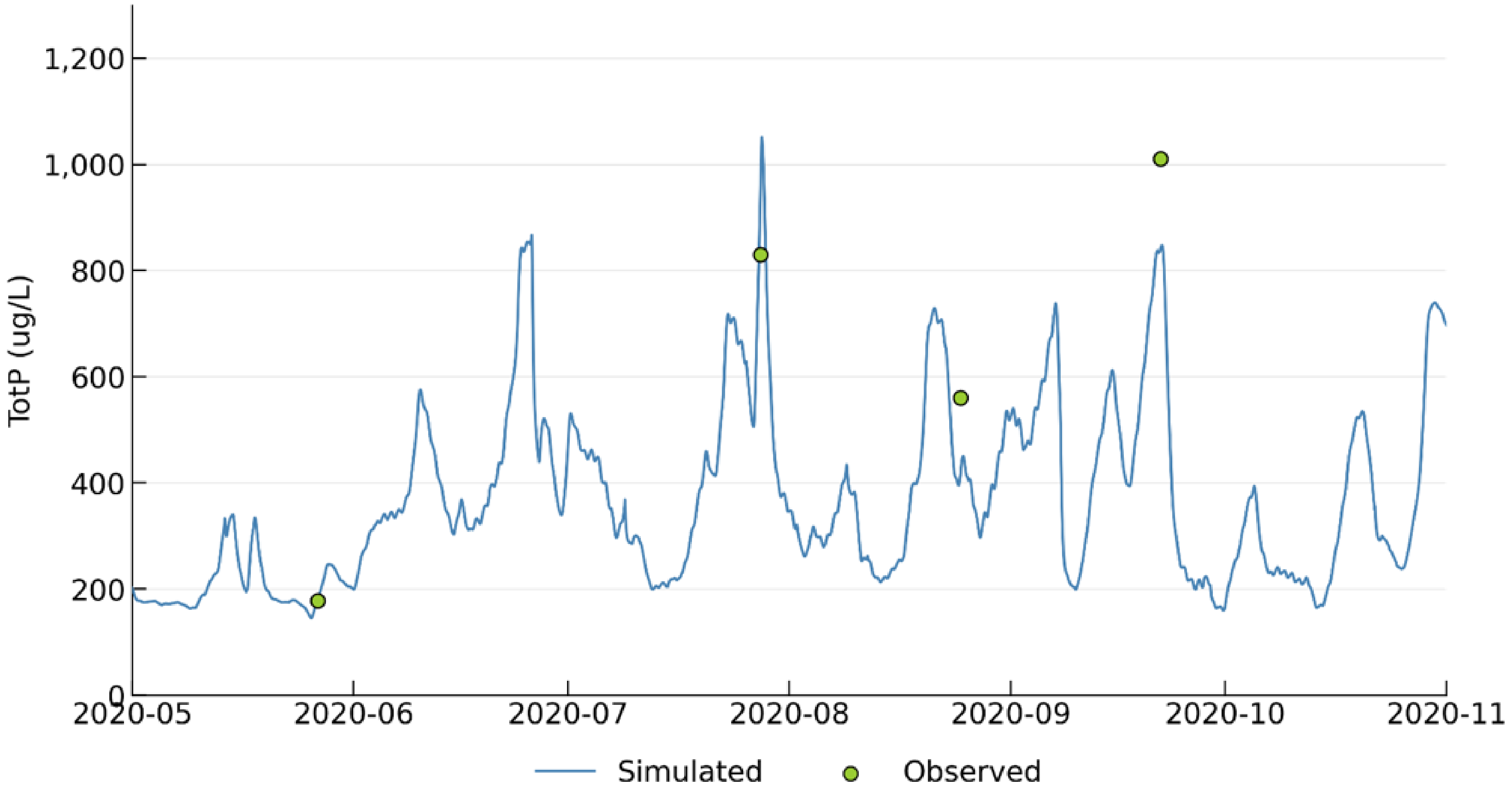
(River Mile: 20.8)



Total Phosphorus Calibration

Des Plaines River at HWY 120

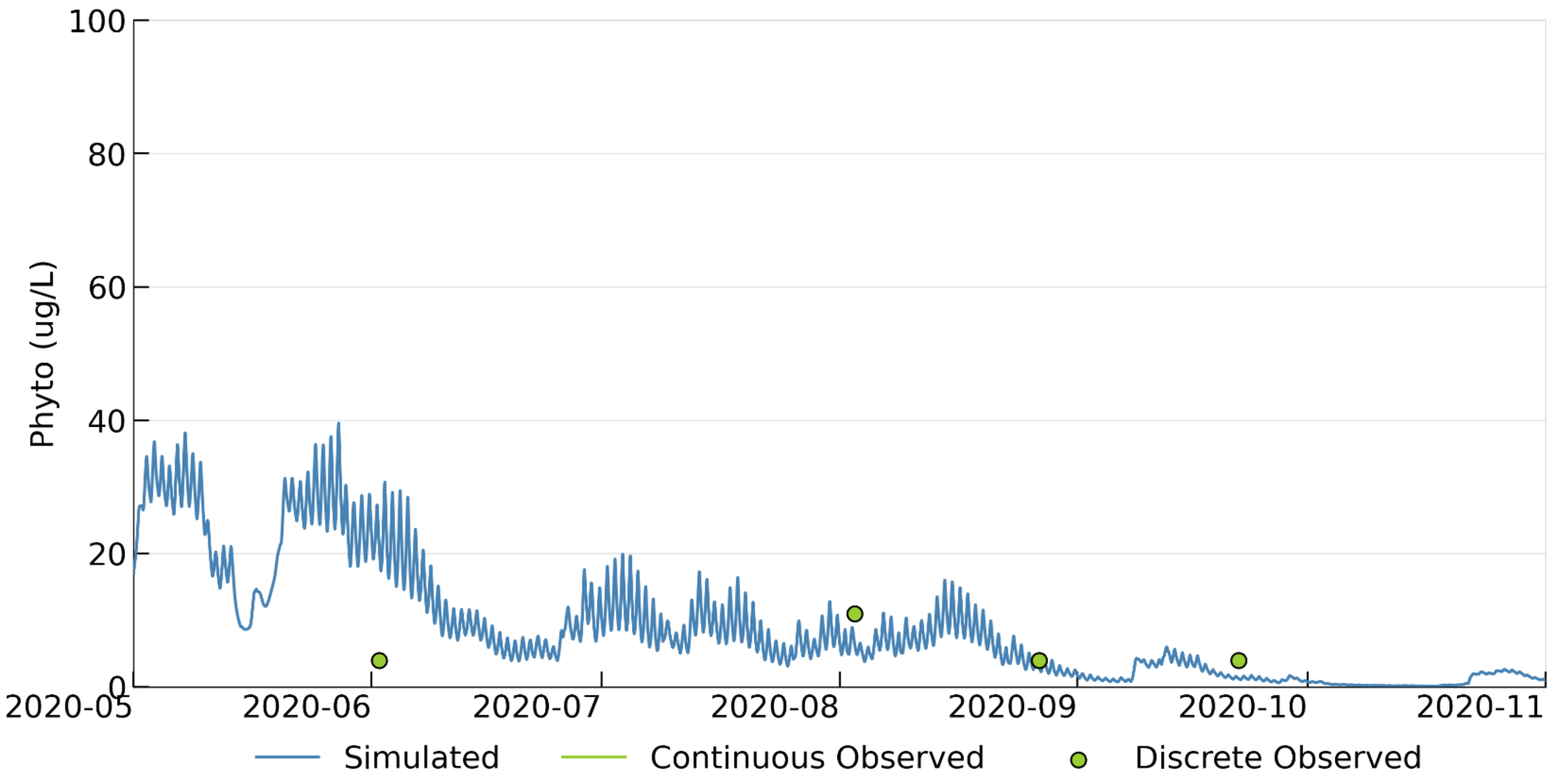
(River Mile: 20.8)



Chlorophyll-a Calibration

Des Plaines River at Rockland Rd.

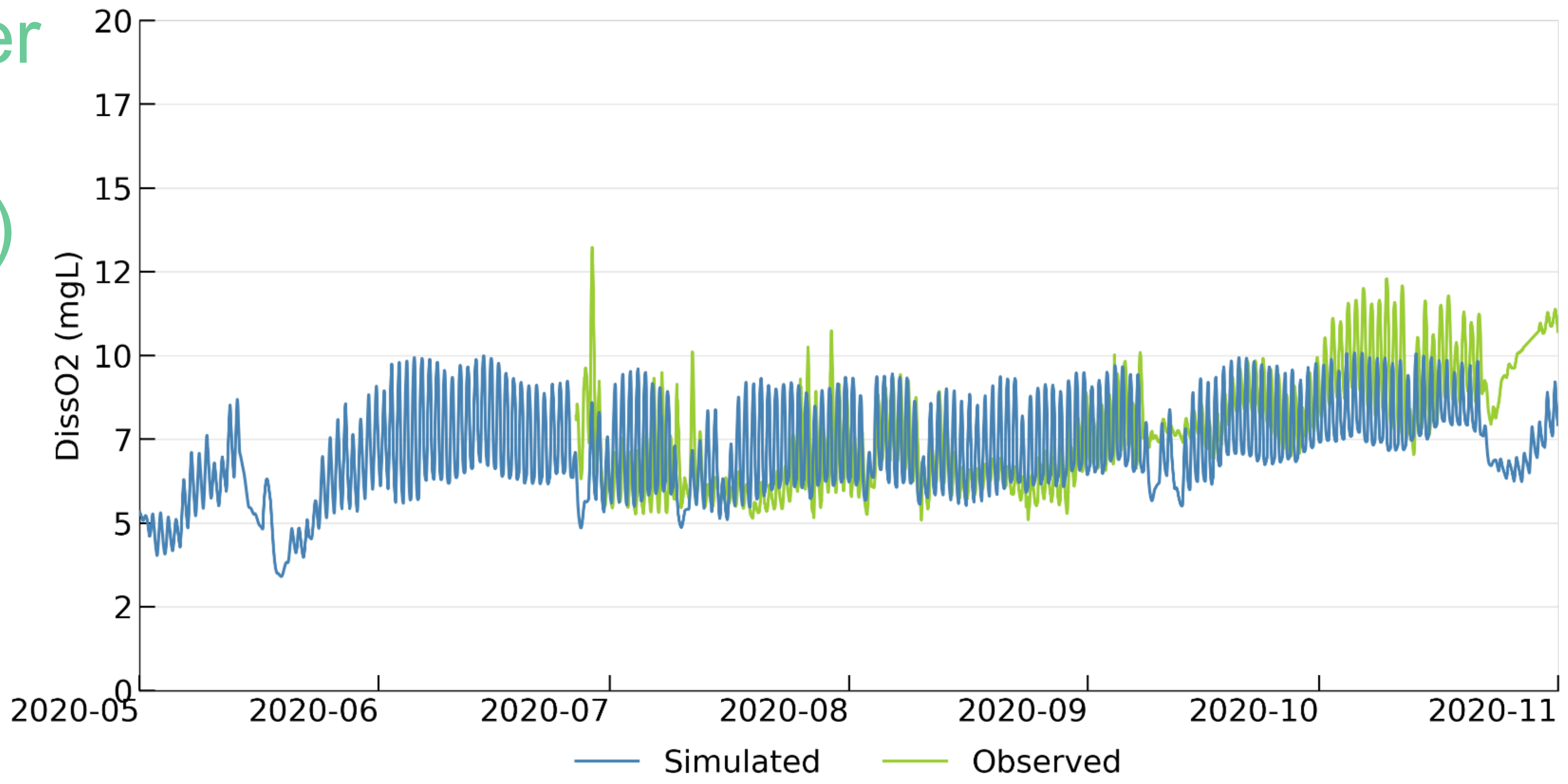
(River Mile: 14.4)



Dissolved Oxygen Calibration

Des Plaines River at HWY 120

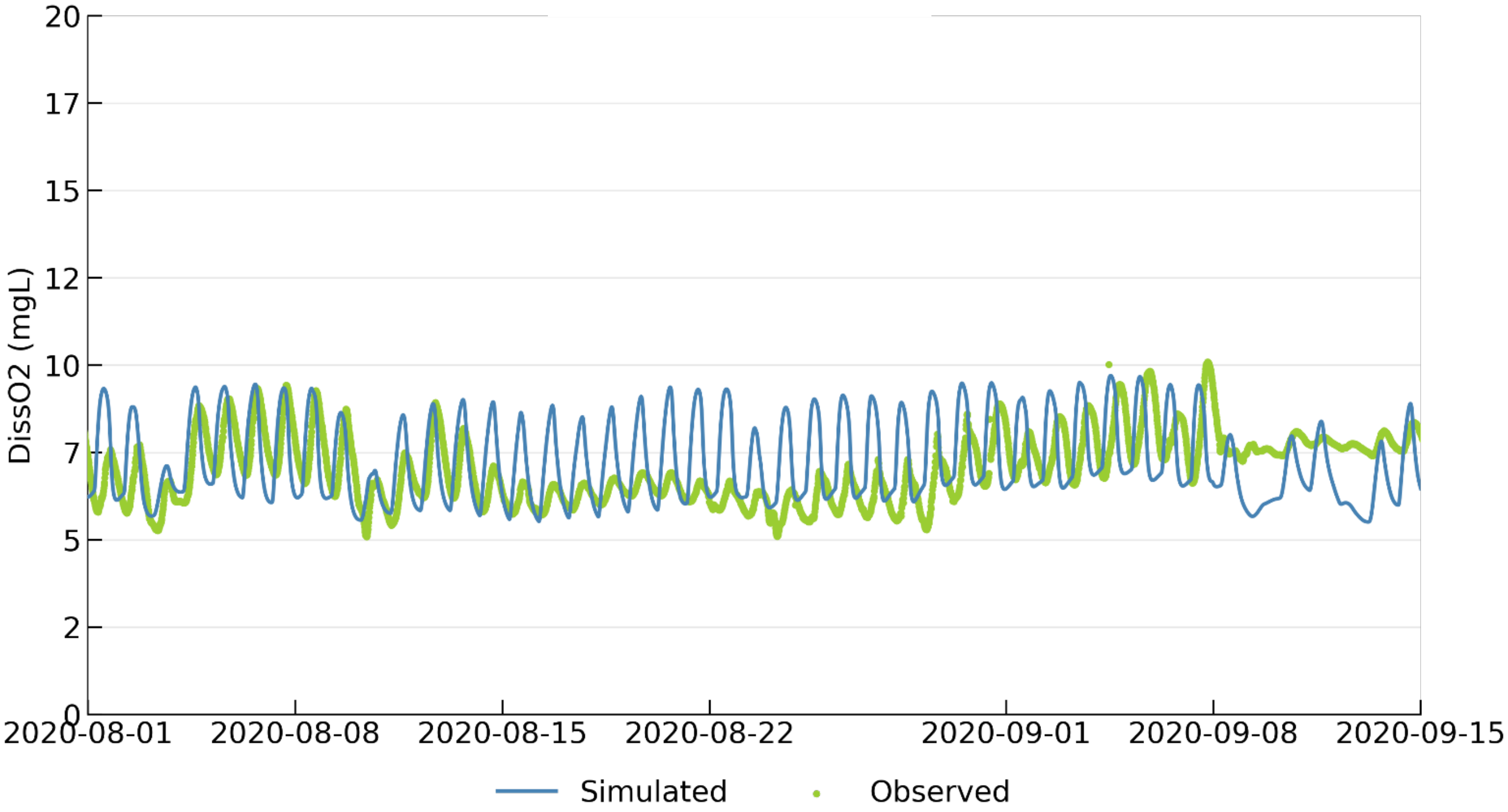
(River Mile: 20.8)



Dissolved Oxygen Calibration

Des Plaines River at HWY 120

(River Mile: 20.8)



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Watershed Management Scenarios

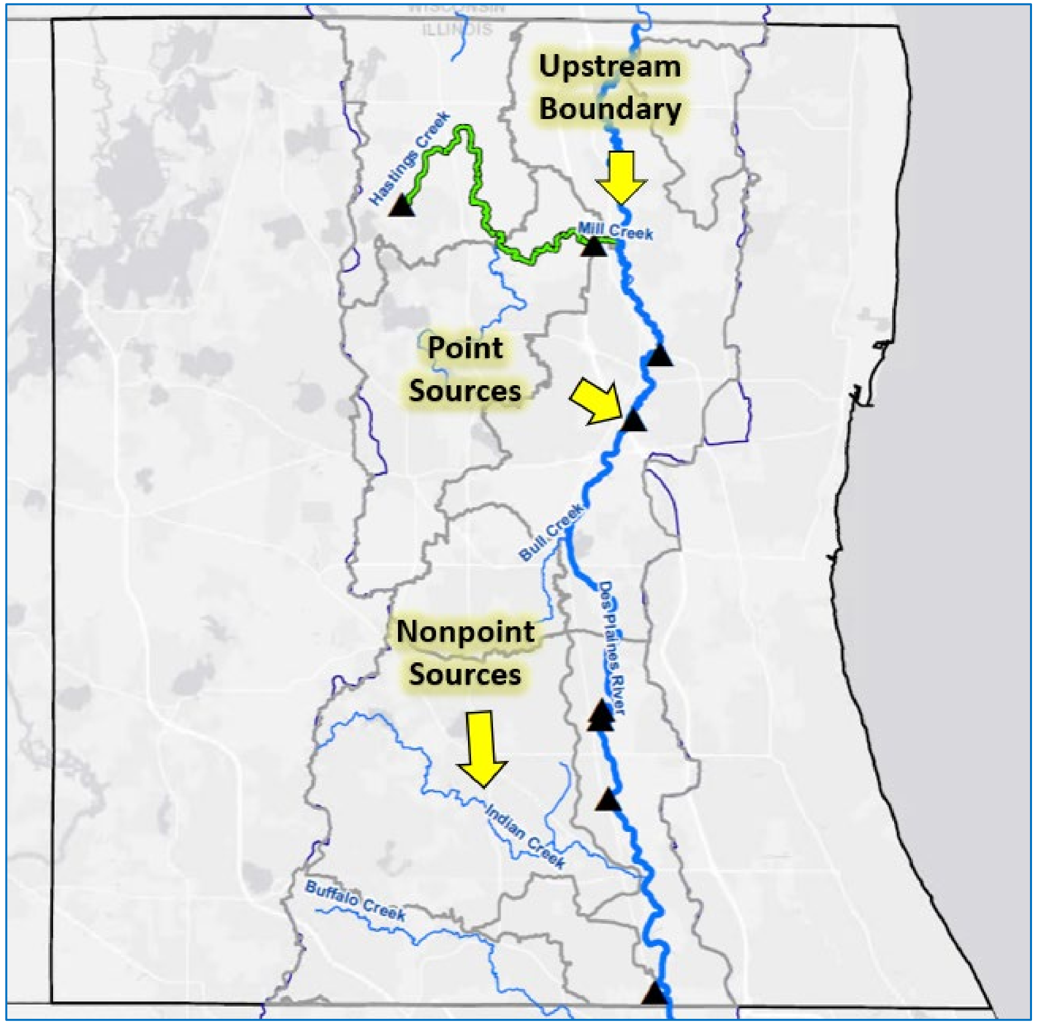
Individual and Combined Scenarios

Watershed Management Scenarios – Individual Scenarios

Upstream Load Reduction
75%

Tributary Load Reduction
75%

WWTP Load Reduction
0.5 and 0.1 mg/L



Key Takeaways

Takeaway #1: Upstream TP reduction reduces sestonic Chl-a and improves DO following large flow events

Takeaway #2: Tributary TP reductions reduce sestonic Chl-a but has minimal impact on DO

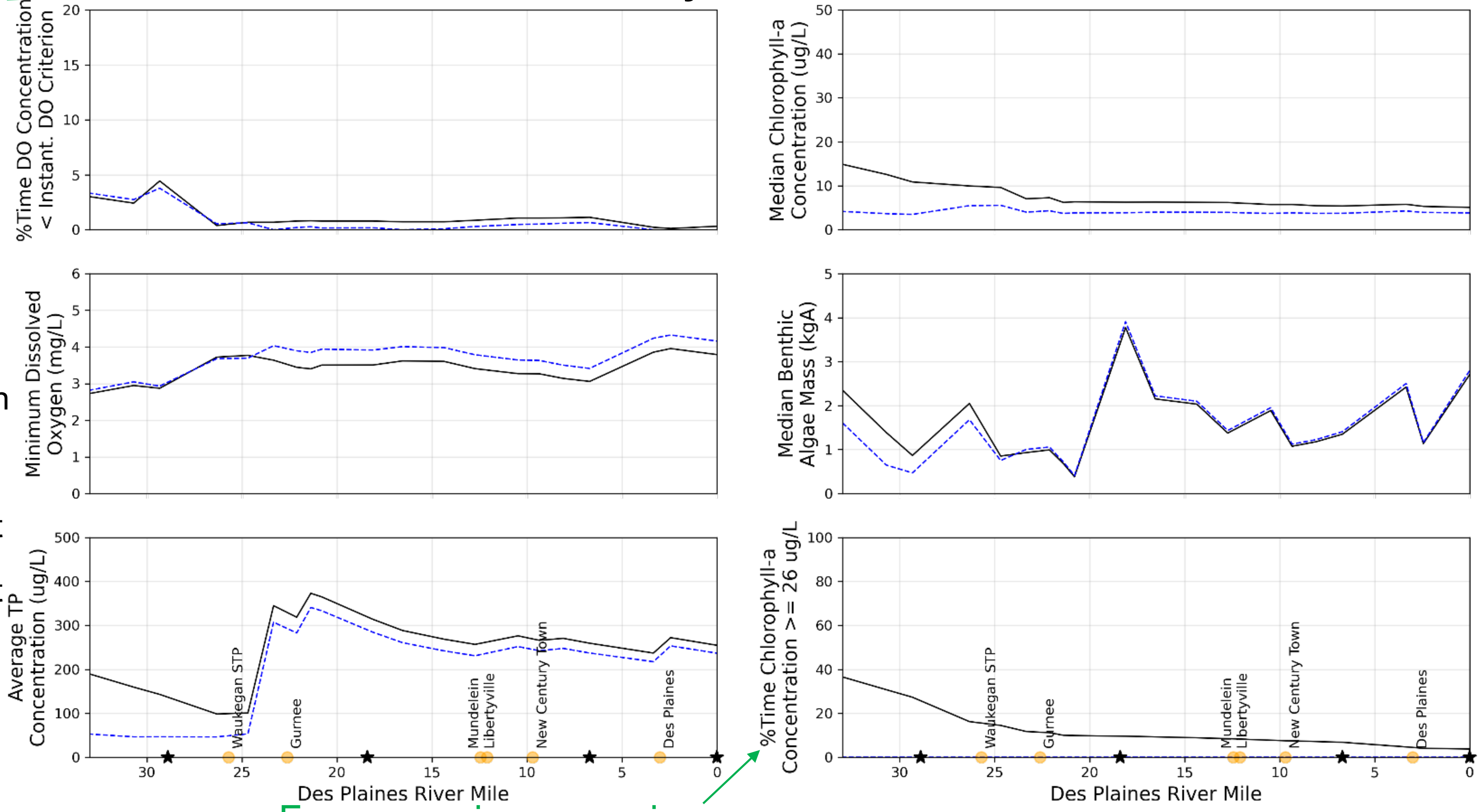
Takeaway #3: POTW TP reductions have minimal impact on water quality

Results Presentation Format

Analysis Period: Growing season, low DO period, or high flow period

- WWTP
- ★ Tributaries
- —— Baseline
- - - - 75% Upstream Reduction
- - - - 75% Nonpoint Reduction
- - - - 0.5 mg/L POTWs effluent
- ······ 0.1 mg/L POTWs effluent

Analysis Period



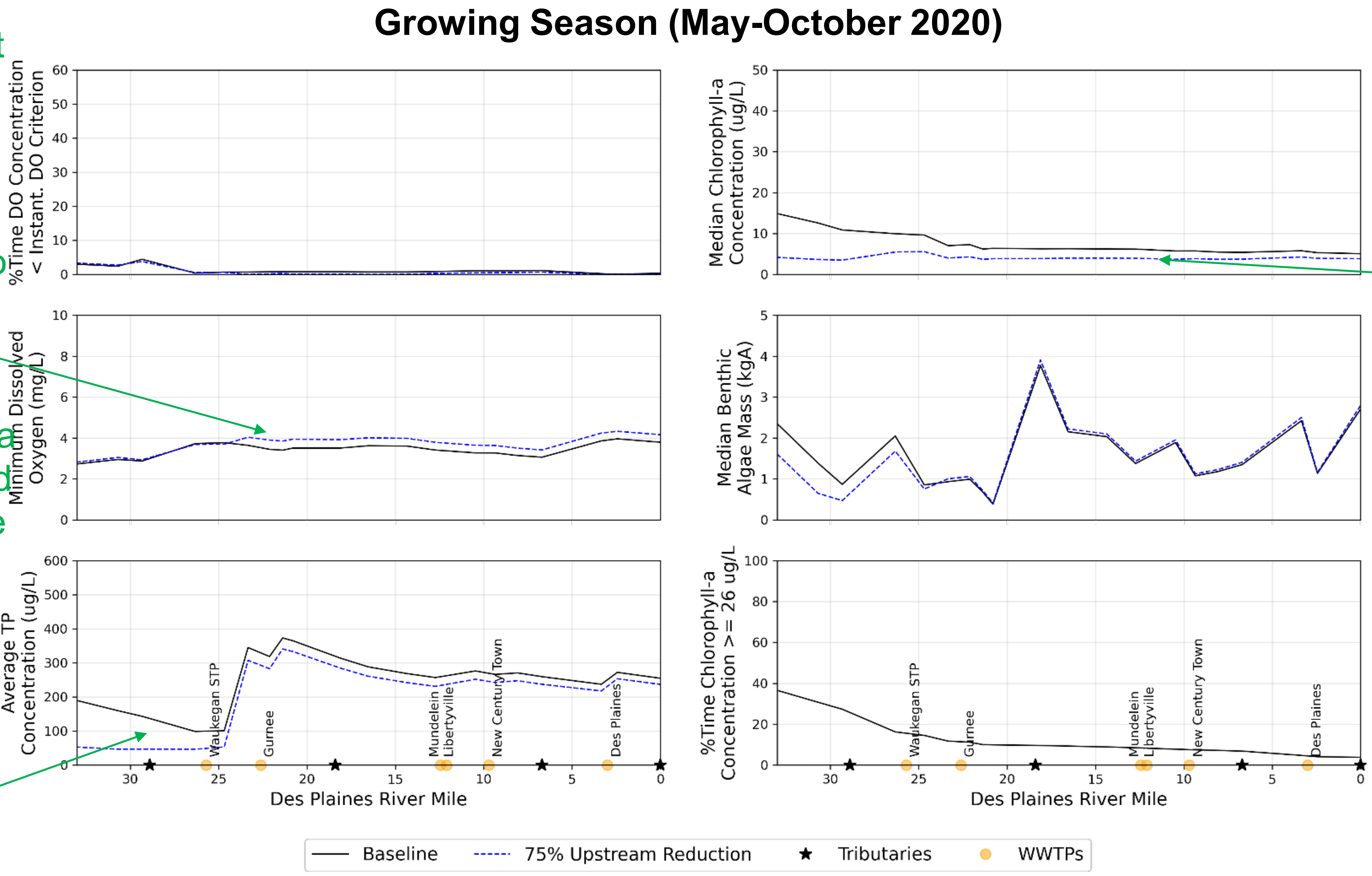
For comparing scenarios, not a "threshold"

Baseline and 75% Upstream Reduction

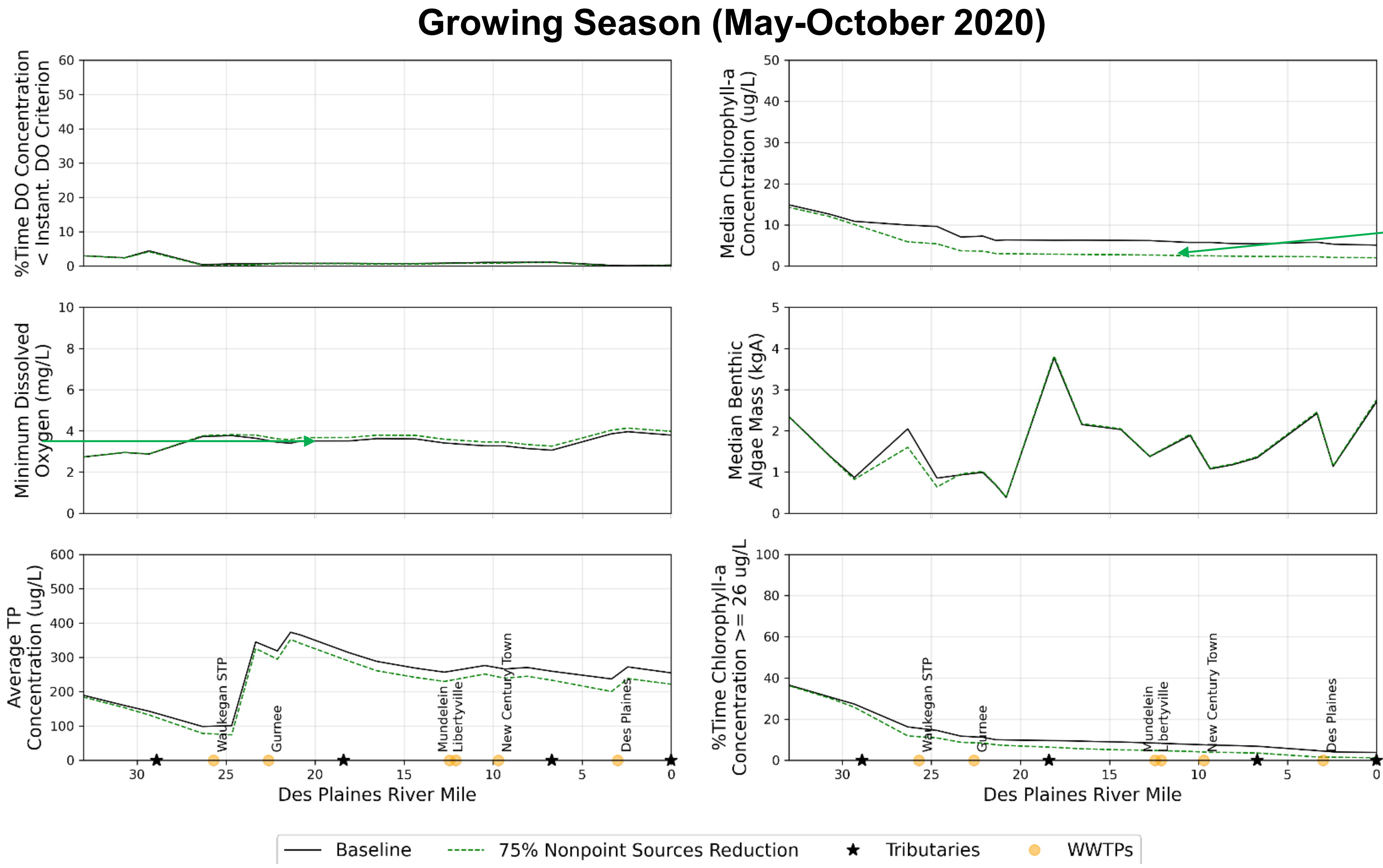
Improvement in minimum DO after RM 25 following large wet events due to reduced DO swings with reduced upstream Chla and increased benthic algae

Reduction in TP due to reduction in upstream TP

Reduction in Chl-a, due to reduction in upstream Chl-a boundary



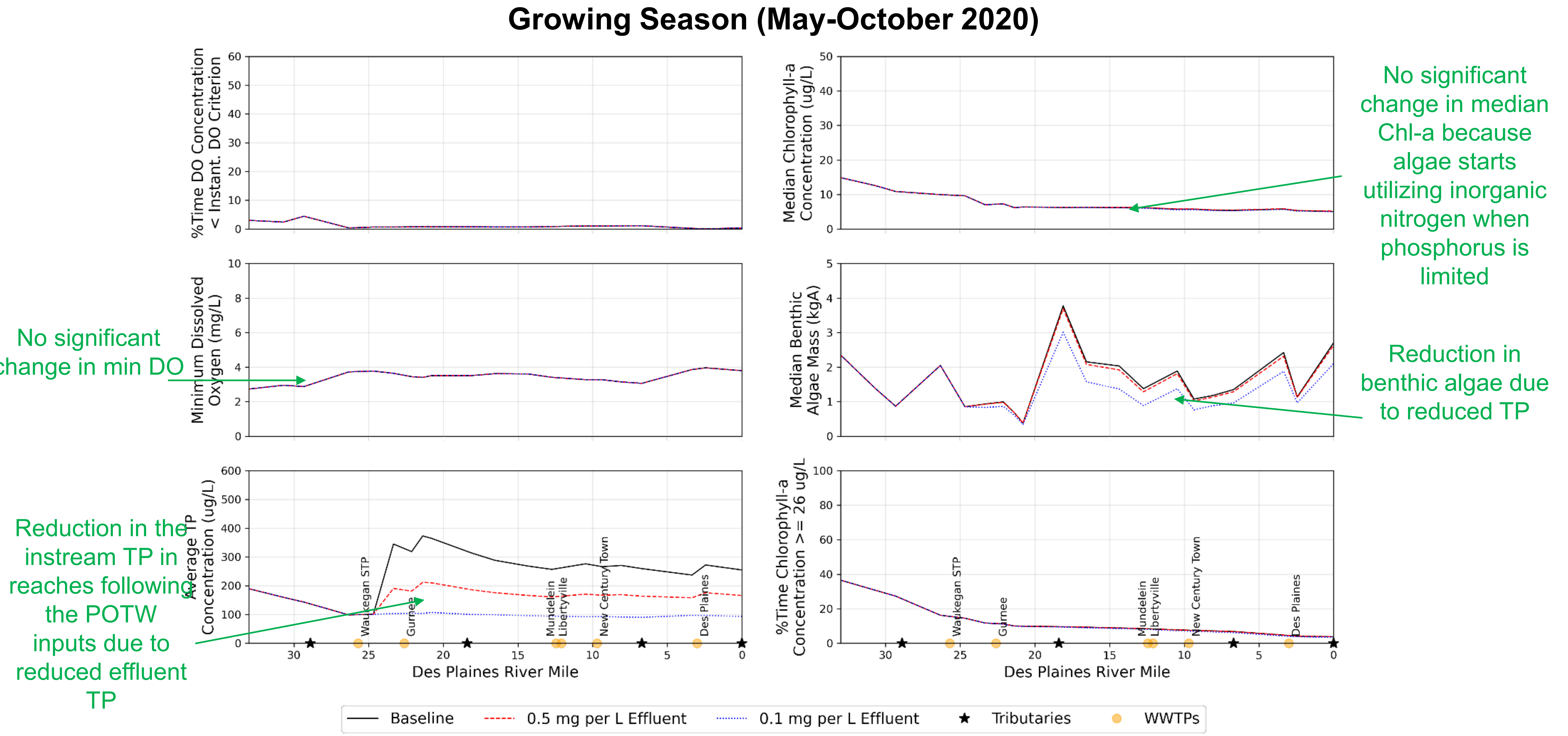
Baseline and 75% Nonpoint Reduction – Longitudinal



Slight reduction in Chl-a due to reduced nonpoint sources Chl-a and TP

No significant impact on DO

Baseline and POTW Reductions – Longitudinal



Next Steps

Documentation and Implementation Plan

NARP Next Steps

- Run additional scenarios based on Monitoring Committee
- Present the NARP progress to Illinois EPA
- Document the modeling setup, calibration, and management scenarios in a NARP report chapter
- Develop a NARP Implementation Plan