Tile Drainage
Water Quality Assessment in
Saline Soils in North Dakota

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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
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Steve Fischer – Lake Agassiz RC&D Coordinator
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
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

Tipping Bucket

Current Sensor
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?

Wastewater Standards?
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

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

- **1993 Study**: Average in 1993 study on Elm River 0.55mg/L
- **2004/05 Study**: Average in 2004-05 study on Rush River 0.4mg/L
- **2007 Study**: Average in 2007 study on Maple River 0.73mg/L

**Standards of Quality for Waters of the State**: 0.1mg/L
Sulfates

- 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

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

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

- National Secondary Drinking Water Standards: 500mg/L
< .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
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

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

Magnesium

"Hard Water"

Sites 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

Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Soils?
Soil Type: Fargo Silty Clay
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

Sites 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
Same soils... no chlorides
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
Selenium

- 95% CI Notched Outlier Boxplot
- Mean
- + Outliers > 1.5 and < 3 IQR
- X Outliers > 3 IQR

Aquatic life value Chronic exposure level 5ug/L
Aquatic Life Threshold Acute 20ug/L

Site 1-7 Elm River watershed, 8-12 Rush River watershed, 13-18 Maple River watershed
1500
2000
2500

ug/L

1 2 3 4 5 6 7 8 9 10 11 12

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
Questions?