Establishing State-Wide Nutrient Criteria Using a Stochastic Modeling Approach

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Presentation Outline

- Criteria development in ND
- Nutrient criteria development
  - Classification of lakes and reservoirs
  - Model development
  - Products for setting criteria
- Next steps for setting nutrient criteria
- Lessons learned

Background for Nutrient Criteria Development

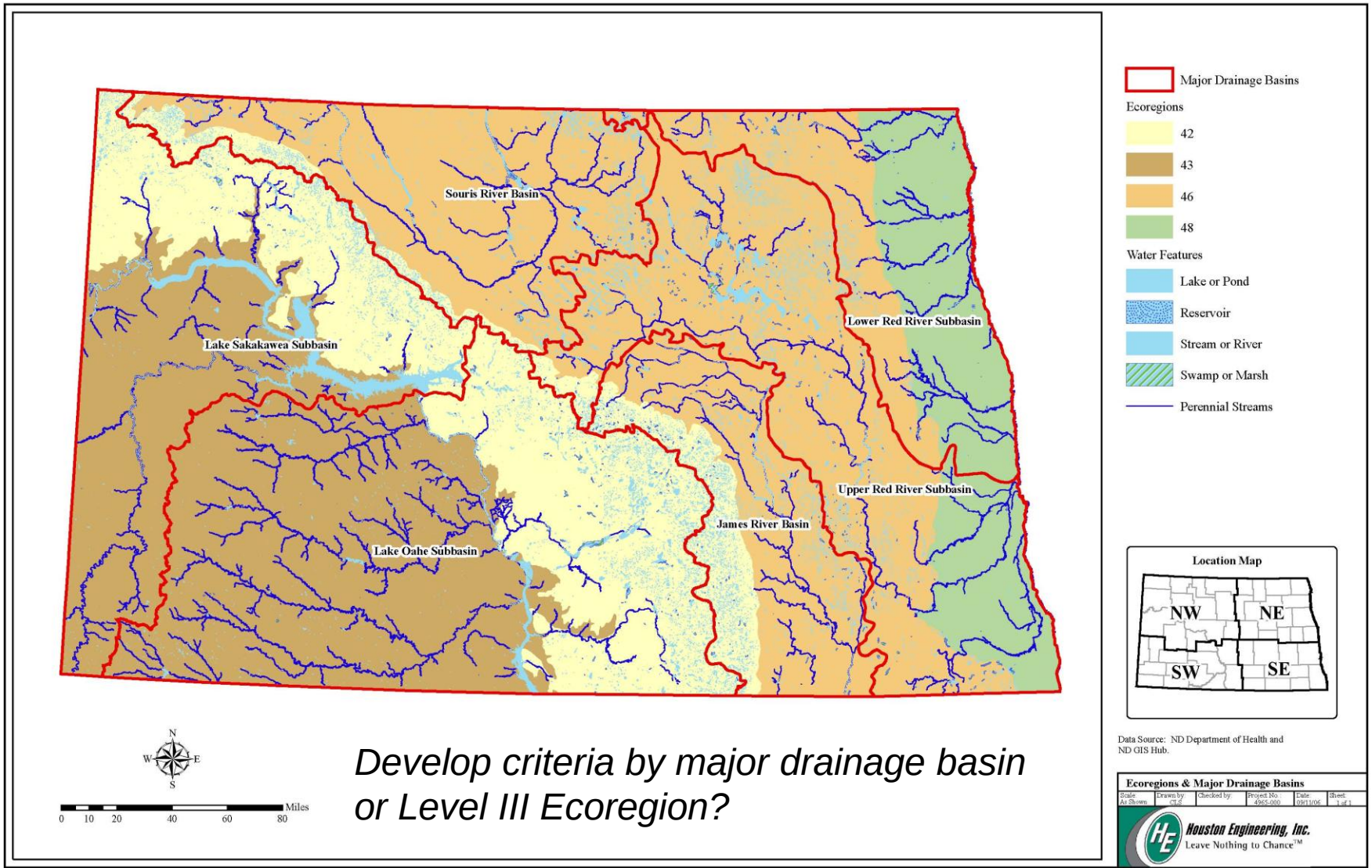
- EPA working with all states to develop nutrient criteria for protecting streams, lakes and wetlands
  - North Dakota within EPA Region 8
- Numeric Standards N.D. Administrative Code 33-16
  - Total TP Restoration Goal = 20 ppb

This work began when the restoration goal established by the NDAC was 100 ppb total phosphorus

North Dakota Used a Road Map to Begin Criteria Development

- Prepared *Implementation Plan* (2007)
- ND is lacking information for "reference" conditions
  - Existing data lacks in abundance and distribution
  - Consider regional modeling
- Recommended:
  - First lentic (non-flowing), then lotic (flowing), systems; address wetlands separately
  - Stratify criteria by hydrologic planning regions before using ecoregions

North Dakota Used a Road Map to Begin Criteria Development



Develop criteria by major drainage basin or Level III Ecoregion?

State-wide Classification of Lentic Systems was Critical First Step

- Must determine which water bodies are lakes? reservoirs? or wetlands?
- Lake and reservoir classes must be further divided into sub-classes (181,000 lentic water bodies)
  - Must reflect how system will respond to environmental conditions
- Considered 11 metrics (mixing characteristics, morphoedaphic index, residence time, morphometry)
- Established four sub-classes for lakes and reservoirs

Description of Physical Data for Classes

Lakes

- Minimum 10 acres
- Max depth > 1 meter
- Minimum open water area of 1000 sq. meters
- No dam

Defined from NHD, NWI, ND G&F

Reservoirs

- Some water control structure
- “Short” residence time

Assigned Class	Average Surface Area (acres)	Average Volume (ac-ft)	Average Drainage Area (sq.mi.)
LAKES (n=10,335)			
I	74.1	575.9	13.8
II	156.8	1,770.8	12.9
III	364.3	4,444.3	16.6
IV	1,203.5	68,204.0	80.2
RESERVOIRS (n=687)			
I	86.2	637.8	70.0
II	279.6	2,760.1	144.8
III	1,613.0	19,741.5	1,167.9
IV	1,542.7	28,570.0	472.2

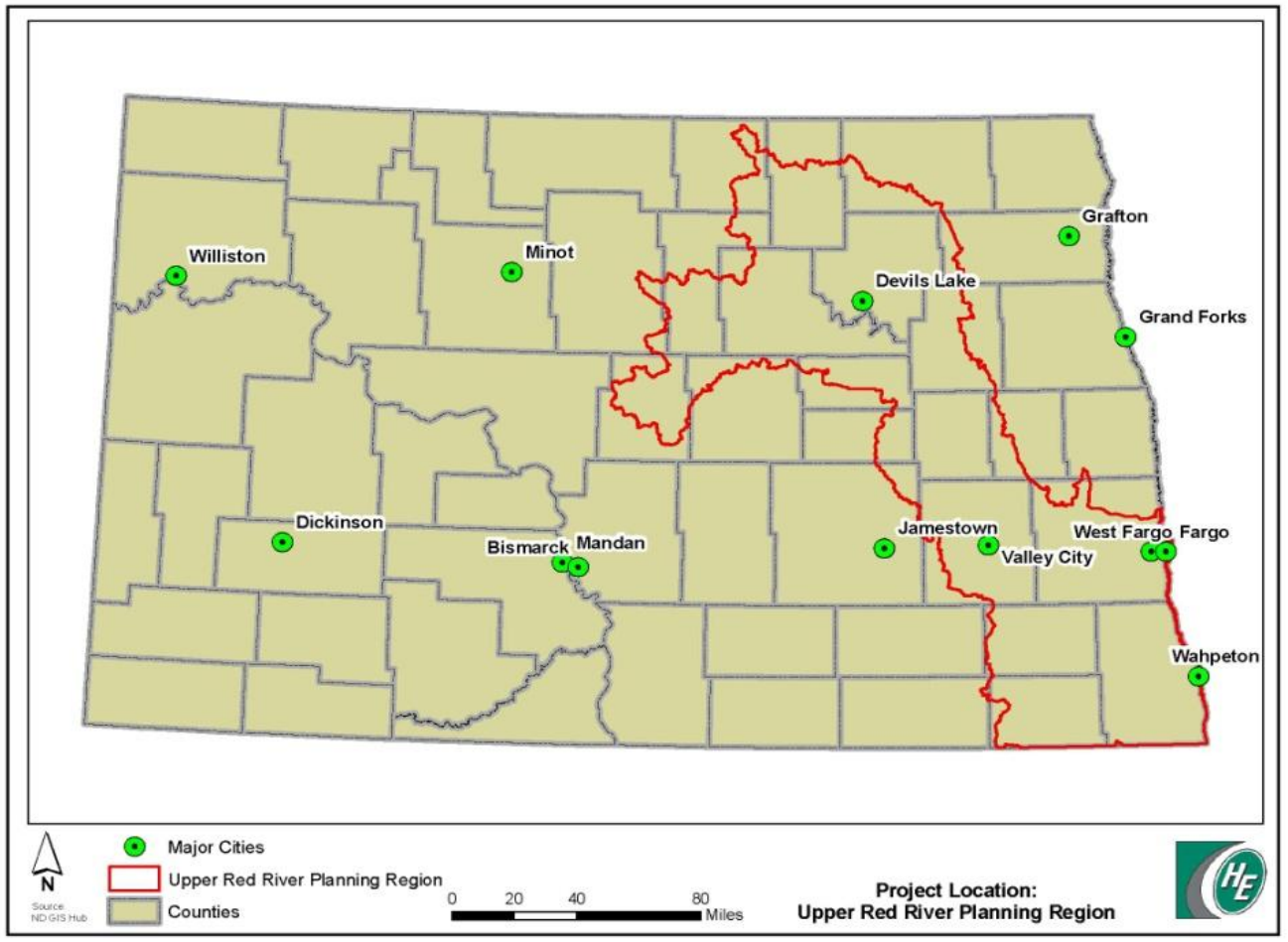
Classifying metric = (SA / DA) * VOL

General Approach to Setting Lentic Criteria

- Developed regional watershed model for loads and runoff
- Linked regional watershed model to regional lake and reservoir models to:
  - Establish “current” conditions based on land use
  - Adjust land use parameters to assess what a potential “reference” condition may demonstrate
- Chose **Upper Red River Basin** as pilot area for developing regional model

North Dakota Nutrient Criteria Pilot Area – Upper Red River Basin

- URRB statistics
  - 13,420 Square Miles
  - 309 12-digit HUC basins
  - 2,085 Lakes, 183.97 sq mi (excludes Devils Lake)
  - 46 Reservoirs, 33.73 sq mi

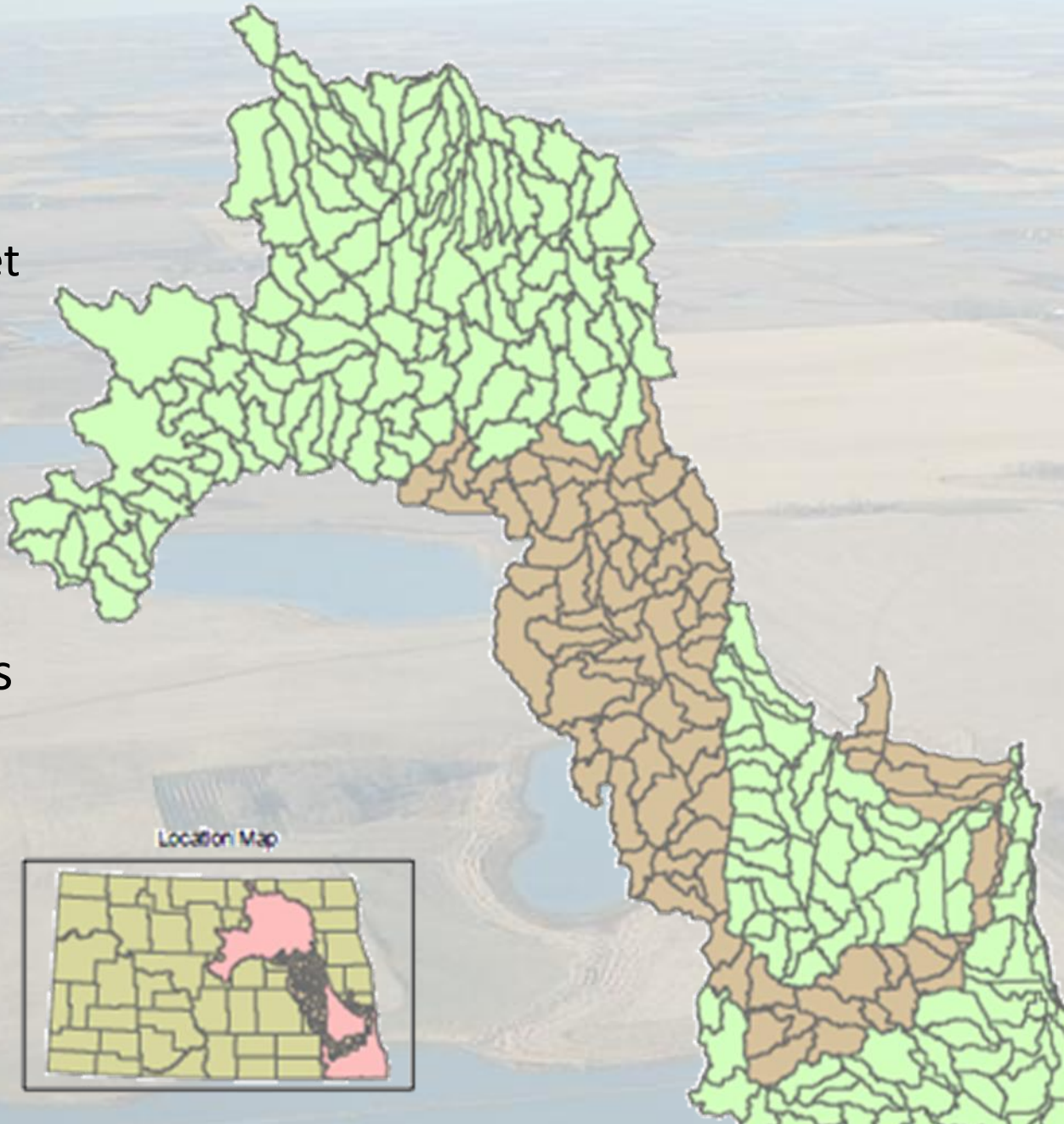


Implementation of *Stochastic Modeling Approach*

- Define model inputs with probability distributions
  - Receiving water: Surface areas, drainage areas, volumes
  - Landscape: Curve numbers by land use, total phosphorus event mean concentrations, precipitation depths
- Integrated into CNET model (W.W. Walker)
  - BATHTUB foundation
  - Spreadsheet based
  - Quickly evaluate multiple scenarios with same inputs across classes

Building Watershed Inputs

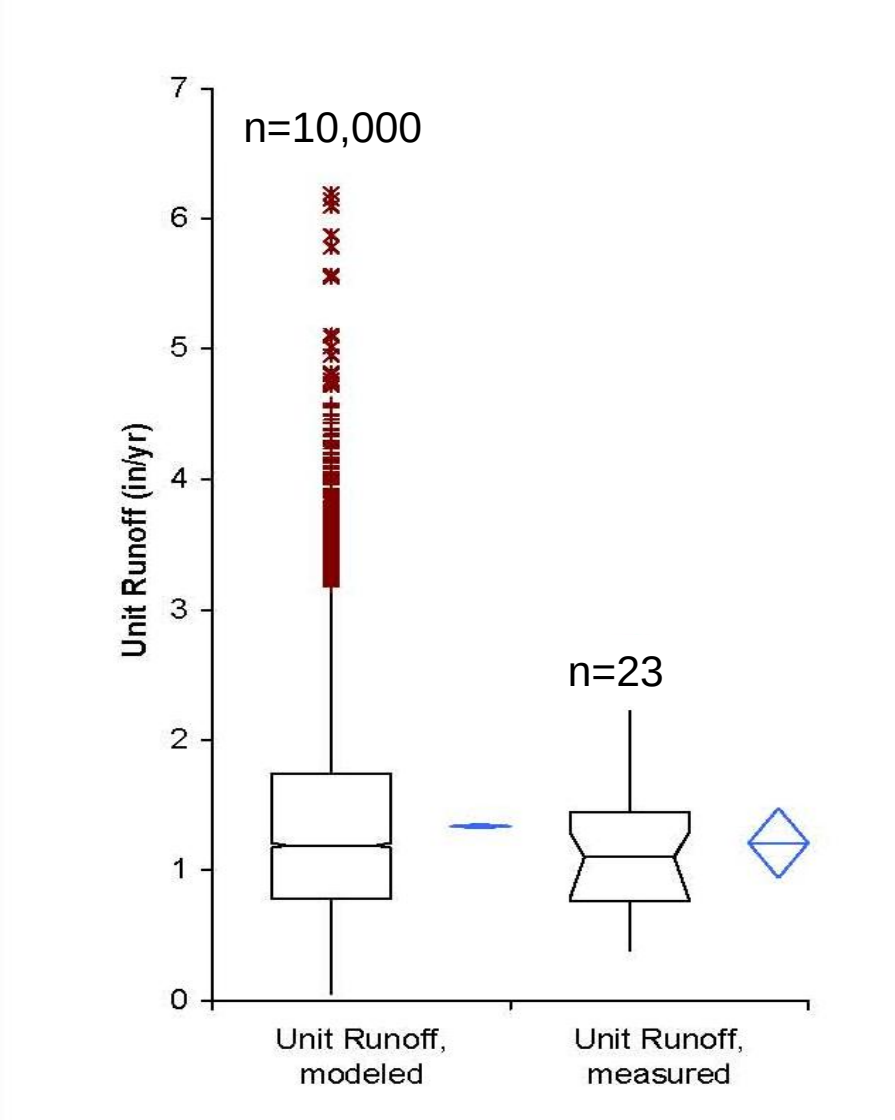
- Defined 5 land uses
  - Agricultural, Forest, Grassland/Shrub/Wet land, Water, Urban
- Sub-sampled 89 HUC's in pilot area
- GIS analysis to determine soils and land use
- Assigned probabilities to curve numbers for each land use



Modifications to CNET Model

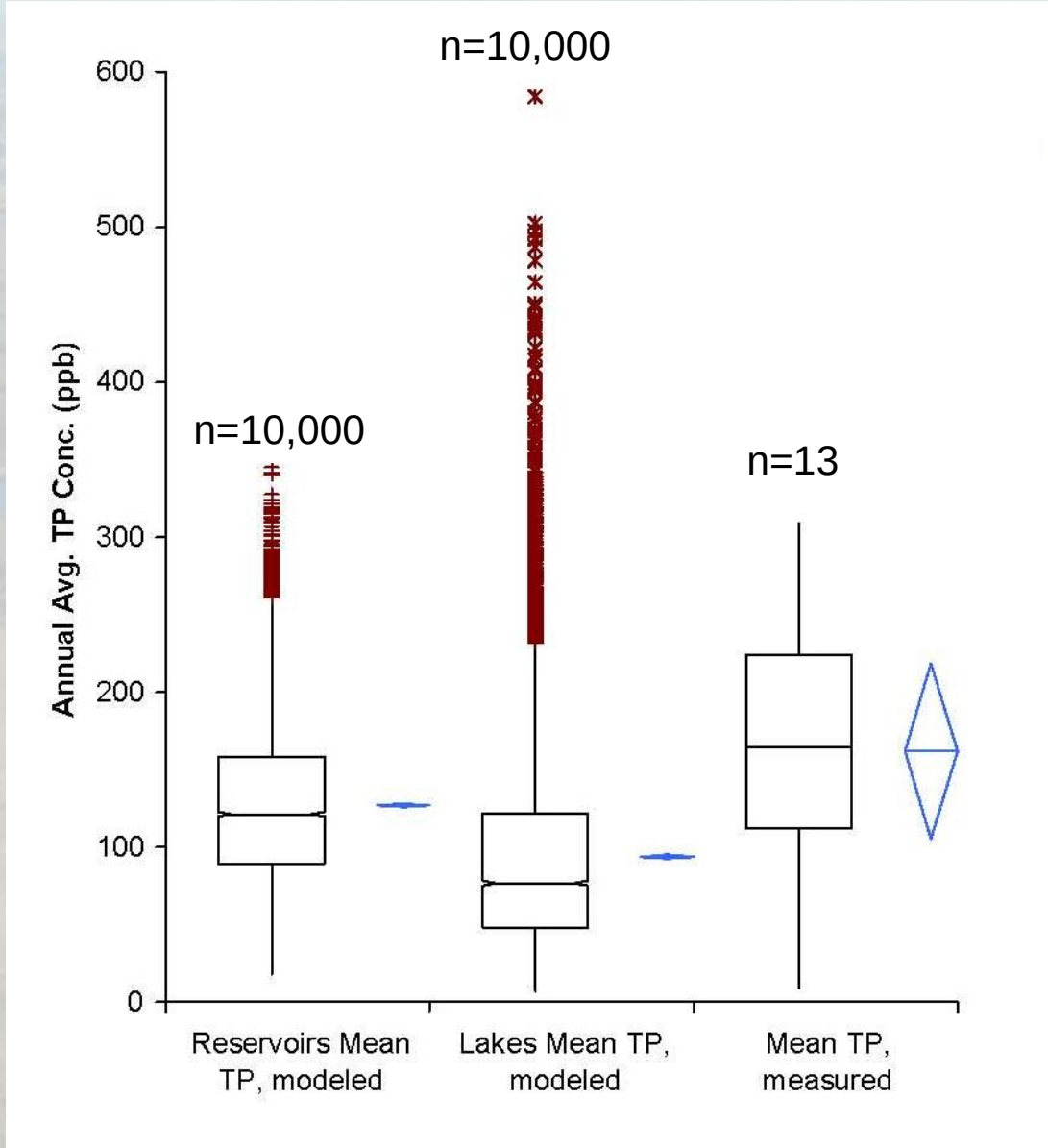
- Altered “annual” time-step for runoff input
- Computed daily runoff volumes and loads
- Ensure spatial consistency
- Secchi and Chl-a models in CNET not entirely reliable (yet)

Runoff “Calibration”



Represents current land use conditions in the URRB (82% cultivated land)

Receiving Water "Calibration" Across All Classes

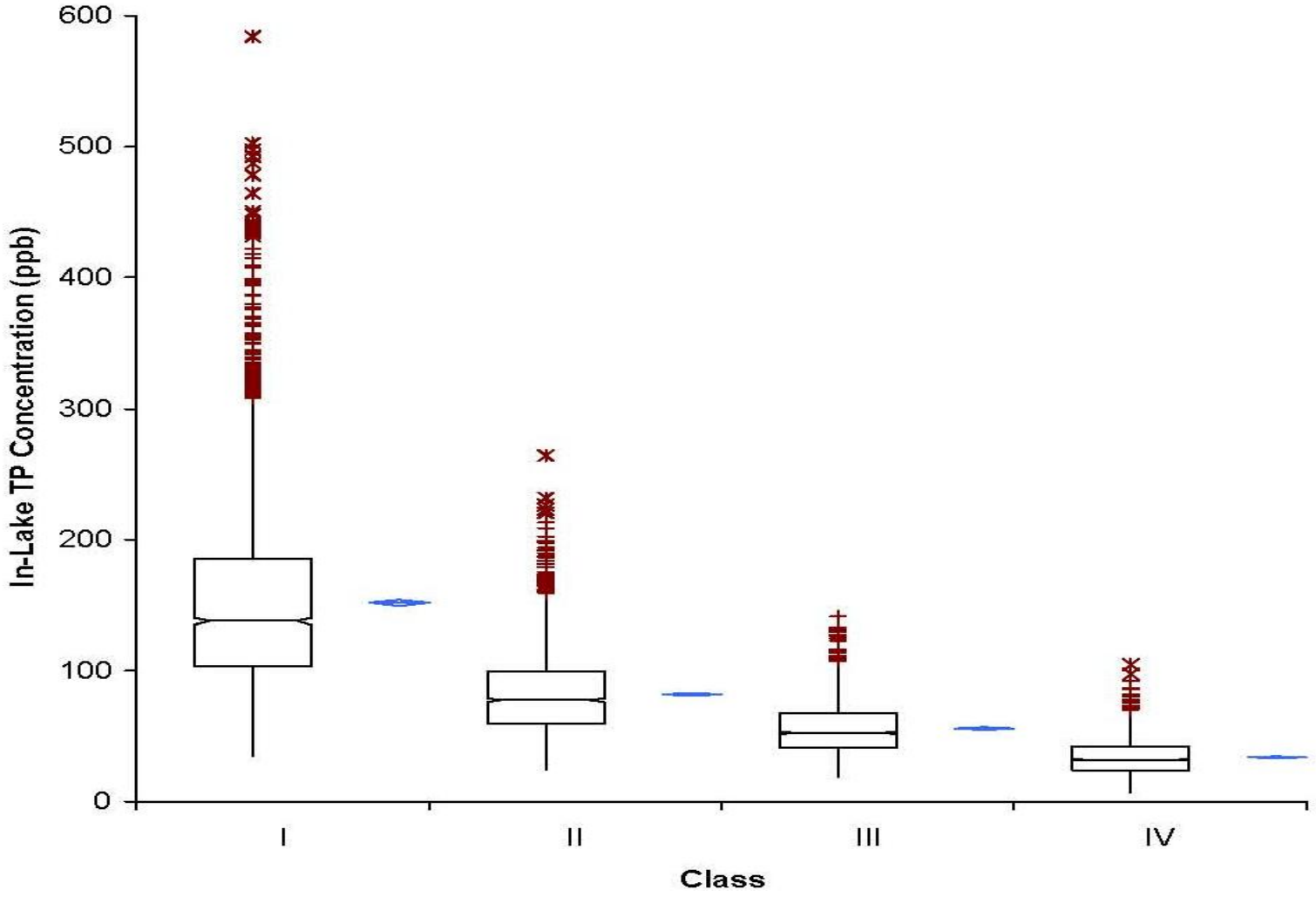


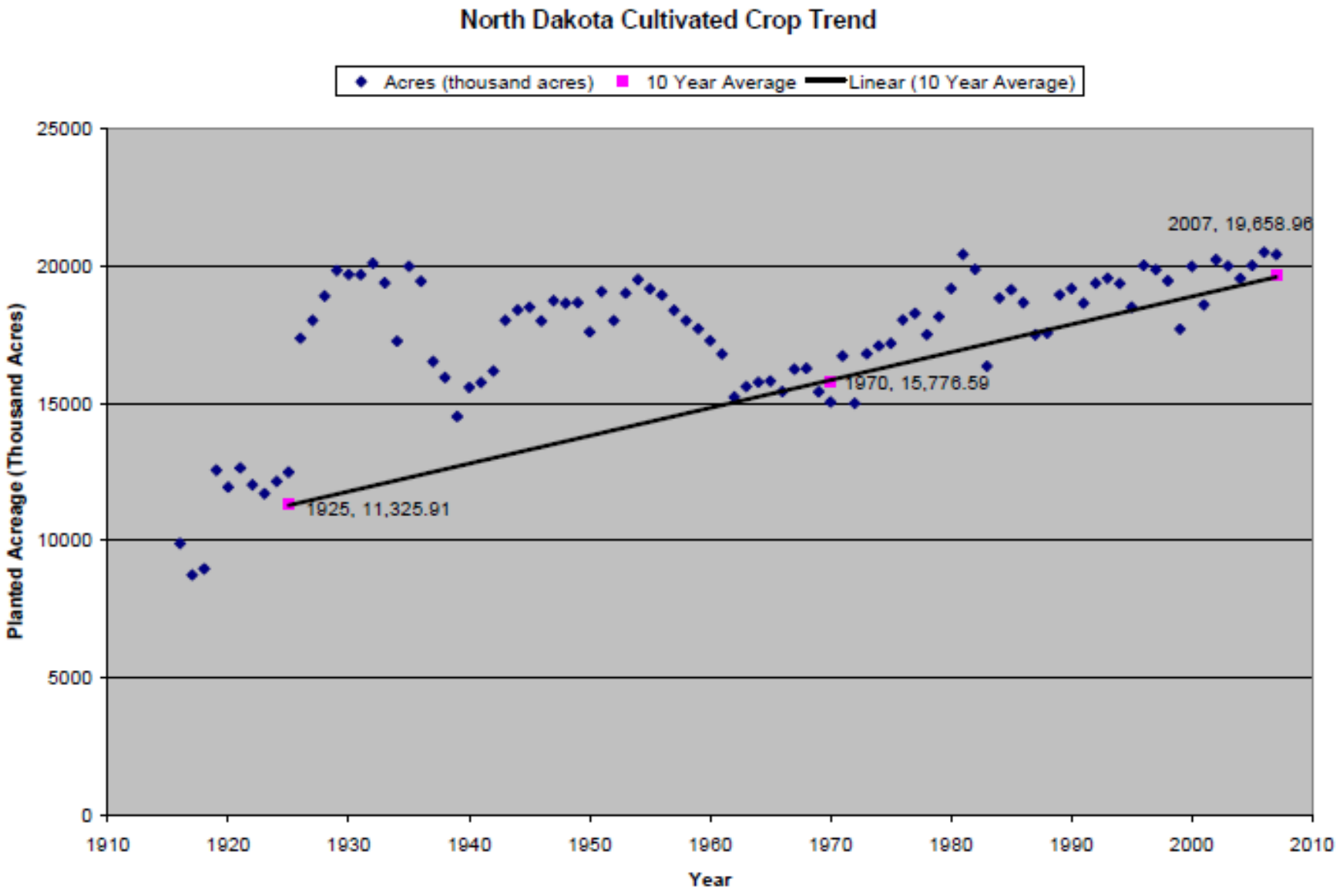
Represents current land use conditions in the URRB (82% cultivated land)

Stochastic Model Outputs

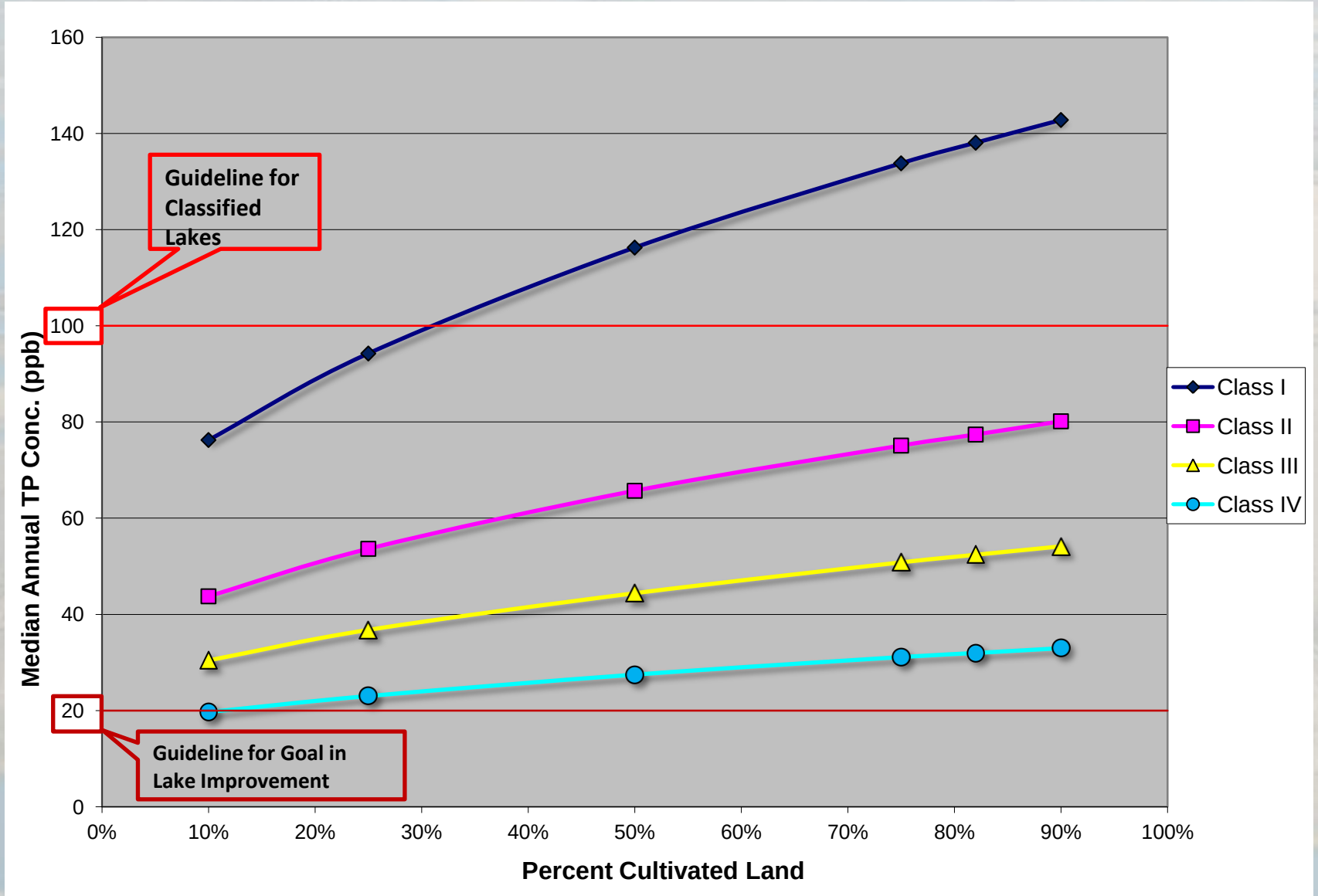
- Existing conditions lake and reservoir response by class
- Use model results to establish possible "reference" or "benchmark" condition
  - Need "benchmark" TP load
  - Watershed model relates TP load to proportion of land cultivated
  - Proportion of land cultivated is tangible / observable

Lake Classes and TP Conc.




North Dakota Cultivated Crop Trend
Acres (thousand acres)
10 Year Average
Linear (10 Year Average)
Planted Acreage (Thousand Acres)
25000
20000
15000
10000
5000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
2007, 19,658.96
1970, 15,776.59
1925, 11,325.91

Lake Response by Class



Conclusions

- Model showed distinct differences between classes
- Model showed potential regional targets for criteria, bounded by ranges
- Need more data to refine model
- Caveats
  - Might appear that some lakes are currently not degraded by water quality (100 ppb standard)
  - Might appear that some lakes may not meet improvement (20 ppb goal)

Lessons Learned

- Lack of data is key issue
- Stochastic approach was valuable
  - Addressed gaps in data
    - Physical lake / reservoir characteristics
    - Water column concentrations
  - Multiple scenarios and trials evaluated simultaneously streamlined effort
  - Incorporated uncertainty across range of landscape / environmental conditions

Next Steps

- More data collection
- Policy decisions to assess acceptable thresholds for eutrophication
- Model refinements and further progress beyond pilot area

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Thank you!