Tile Drainage Water Quality Assessment in Saline Soils in North Dakota

2010 National Monitoring Conference
April 29, 2010

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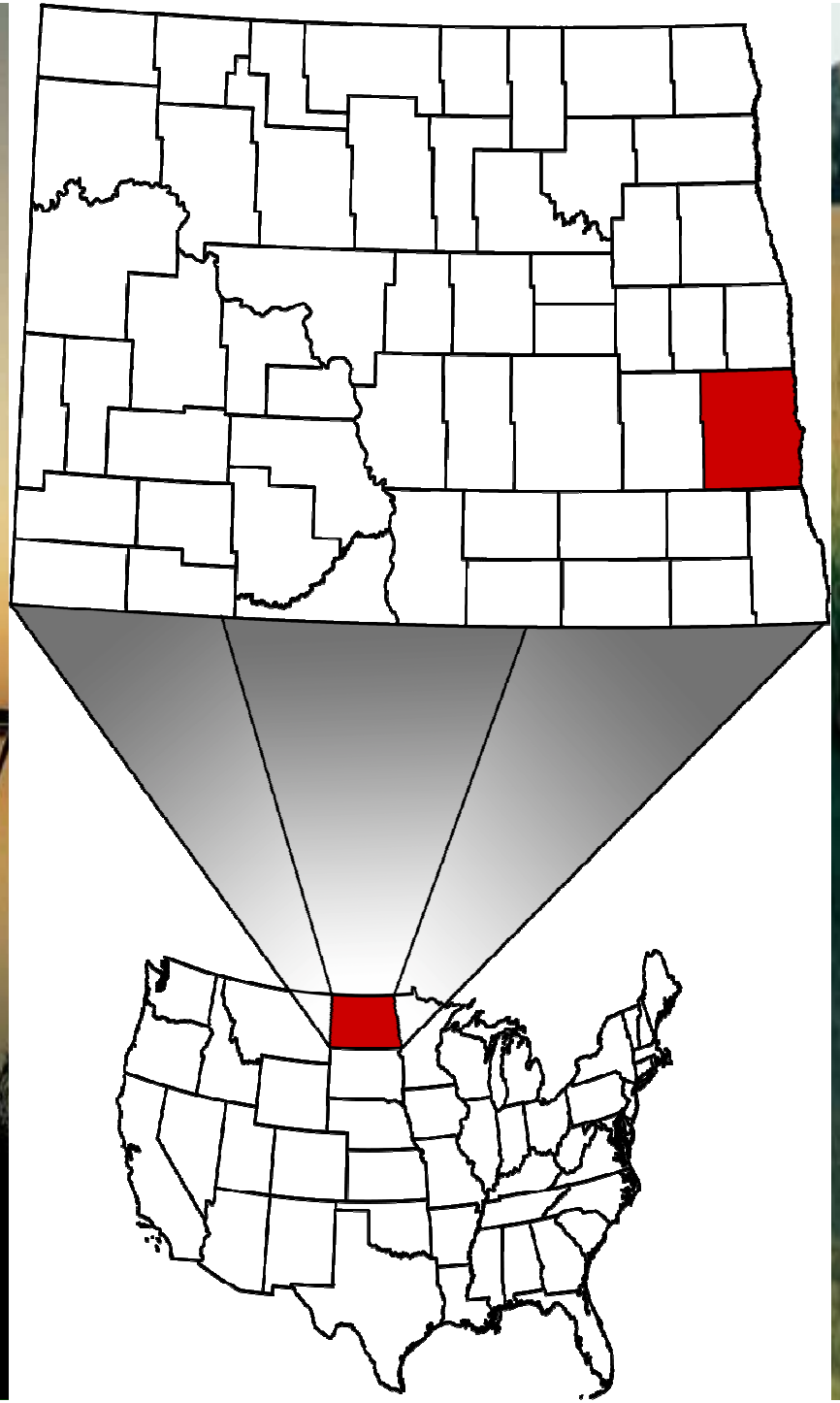
Agricultural & Biosystems Engineering

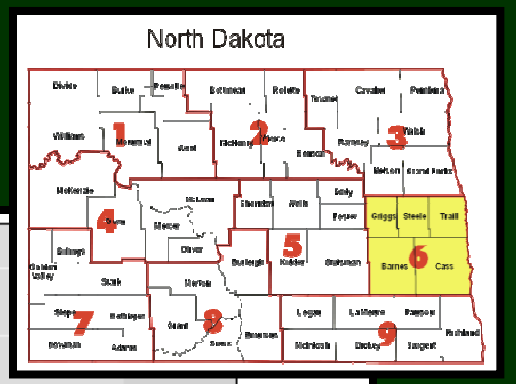
NDSU Extension Service
North Dakota State University

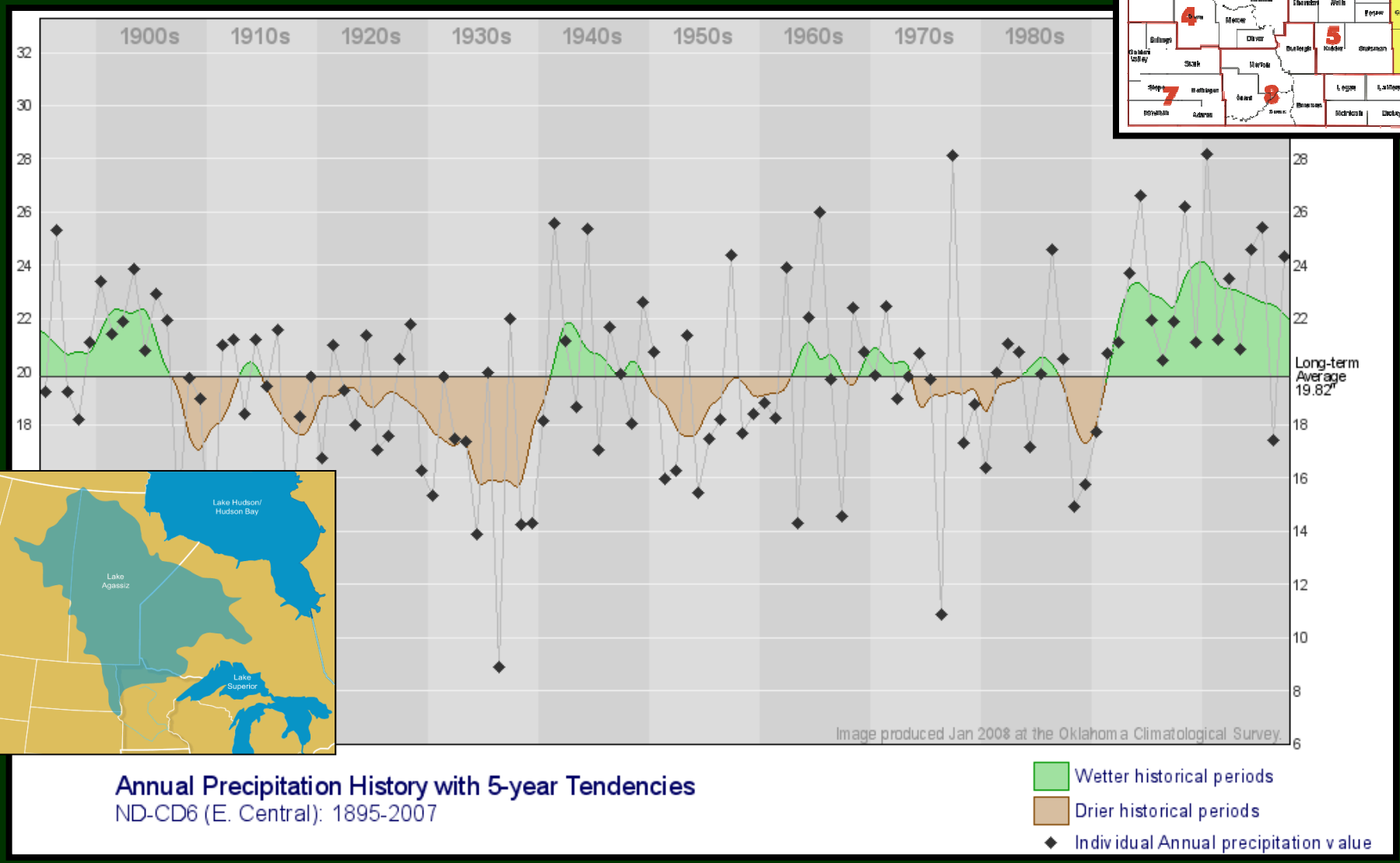
NORTHERN PLAINS & MOUNTAINS
Regional Water Program



KATHRYN 15
CLAUSEN SPRINGS 21
LITTLE YELLOWSTONE 20
AMERICA'S BYWAYS

East Central #6





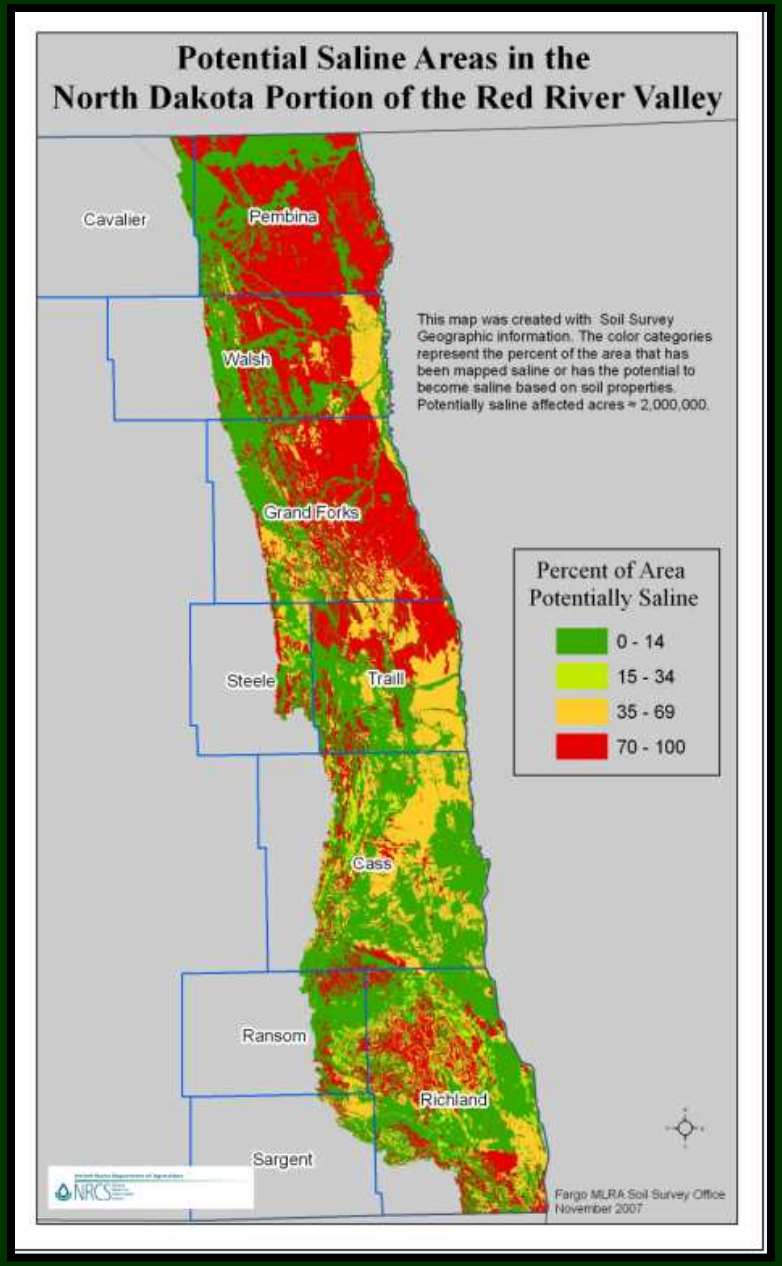
Annual Precipitation History with 5-year Tendencies
ND-CD6 (E. Central): 1895-2007

Wetter historical periods
Drier historical periods
Individual Annual precipitation value

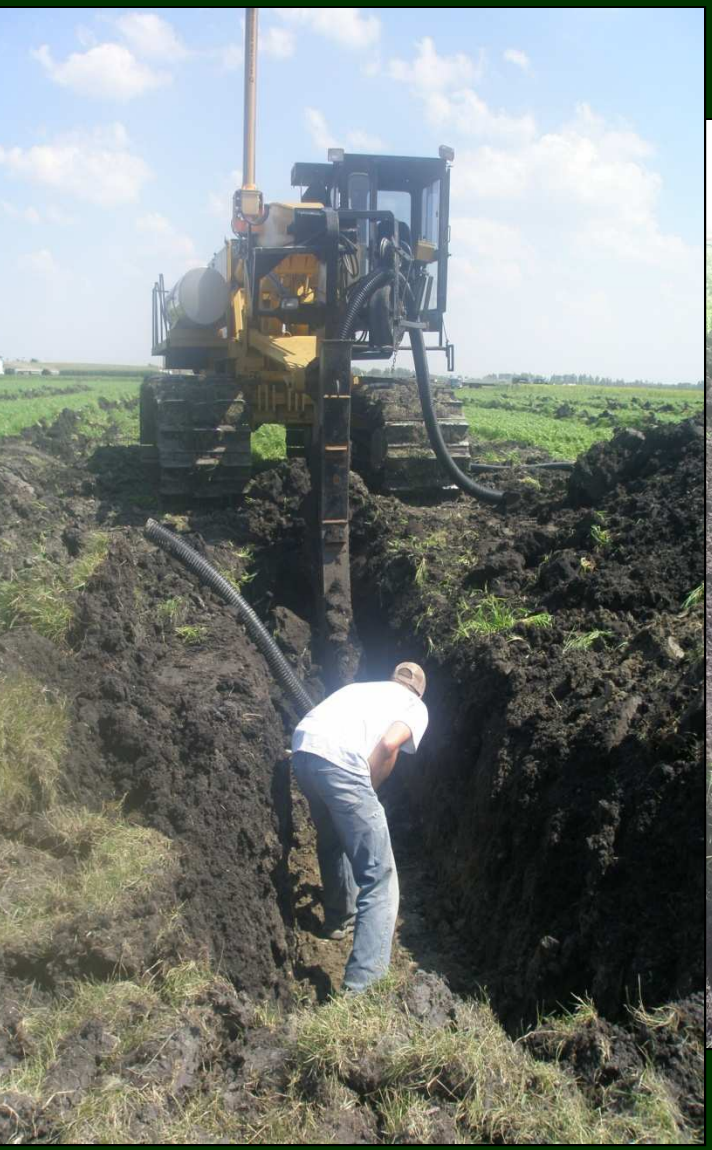
Our unusual situation…..

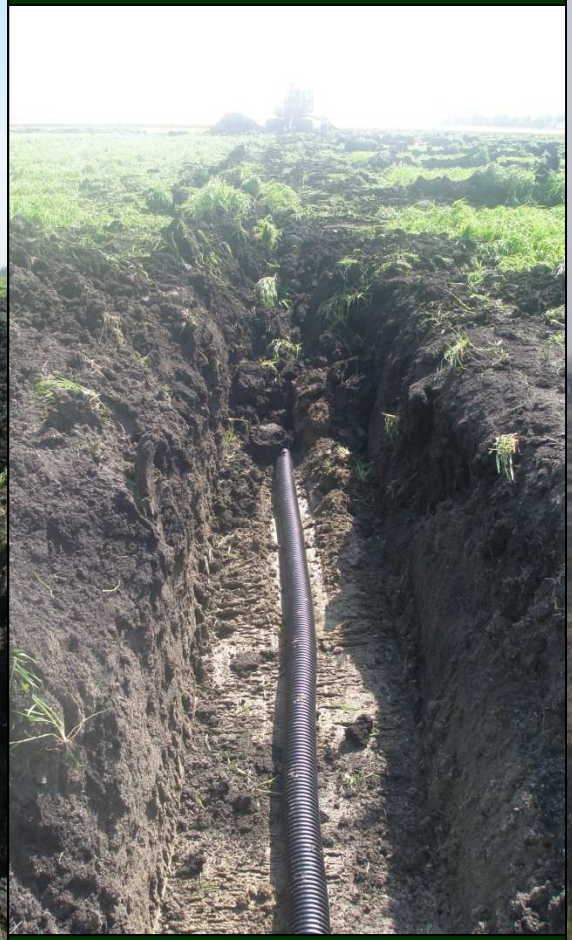
- Increased salinity
  - Calcium carbonate
  - Magnesium sulfate
  - Sodium sulfate

Franzen 2007



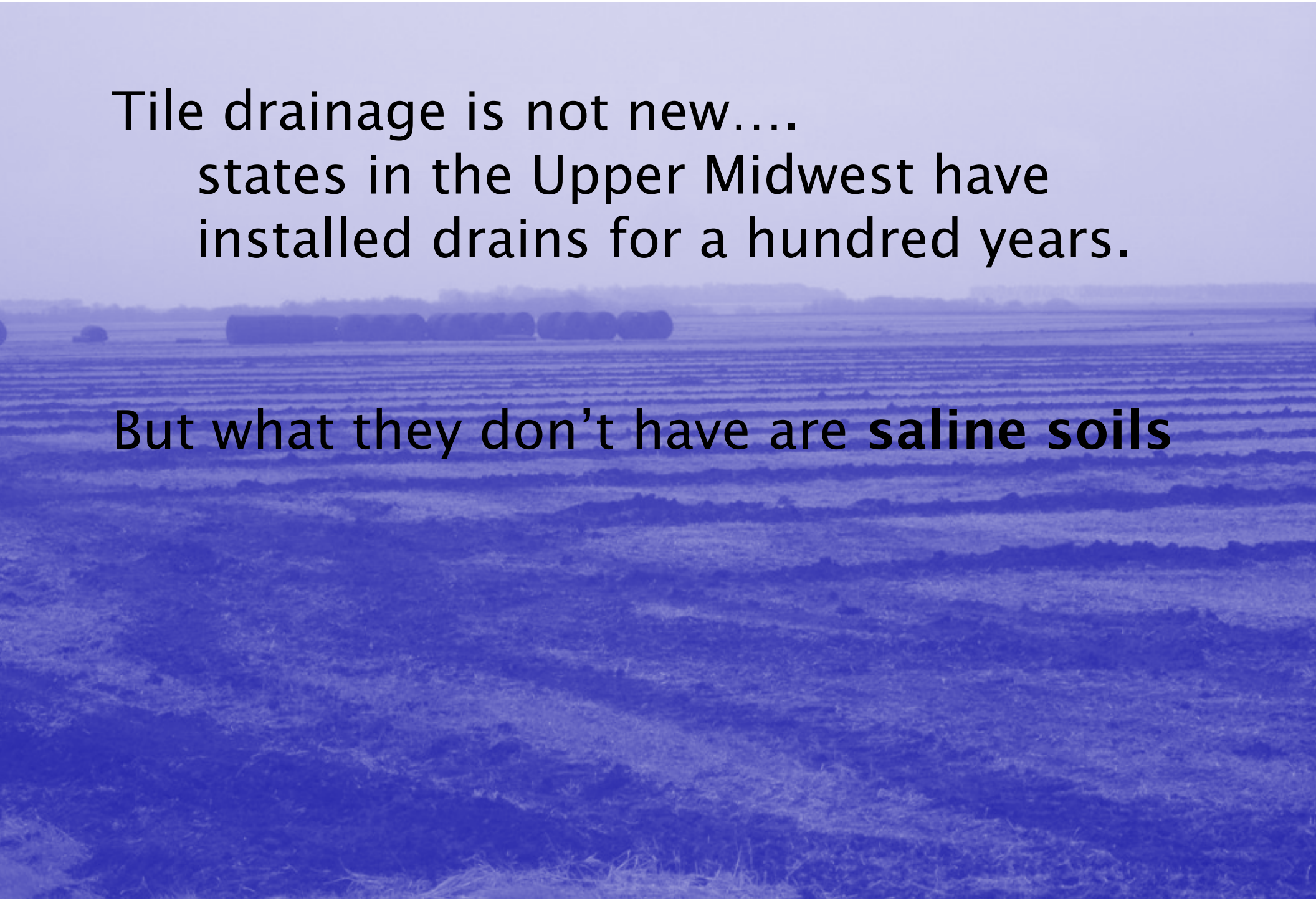
Response





Reasons for subsurface tiling

- Lower water table
- Reduce salts
- Earlier access to fields



Tile drainage is not new….
states in the Upper Midwest have
installed drains for a hundred years.

But what they don't have are **saline soils**

Questions…..
Water quality
Water quantity

- Focus Group – April 2008
  - Land owners
  - Tile drain installers
  - County, State and Federal Agencies
    - County Water board members
    - Soil Conservation District board members and technicians
    - Health Department
    - NRCS
    - RC&D members
    - State Water Commission
  - NDSU
    - Engineers
    - Soil Scientists
    - Hydrologists

Discussion included

- Acres tile drained
  - Do we really know?
- Permitting
  - Authority
  - Based on what?
- Impacts
  - Water Quality & Quantity
  - Neighbors – Red River – Lake Winnipeg

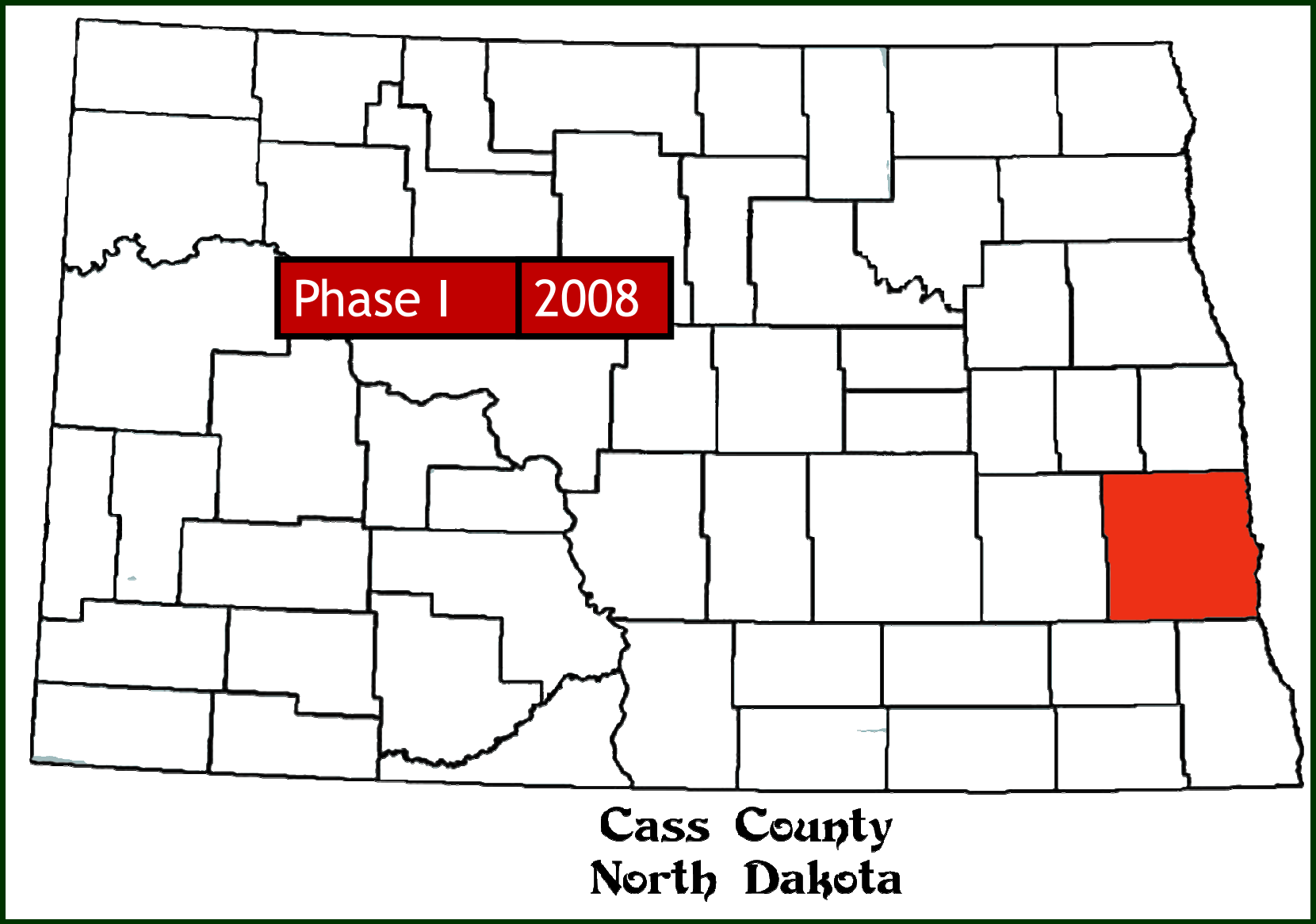
Red River Valley Tile Drainage Water Quality Assessment
Phase I
Phase II

Roxanne Johnson – Extension Water Quality Associate
Thomas Scherer – Extension Agricultural Engineer
Steve Fischer – Lake Agassiz RC&D Coordinator

NDSU Extension Service
North Dakota State University

Funding

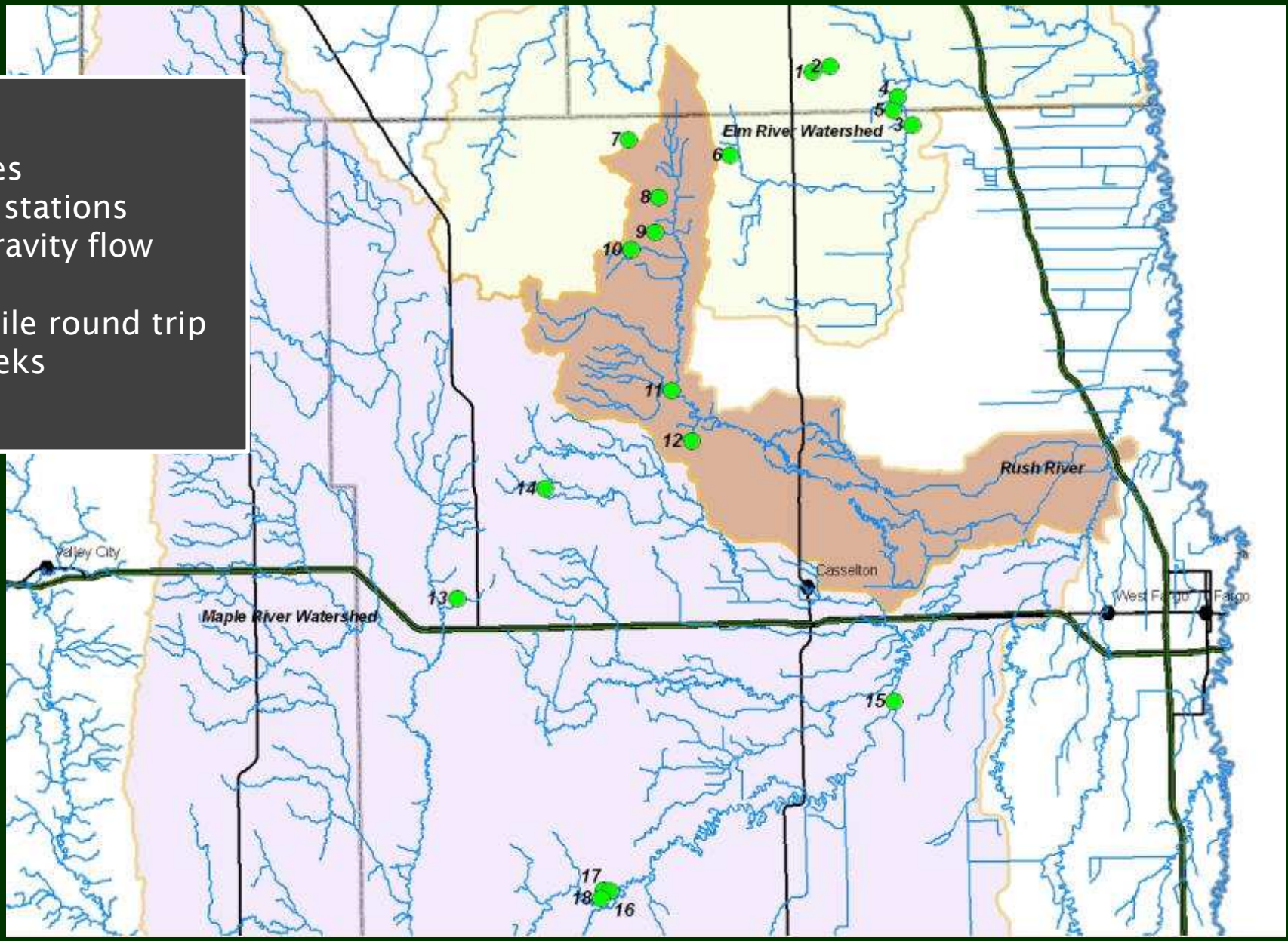
- 319 Nonpoint Source Pollution
  - ND Department of Health
  - Fargo and Bismarck
- Cass County Soil Conservation District
- North Dakota State Water Commission
- NIFA, Northern Plains & Mountains Regional Water Program


Phase I
2008
Cass County
North Dakota

18 sites
2 lift stations
16 gravity flow

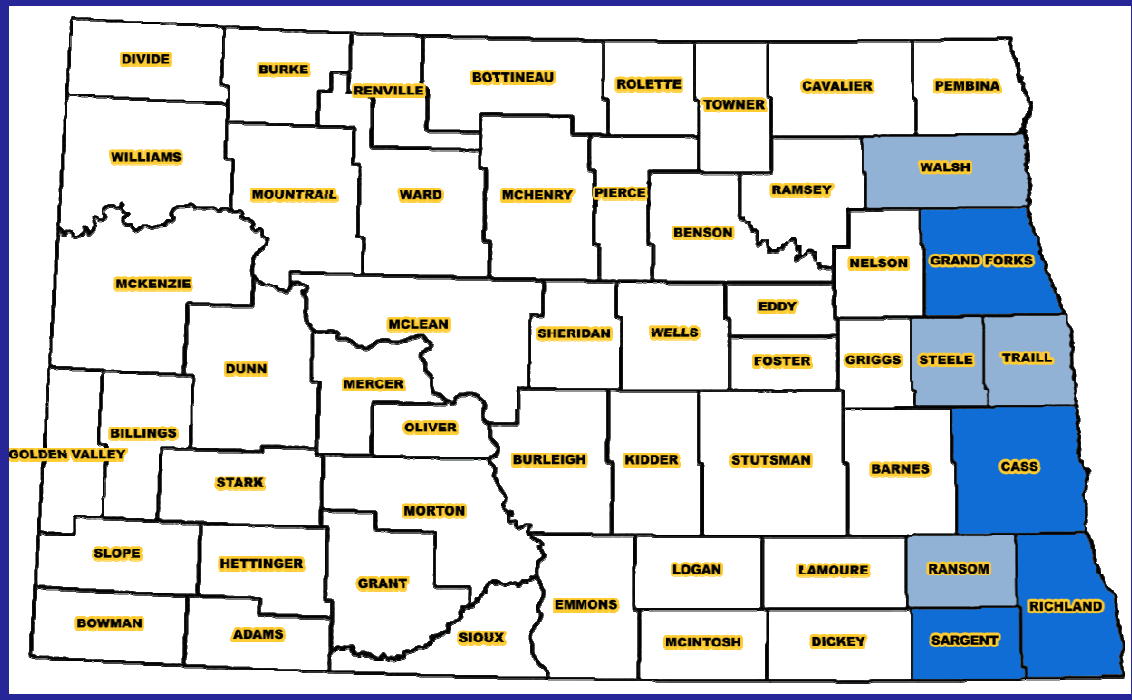
170 mile round trip
32 weeks

Watersheds:
Elm
Maple
Rush



- Cooperators
  - 10 land owner/operators
    - Tile maps
    - Cropping and fertilizer history
    - Soil tests
    - Precipitation

Phase II 2009-2013



Funding:

North Dakota State Water Commission

Cass County Soil Conservation District

EPA 319 Nonpoint Source Pollution

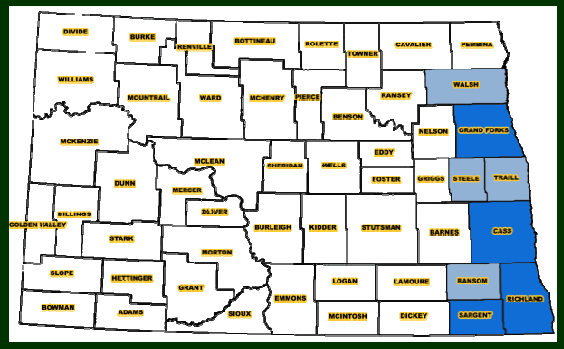
NIFA Northern Plains Regional Water Quality Program

Phase II 2009-2013

Soils must be salt affected

Four sites:

1. Sample - Drain or lift station (automated sampler)
2. Sample - Downstream location within a mile from the tile outlet
3. Sample - Surface runoff of tiled field
4. Sample - Surface runoff of comparable un-tiled field



Automated Sampler

Phase II 2009-2013

Soils must be salt affected

Four sites:

4. Flow
5. Precipitation
6. Soil testing

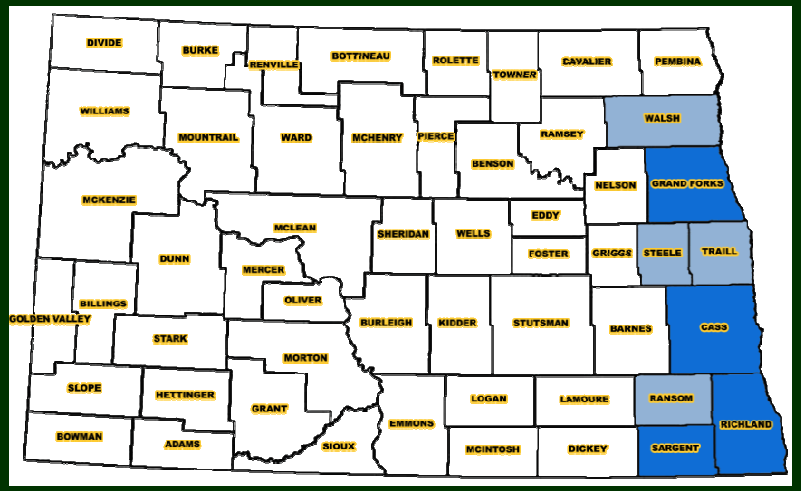
Current Sensor

Tipping Bucket

Phase II 2009 - 2013

Four sites:

1. Grab samples
2. Precipitation
3. Flow (3 of 4)



Work with landowners to develop site specific BMPs

What's important?

Nitrogen
Phosphorus
Sulfates
Chlorides
Magnesium
Sodium
pH
Trace Metals

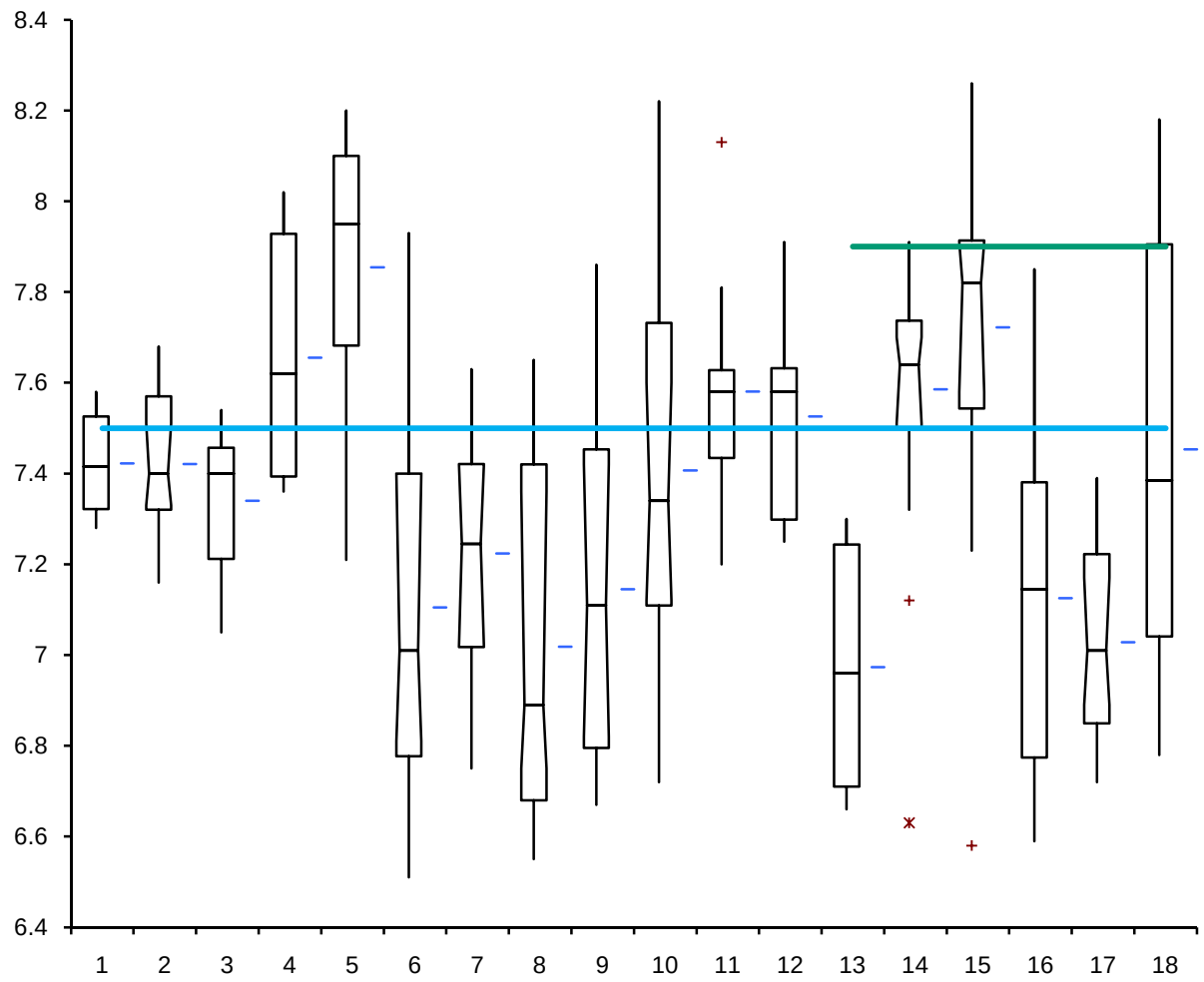
What Standards Do We Use?

Drinking Water Quality?

Ambient Water Quality Criteria?

Standards of Quality for Waters of the State? CHAPTER 33-16-02.1

Wastewater Standards?



Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed

pH can alter other nutrients

pH

95% CI Notched Outlier Boxplot

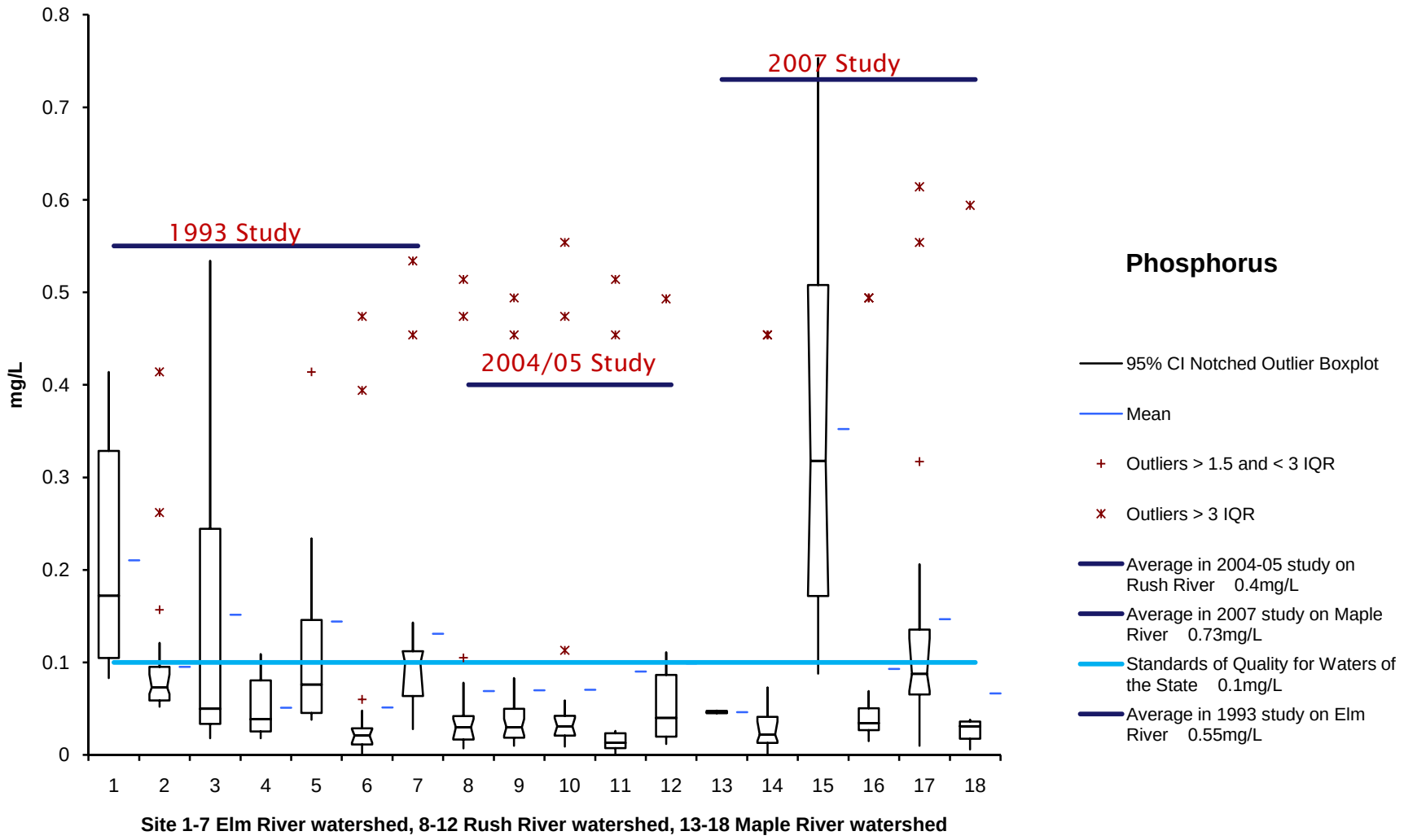
Mean

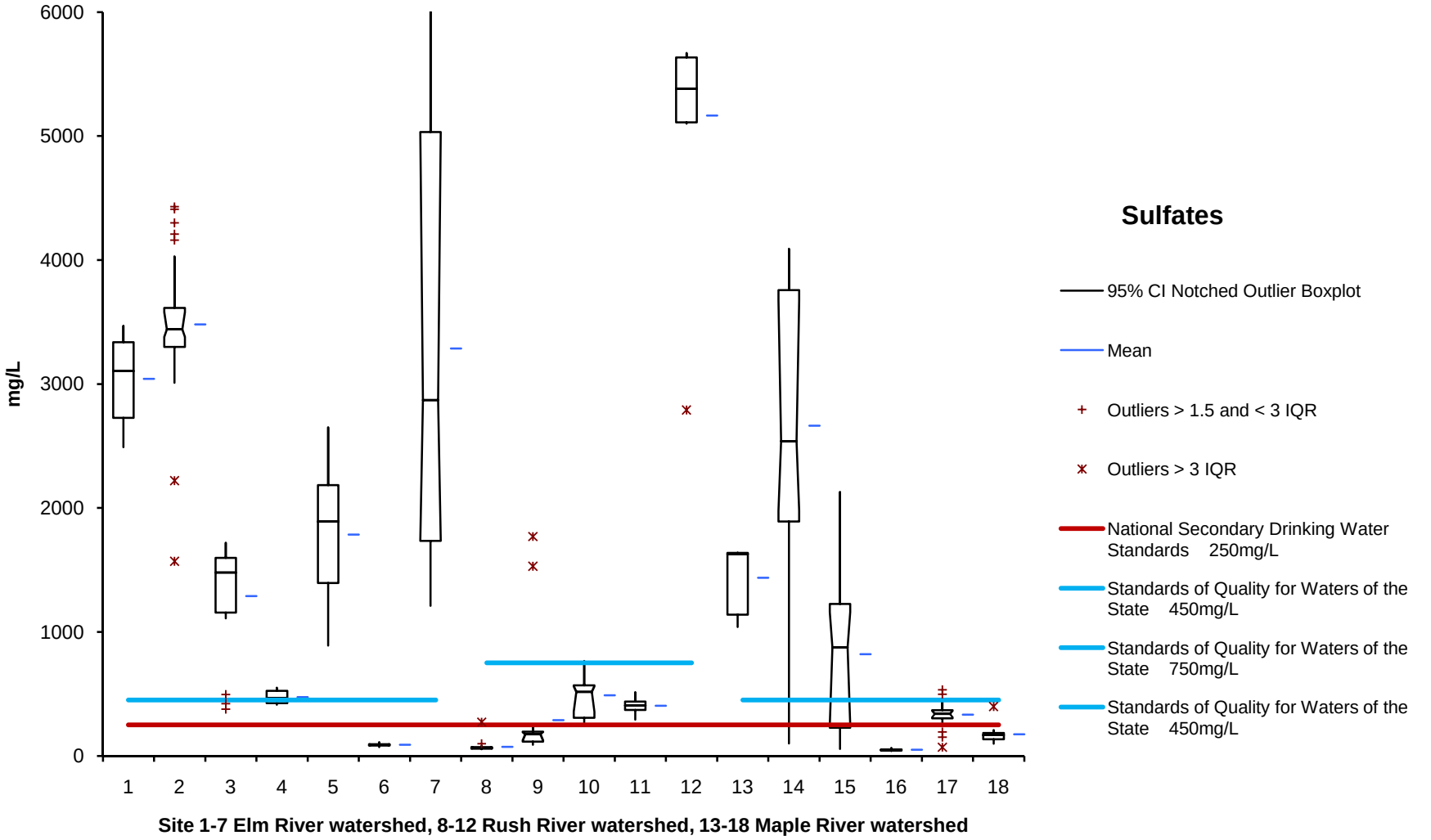
Outliers > 1.5 and < 3 IQR

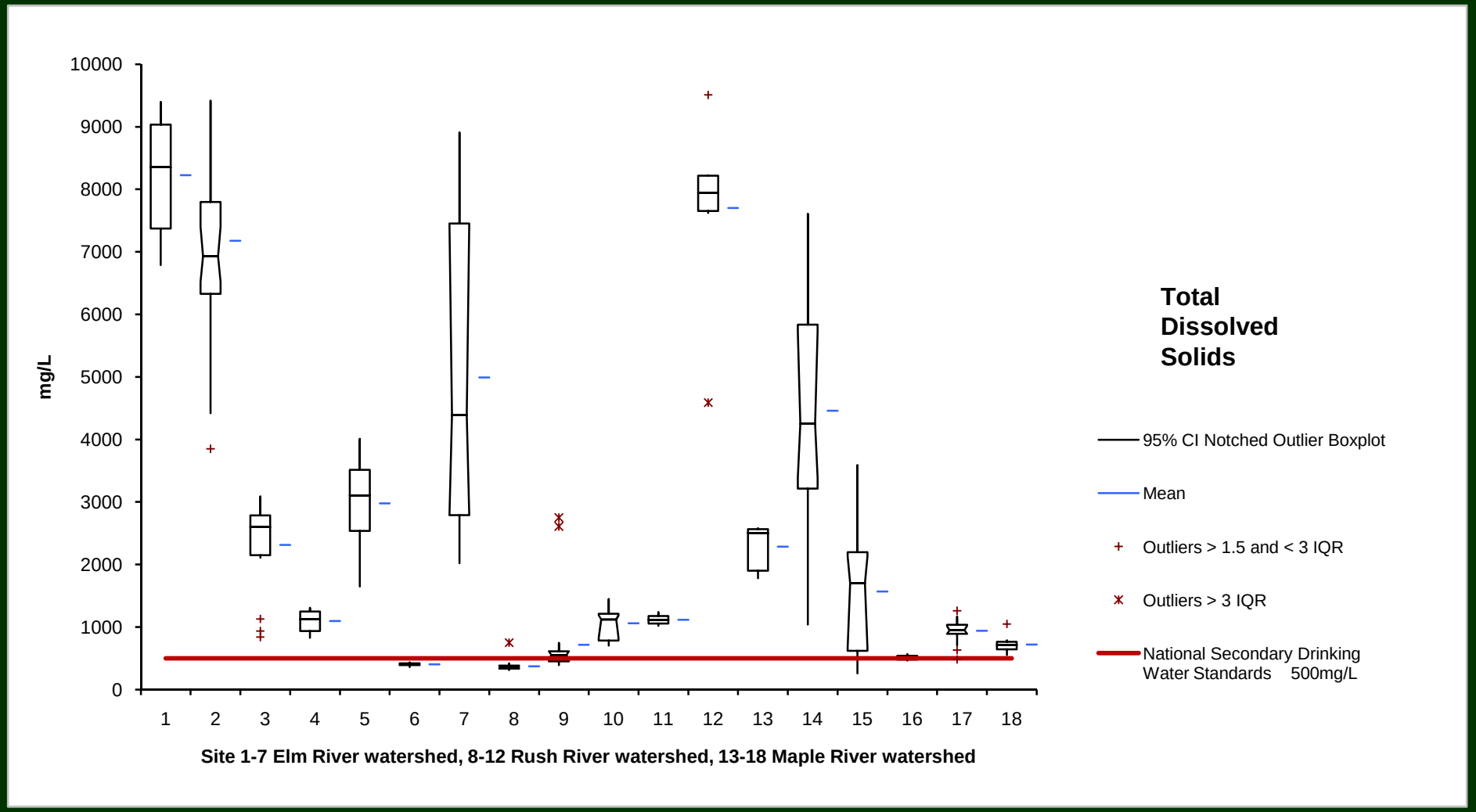
Outliers > 3 IQR

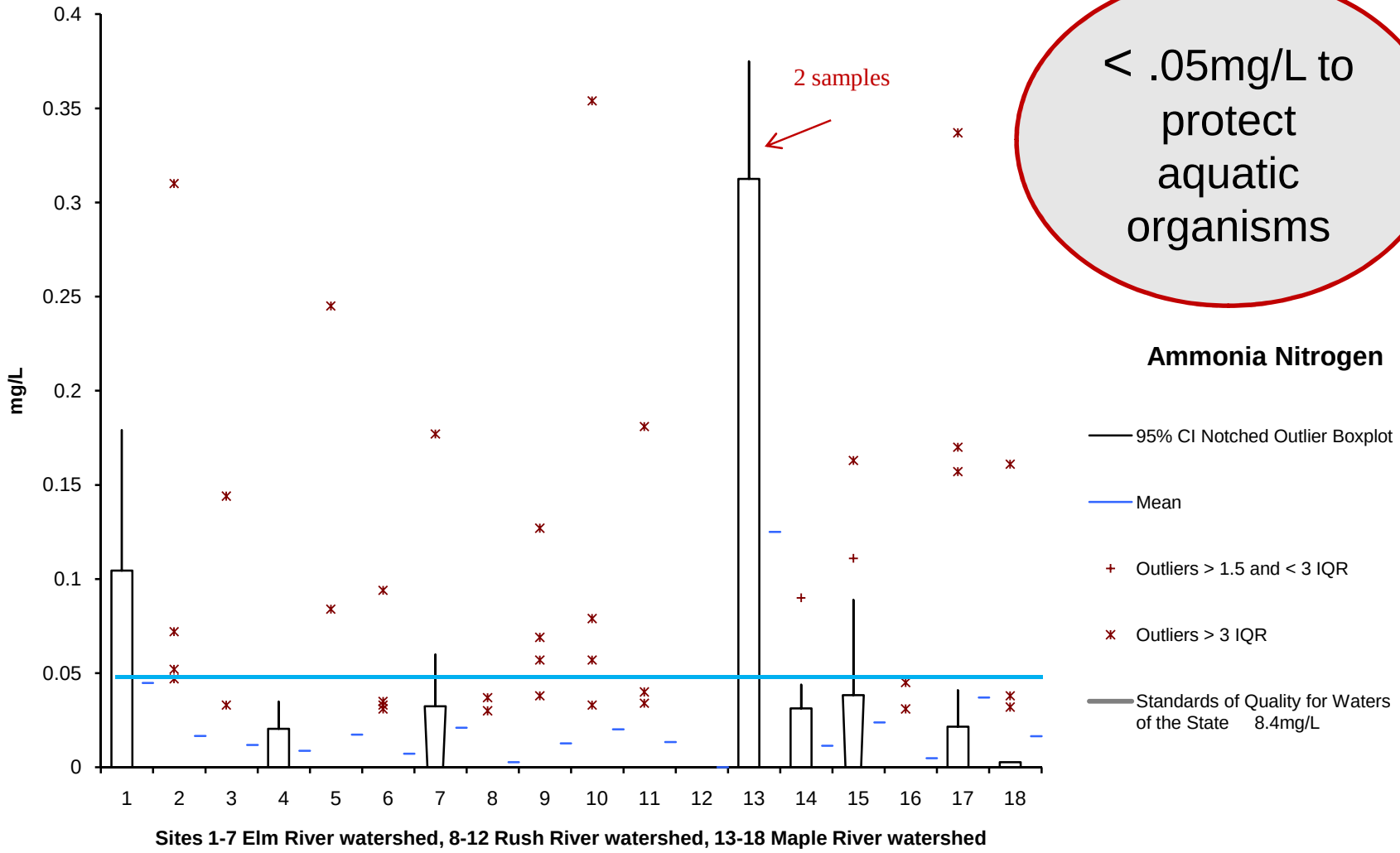
Standards of Quality for Waters of the State 6.0 - 9.0

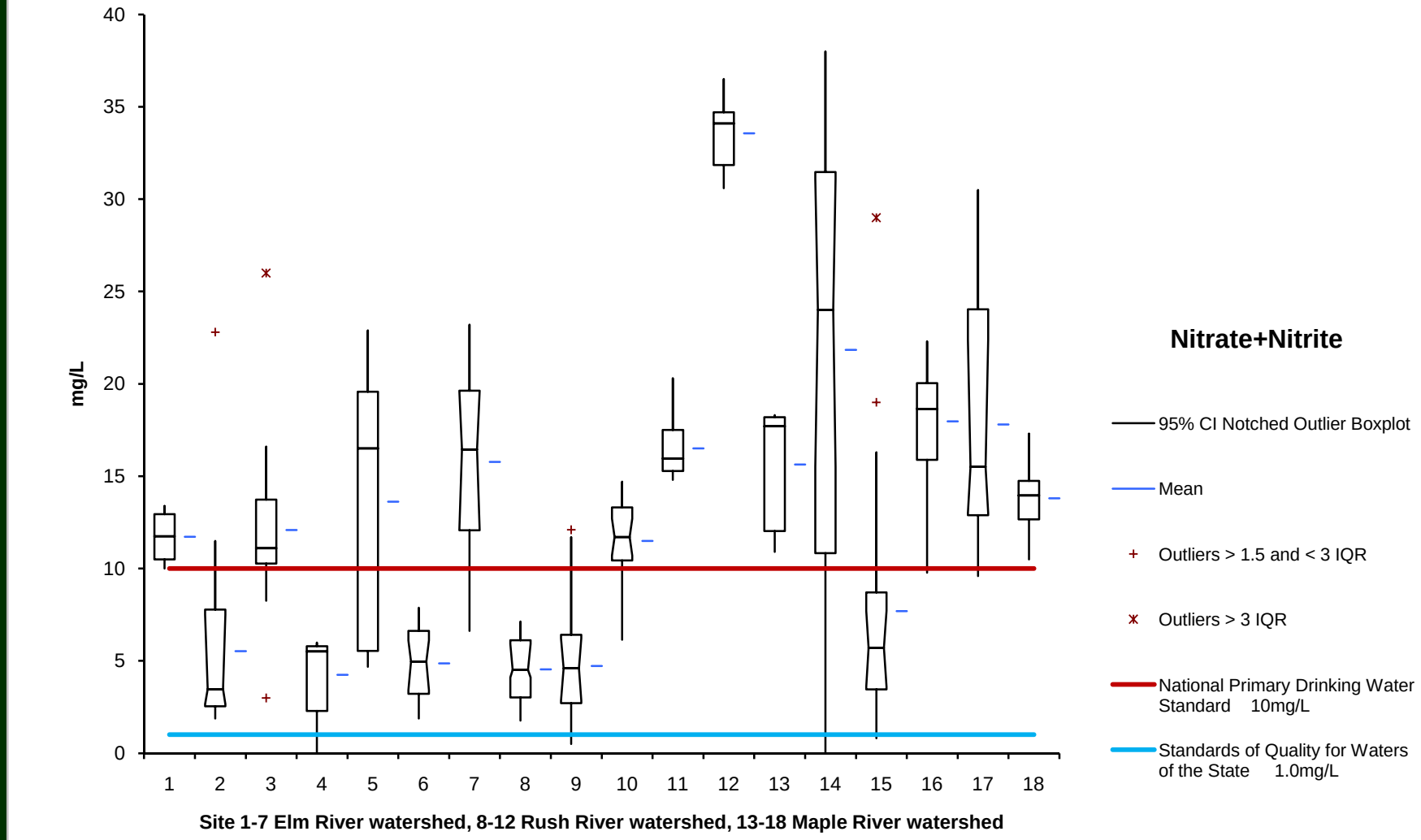
Average in 1993 study on Maple River 7.94

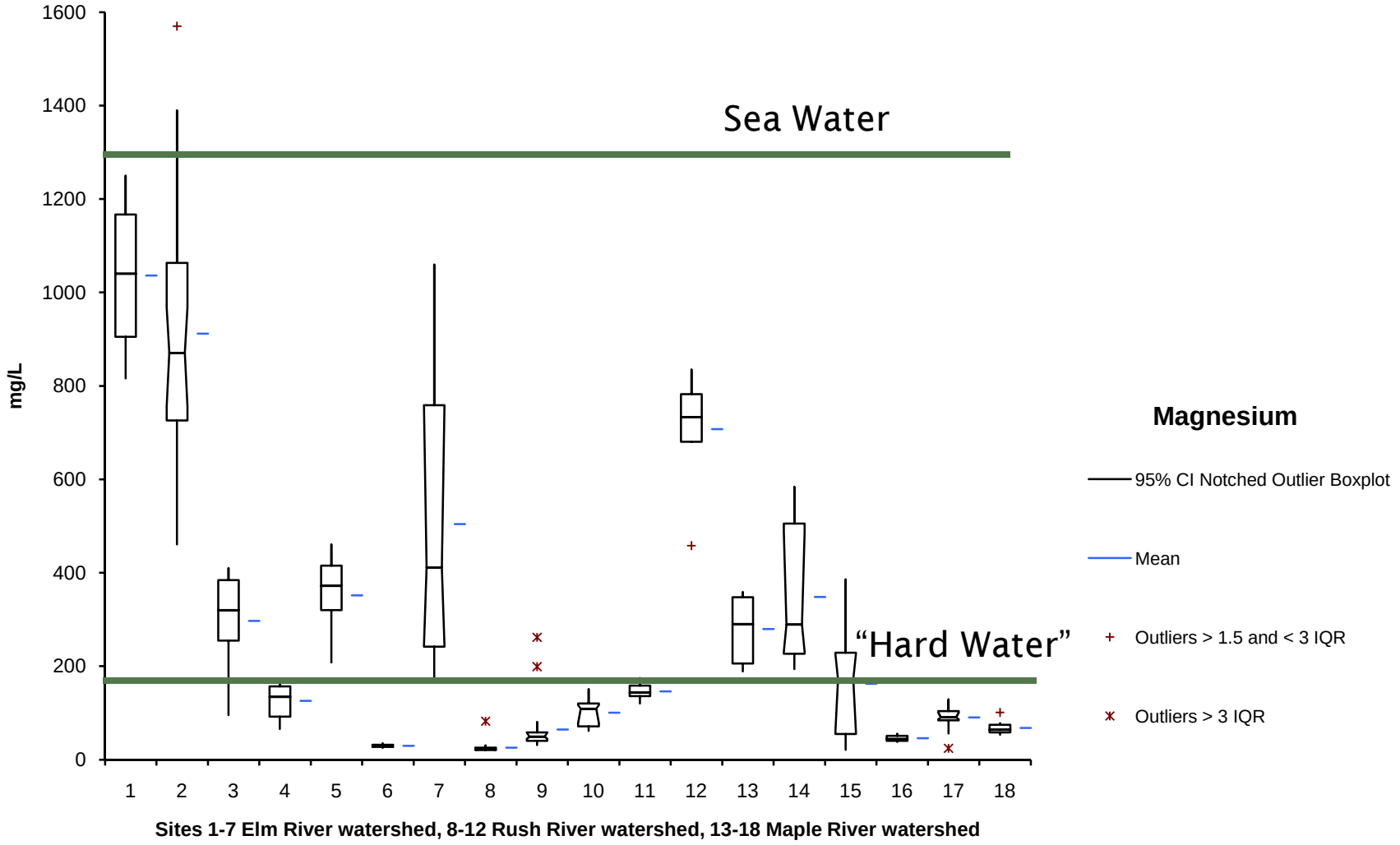

0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
1993 Study
2004/05 Study
2007 Study
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Phosphorus
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
Average in 2004-05 study on Rush River 0.4mg/L
Average in 2007 study on Maple River 0.73mg/L
Standards of Quality for Waters of the State 0.1mg/L
Average in 1993 study on Elm River 0.55mg/L

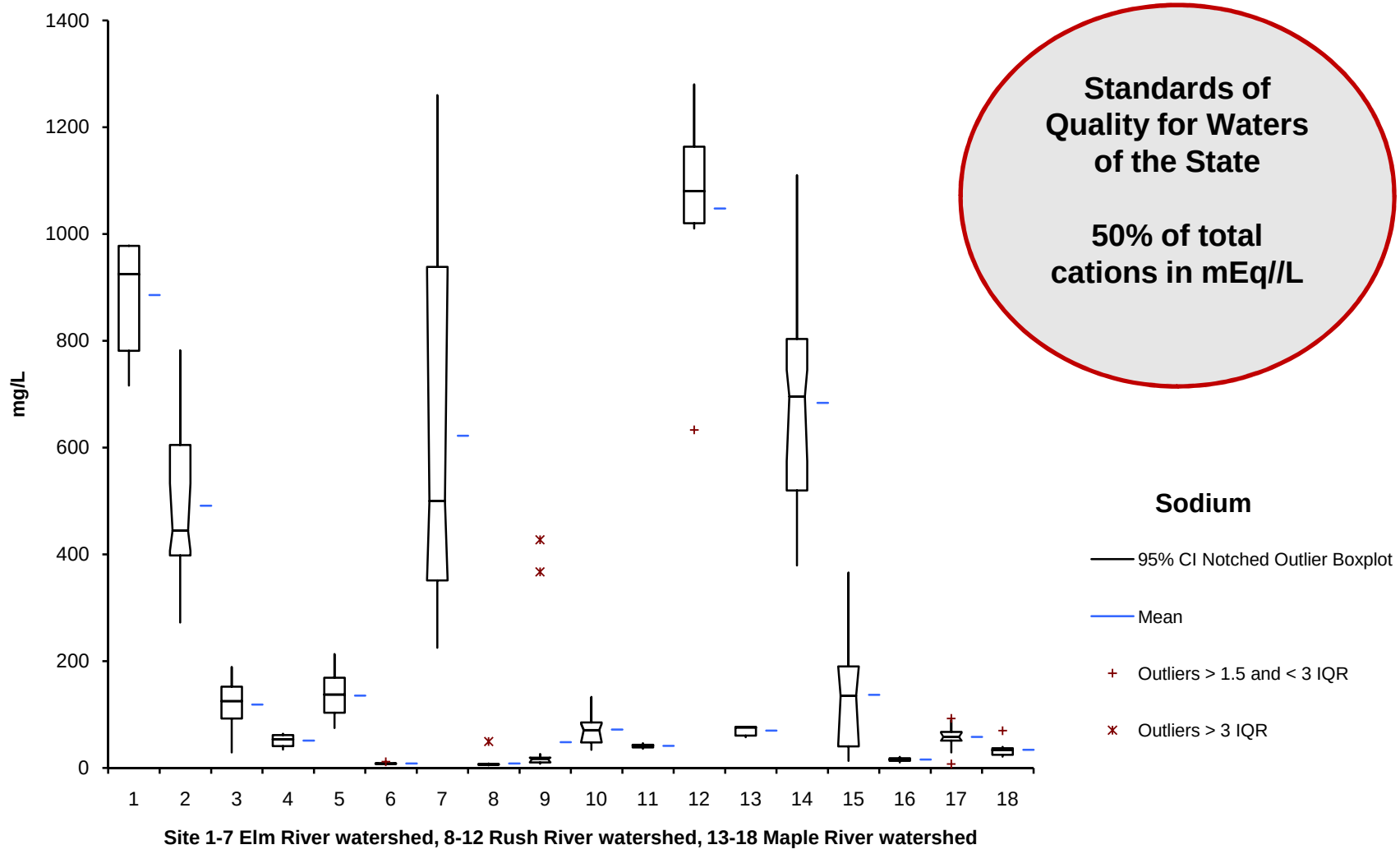

Sulfates
mg/L
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
National Secondary Drinking Water Standards 250mg/L
Standards of Quality for Waters of the State 450mg/L
Standards of Quality for Waters of the State 750mg/L
Standards of Quality for Waters of the State 450mg/L

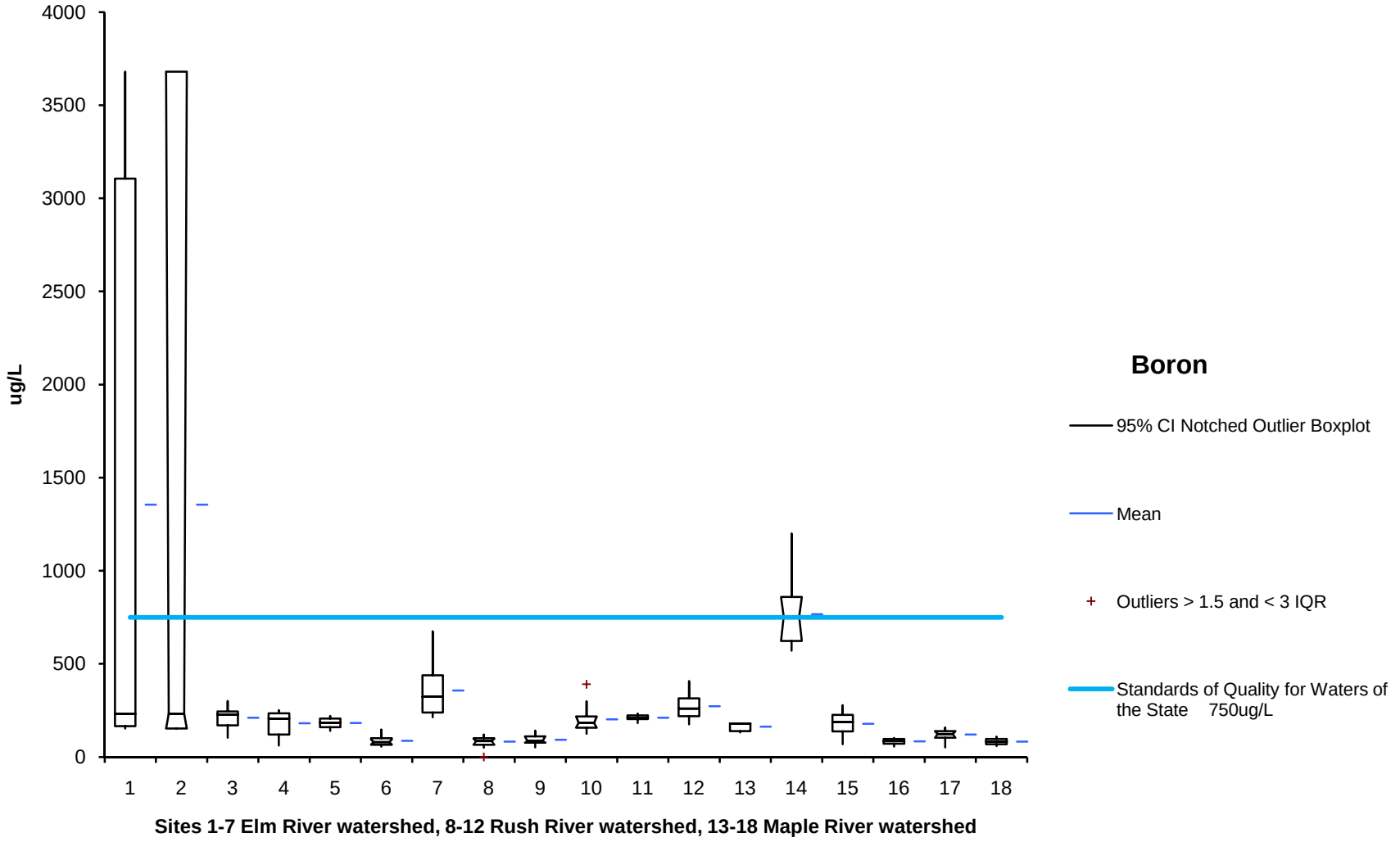

Total Dissolved Solids
mg/L
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
National Secondary Drinking Water Standards 500mg/L
Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed

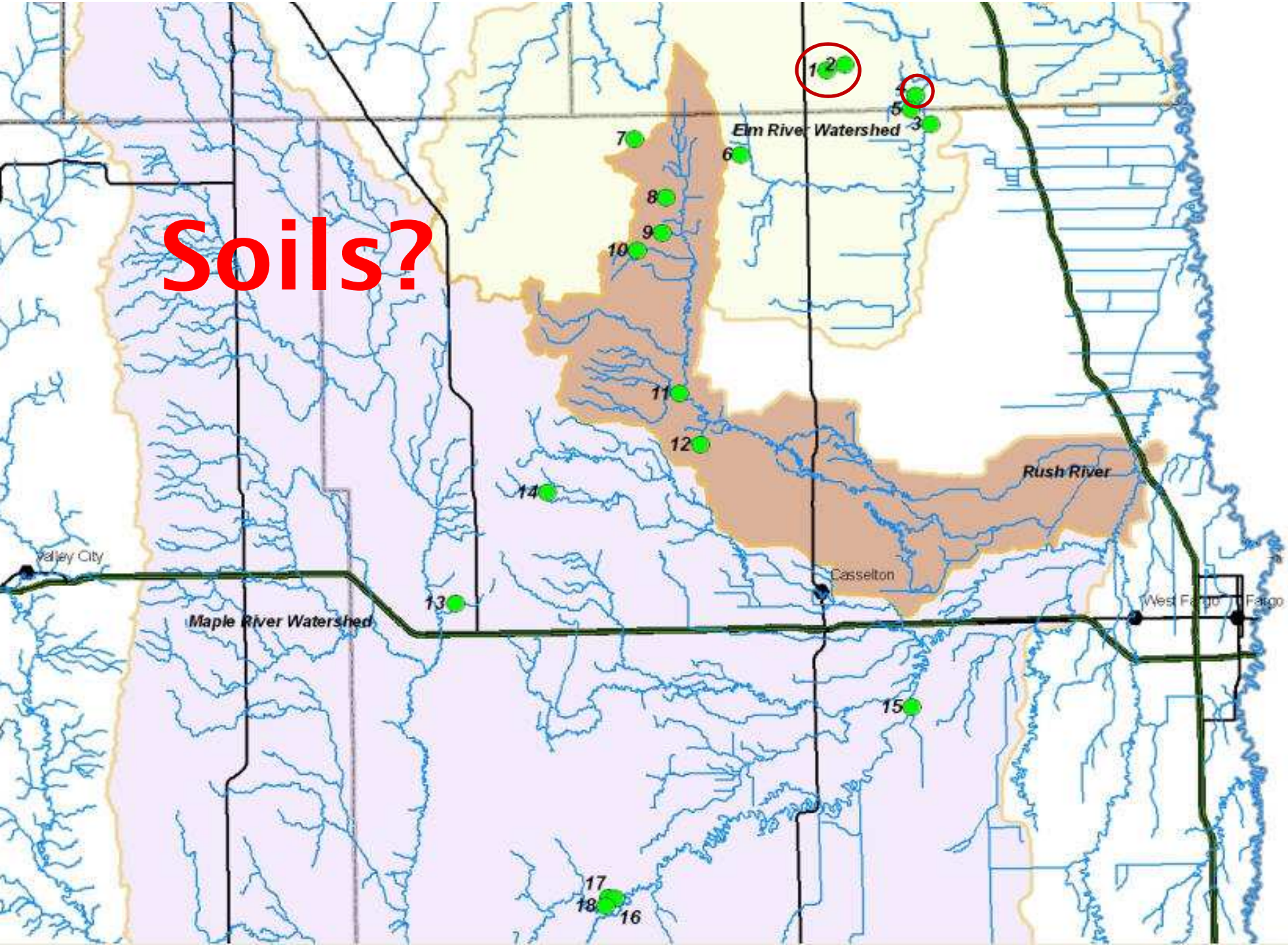

0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
2 samples
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
< .05mg/L to protect aquatic organisms
Ammonia Nitrogen
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
Standards of Quality for Waters of the State 8.4mg/L

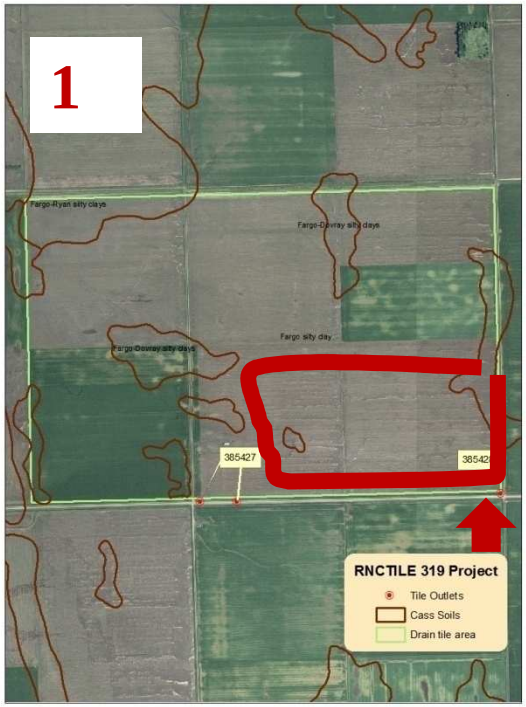

40
35
30
25
20
15
10
5
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Nitrate+Nitrite
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
National Primary Drinking Water Standard 10mg/L
Standards of Quality for Waters of the State 1.0mg/L

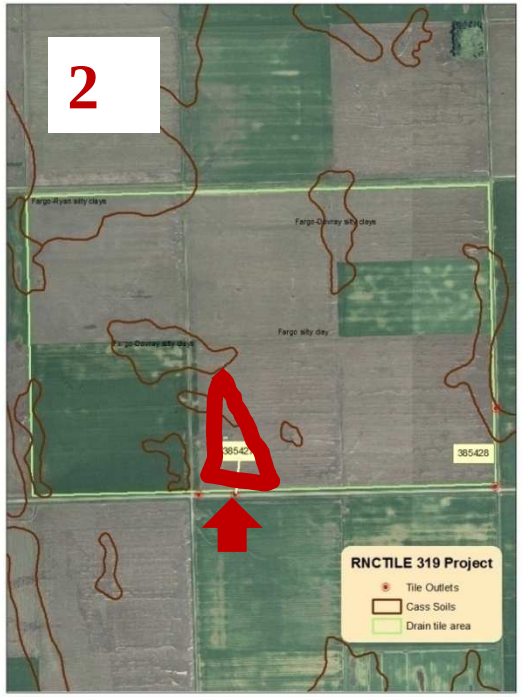

1600
1400
1200
1000
800
600
400
200
0
mg/L
Sea Water
"Hard Water"
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Magnesium
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR

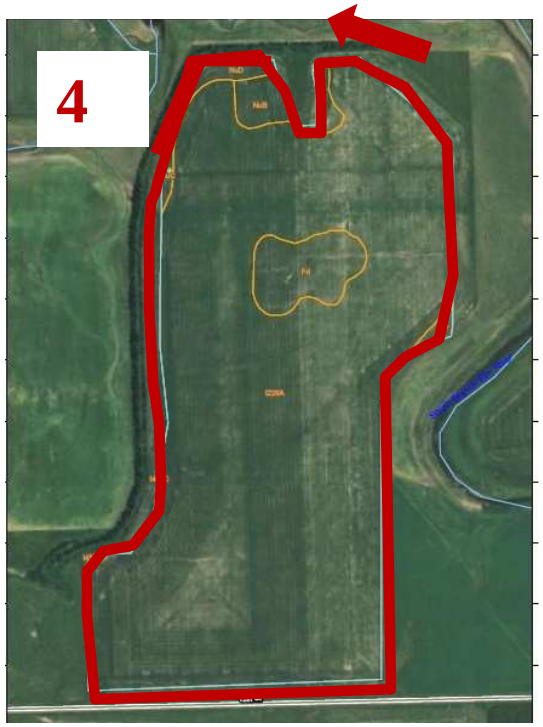

1400
1200
1000
800
600
400
200
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Standards of Quality for Waters of the State
50% of total cations in mEq//L
Sodium
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR


Boron
ug/L
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Standards of Quality for Waters of the State 750ug/L
Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed

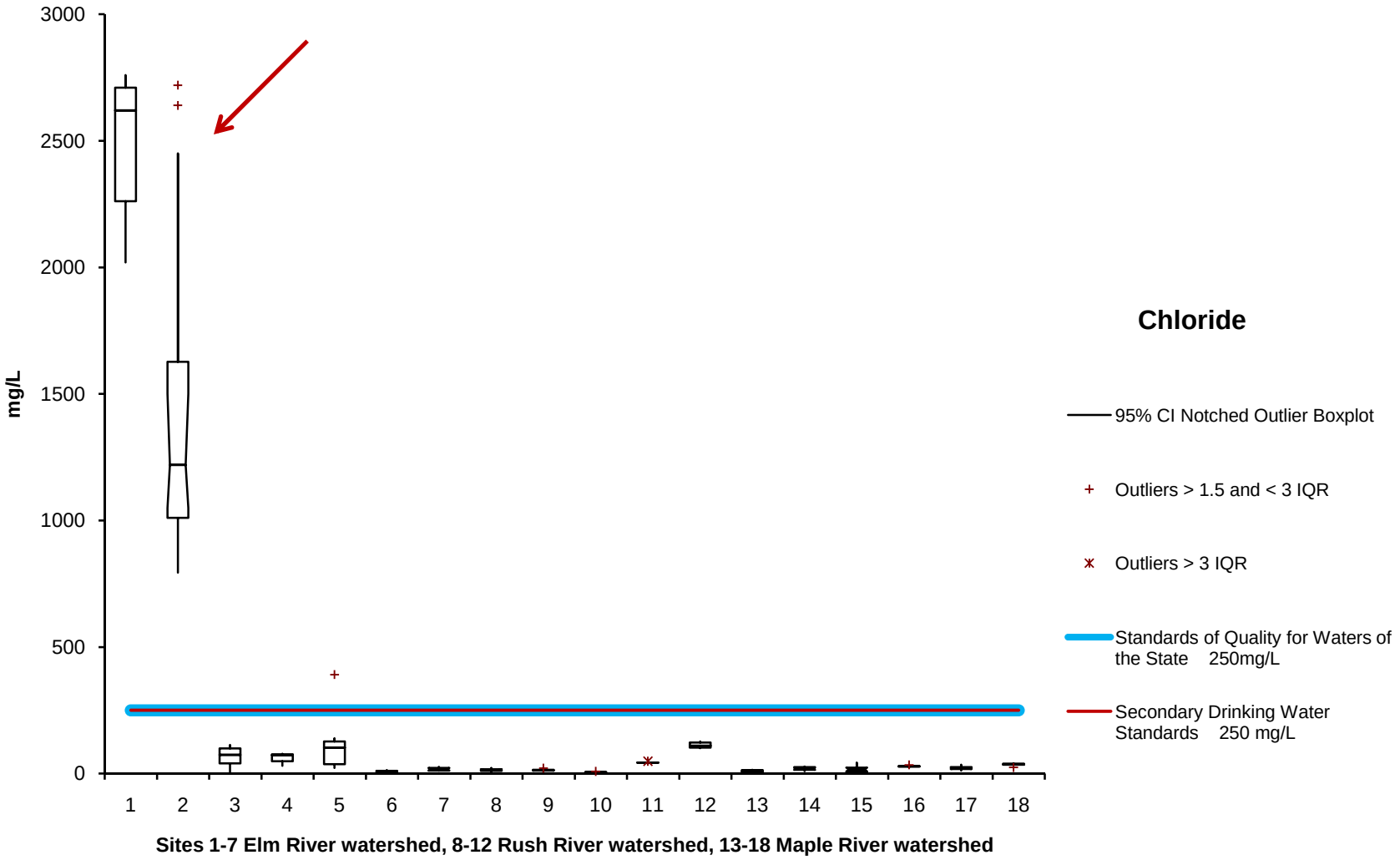

Soils?
Elm River Watershed
Rush River
Maple River Watershed
Valley City
Casselton
West Fargo
Fargo
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

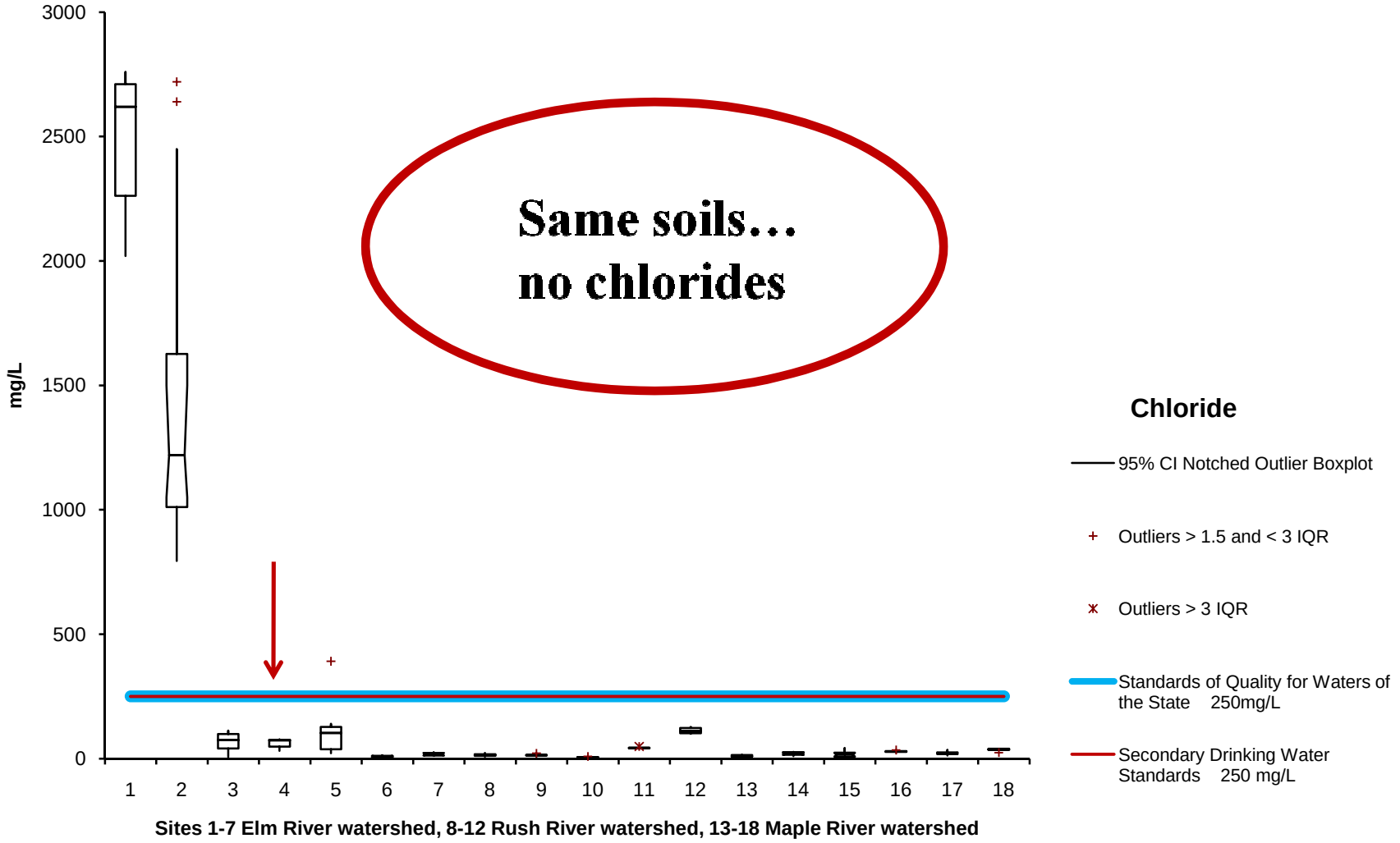




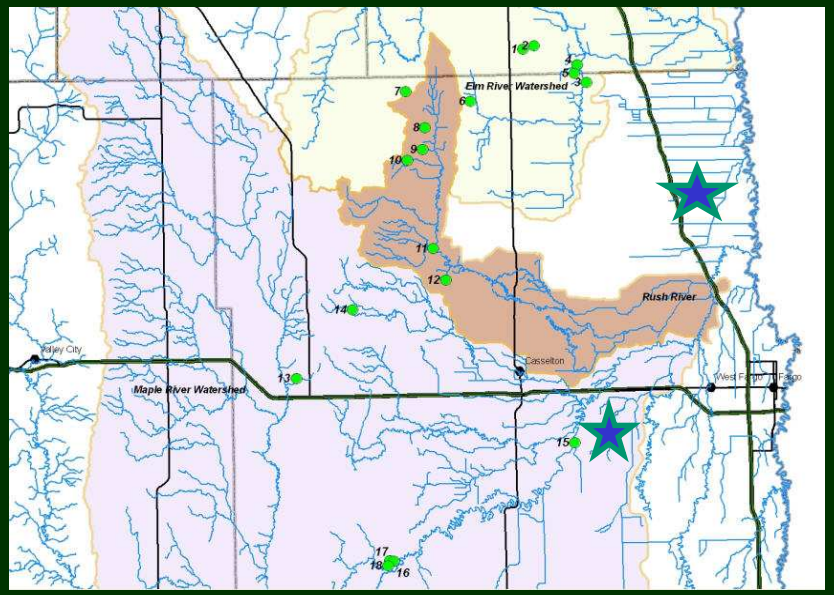


Soil Type:
Fargo Silty Clay


Chloride
mg/L
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
95% CI Notched Outlier Boxplot
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
Standards of Quality for Waters of the State 250mg/L
Secondary Drinking Water Standards 250 mg/L


Same soils…
no chlorides
mg/L
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Chloride
95% CI Notched Outlier Boxplot
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
Standards of Quality for Waters of the State 250mg/L
Secondary Drinking Water Standards 250 mg/L

Conductivity

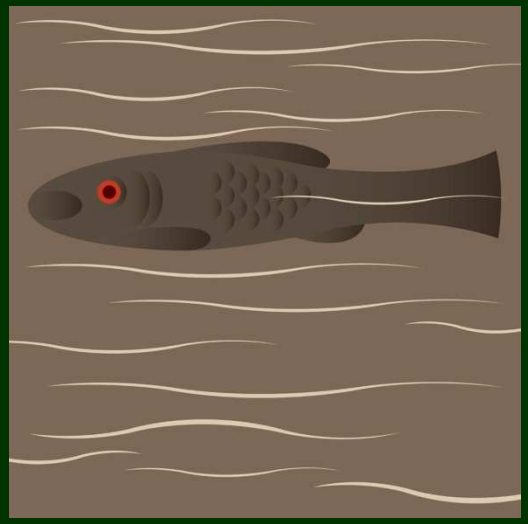


Lift stations have much higher conductivity levels….

? Lower in soil profile
? Topography
? Recharge/Discharge

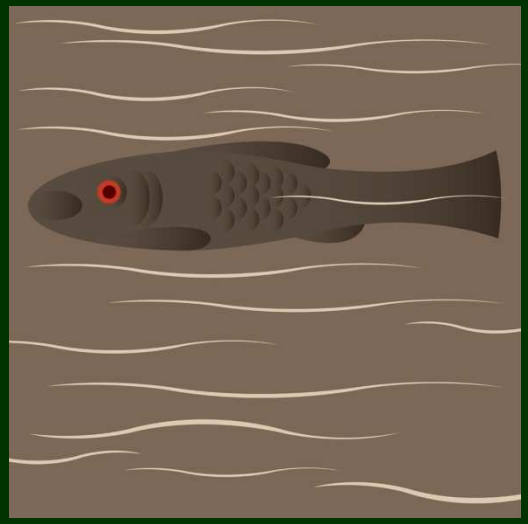
Other Concerns:

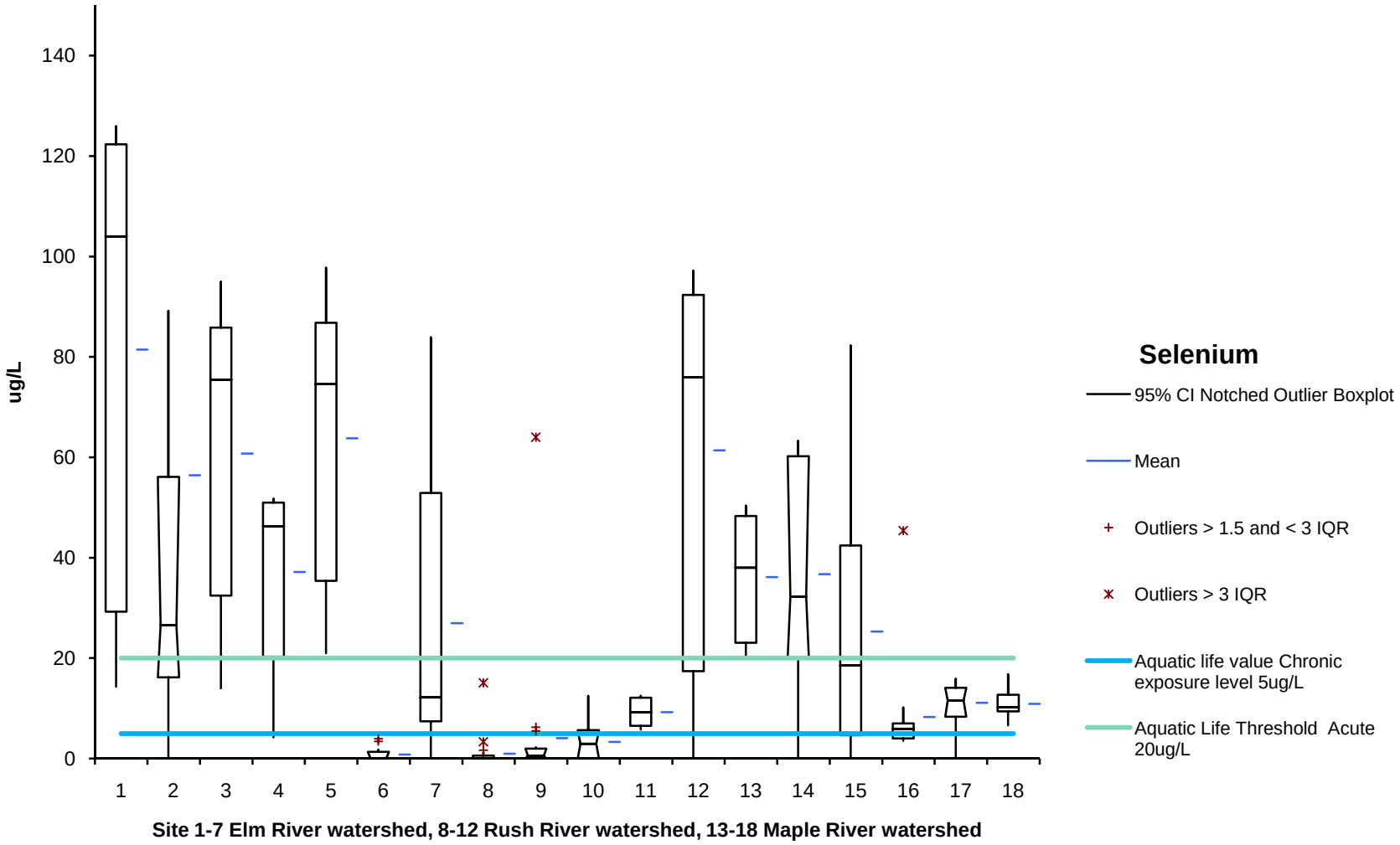
Trace metals and aquatic life.....Arsenic
Copper
Selenium
Aluminum
Lead
Nickel
Zinc

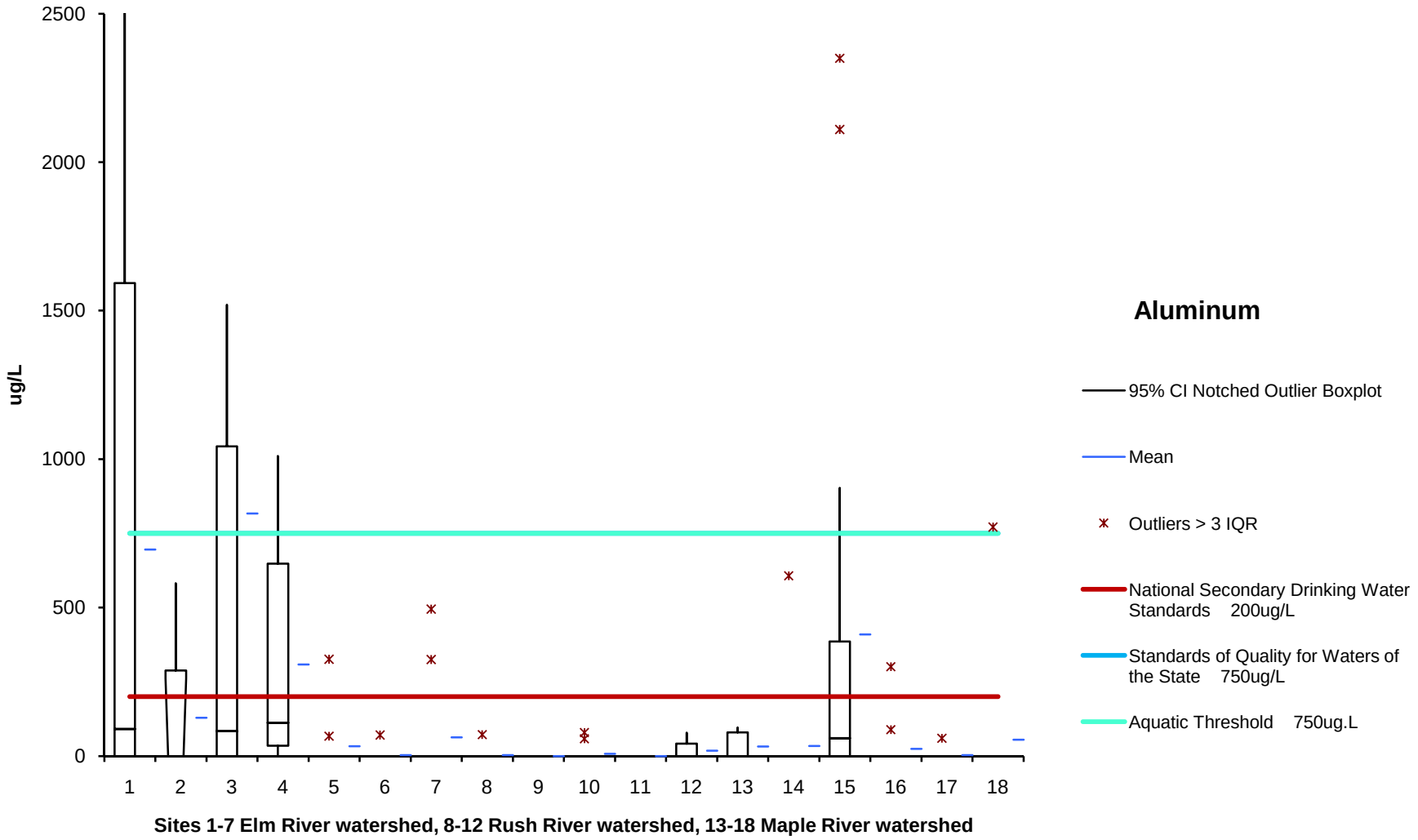


Other Concerns:

Trace metals and aquatic life.....Arsenic
Copper
Selenium
Aluminum
Lead
Nickel
Zinc




ug/L
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Selenium
95% CI Notched Outlier Boxplot
Mean
Outliers > 1.5 and < 3 IQR
Outliers > 3 IQR
Aquatic life value Chronic exposure level 5ug/L
Aquatic Life Threshold Acute 20ug/L


Aluminum
ug/L
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
95% CI Notched Outlier Boxplot
Mean
Outliers > 3 IQR
National Secondary Drinking Water Standards 200ug/L
Standards of Quality for Waters of the State 750ug/L
Aquatic Threshold 750ug.L

What Is The Water Quality On Your Land?

- Soils
- Aquifer/ground water
- Fertilizer use
- Salinity
- Cropping practices

Don’t rely on chance.

- Best Management Practices

Best Management Practices

- Soil samples
- Fertilizer rates/timing
- Bioreactors
  - wood chips
- Outlet location

On-going I&E….

- Working with Discovery Farms in ND, WI, MN, AR
- Working with SCDs in North and South Dakota
- Tile Drain Tours
- Tile Drain Forum
- Tile Drainage Design Workshop
- Work with producers
- Work with state and county agencies to develop science based permitting regulations

Surface Runoff

Surface Drain

Tile Drain

↑ Phosphorus
Arsenic
Bicarbonate

December 5, 2008

NDSU
Extension Service
North Dakota State University