The importance of risk-based decision making for Total Maximum Daily Loads in a changing climate

Ebrahim Ahmadisharaf, PhD

Department of Civil and Environmental Engineering

Outline

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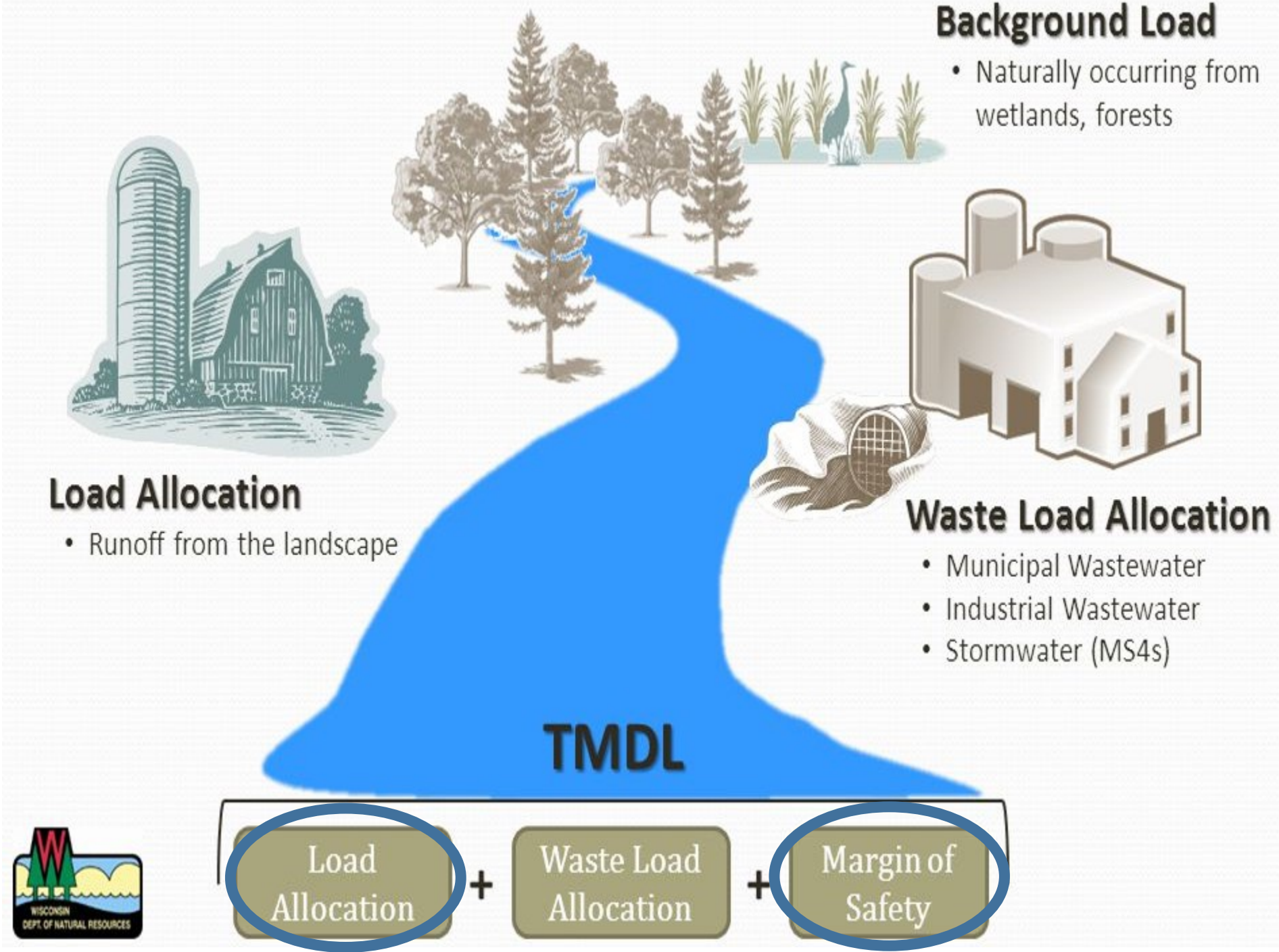
  - TMDLs: Bacteria
  - Water quality modeling and uncertainties
  - Climate change impacts
  - Gaps and objective
- Risk-based decision making framework
  - Concept
  - Illustration
- Future directions
- Summary

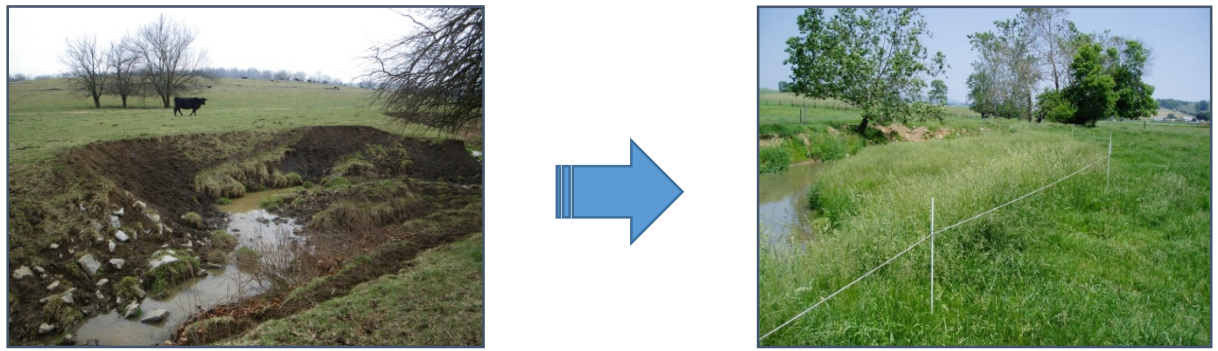
TMDL

- TMDL: Total maximum daily load
  - Amount of a pollutant that can enter a waterbody without violating water quality standards
- Impaired waterbodies

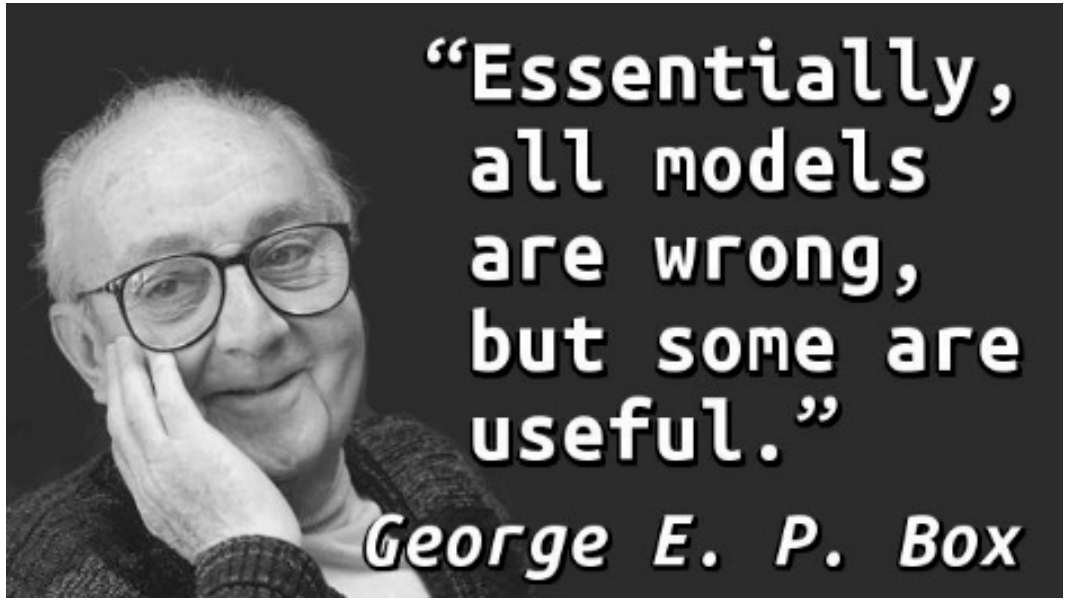

Background Load
• Naturally occurring from wetlands, forests
Load Allocation
• Runoff from the landscape
Waste Load Allocation
• Municipal Wastewater
• Industrial Wastewater
• Stormwater (MS4s)
TMDL
Load Allocation
+
Waste Load Allocation
+
Margin of Safety
WISCONSIN DEPT. OF NATURAL RESOURCES

TMDL Decision Making

- Selection of pollution reduction strategies
- Water quality modeling
  - Decision support



Uncertainties in Water quality Modeling



Uncertainties in Water quality modeling

Data

- **Climate**
- **Soil**
- **Elevation**
- **Hydrologic**

Additional uncertainty

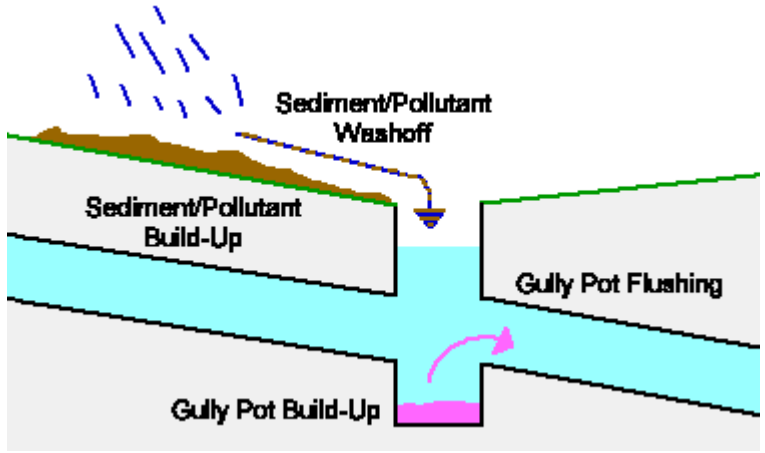
Climate change

Model

- **Structure**
- **Parameters**
- **Calibration**
- **Resolution**

Climate change impacts

- Changes in weather patterns and extremes
  - More extreme rainfall events
  - More pollutant washoff from lands to adjacent streams
  - Nonpoint source pollution



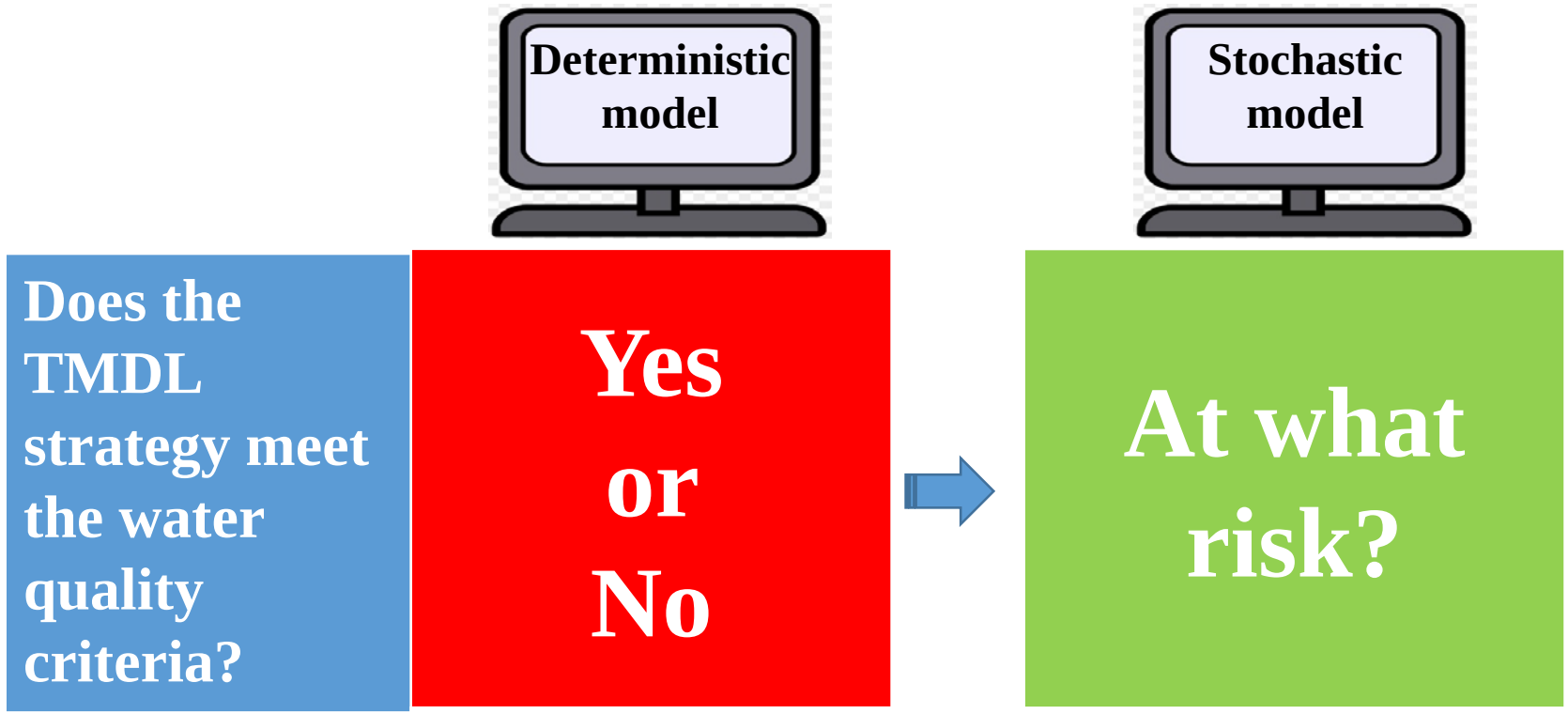
Gaps

1. Margin of safety estimation
   - Implicit and often subjective
   - Uncertainties are not explicitly modeled
   - Uncertainties from the climate change
2. Uncertainties are not transformed to the **decision making** stage

Objective

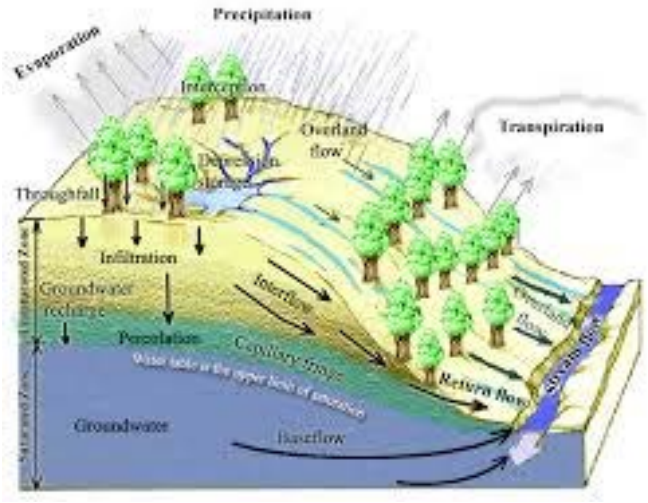
A **risk-based decision making** framework for assessing the reliability of pollutant reduction strategies

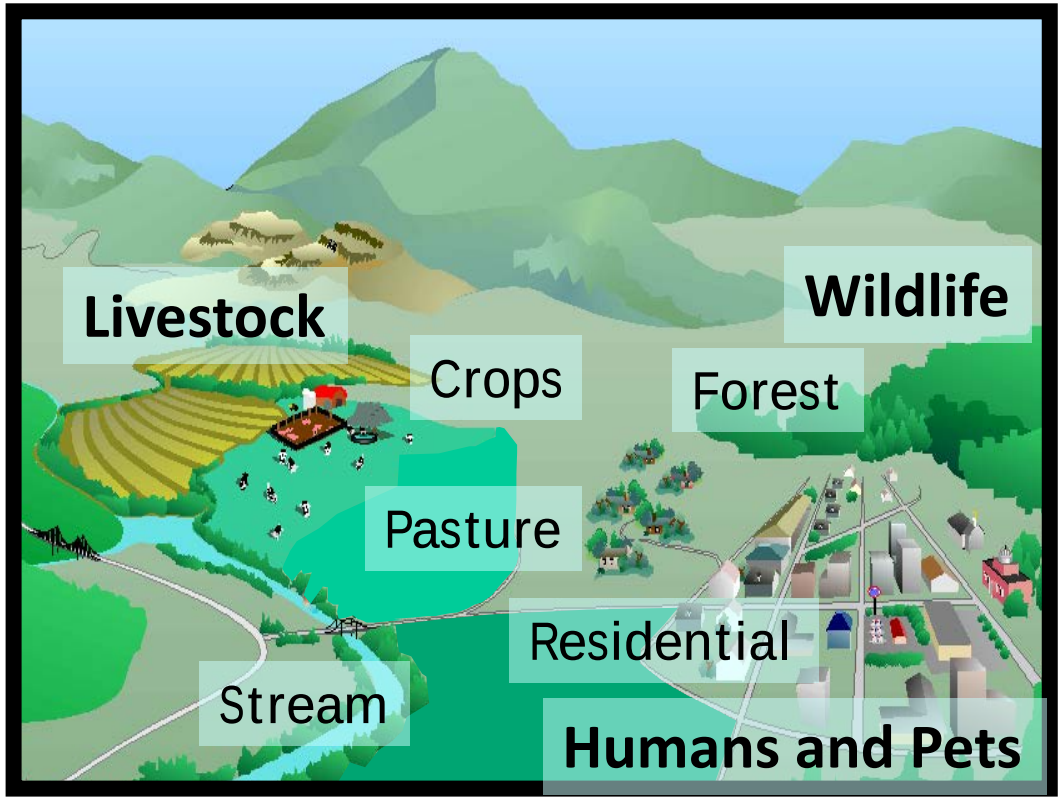
Decision Making:
Risk-based vs. Deterministic



Water Quality Model

- Statistical model
- Watershed model
  - Nonpoint source pollution processes
    - Rainfall-runoff, washoff, dieoff etc.
  - Fate and transport of pollutants





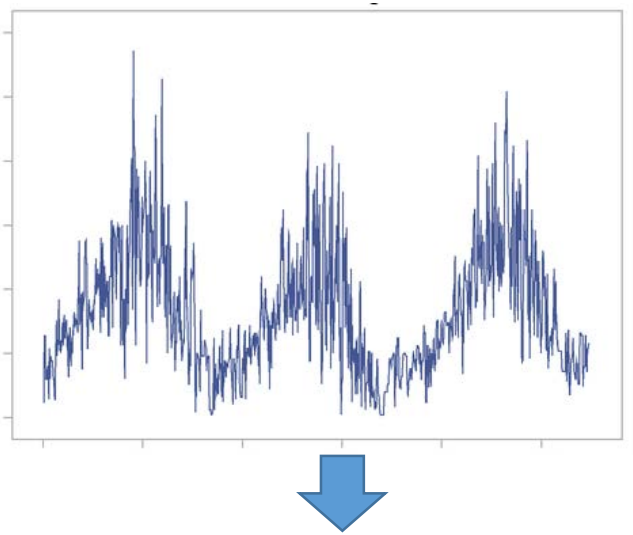
Stochastic Water Quality Modeling

Probabilistic techniques

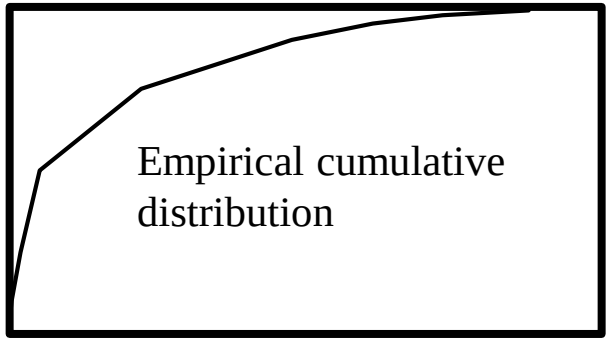
Watershed model

Transform Modeling to Decision Making

- Water quality model
  - Continuous simulations of in-stream bacteria concentration for **various climate scenarios** (**ensemble** modeling)
  - Quantile time series



- Transform the model results to decision making
  - Water quality criteria
  - Florida (E. coli bacteria concentration)



Monthly geomean <126 cfu/100 mL; Percent of months = 0.0%
of exceedance rate <410 cfu/100 mL; Percent of months <10%

Risk-based Analyses of Pollution Reduction Strategies

Deterministic modeling

Successful or not?

Probabilistic modeling

Decision making risk level:

- Conservative decision making
- Aggressive decision making
- Normal risk tolerance

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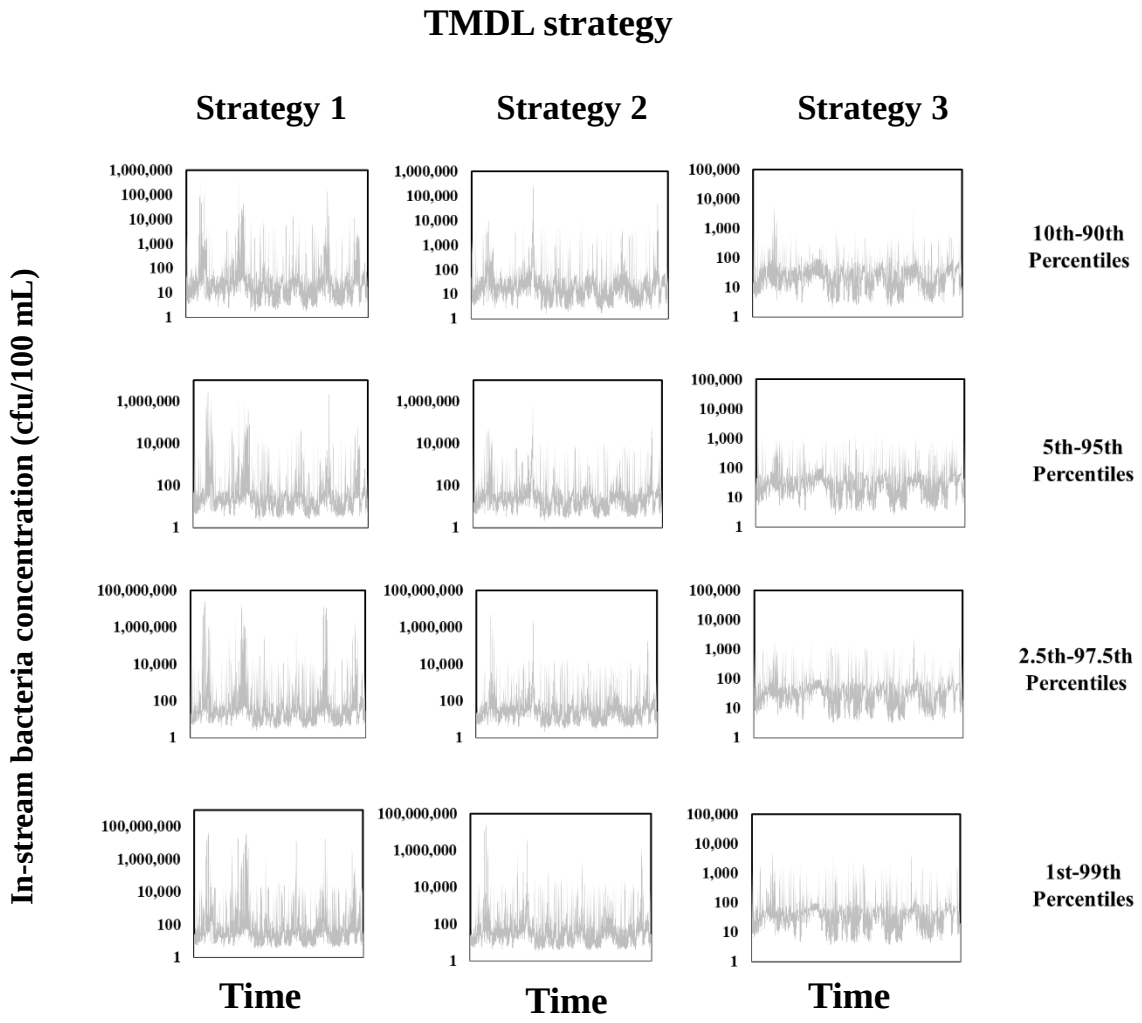
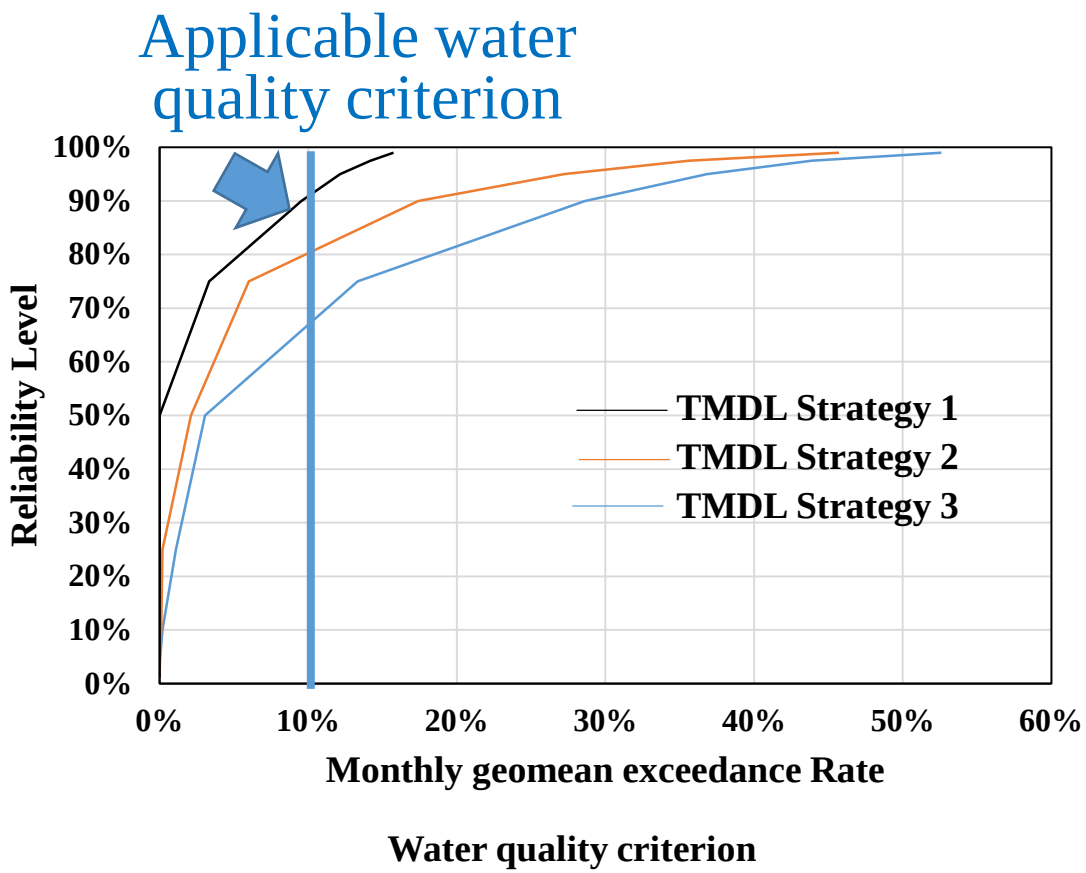
Water Quality Model Results

Ensemble modeling for various climate scenarios



Exceedance Rates of Pollutant Reduction Scenarios



How reliable the proposed TMDL strategy is under various climate scenarios?

Future Directions

- Climate change and other uncertainties
  - Relative contributions
- Develop TMDL strategies probabilistically
  - Stochastic optimization

Summary

1. Climate change impacts on bacteria pollution and non-point source pollution
2. Effectiveness of TMDL strategies under climate change
3. Risk-based decision making framework for bacteria TMLDs based on applicable water quality criteria
4. Prioritize TMDL strategies by incorporating various climate scenarios


Questions?
eahmadisharaf@eng.famu.fsu.edu