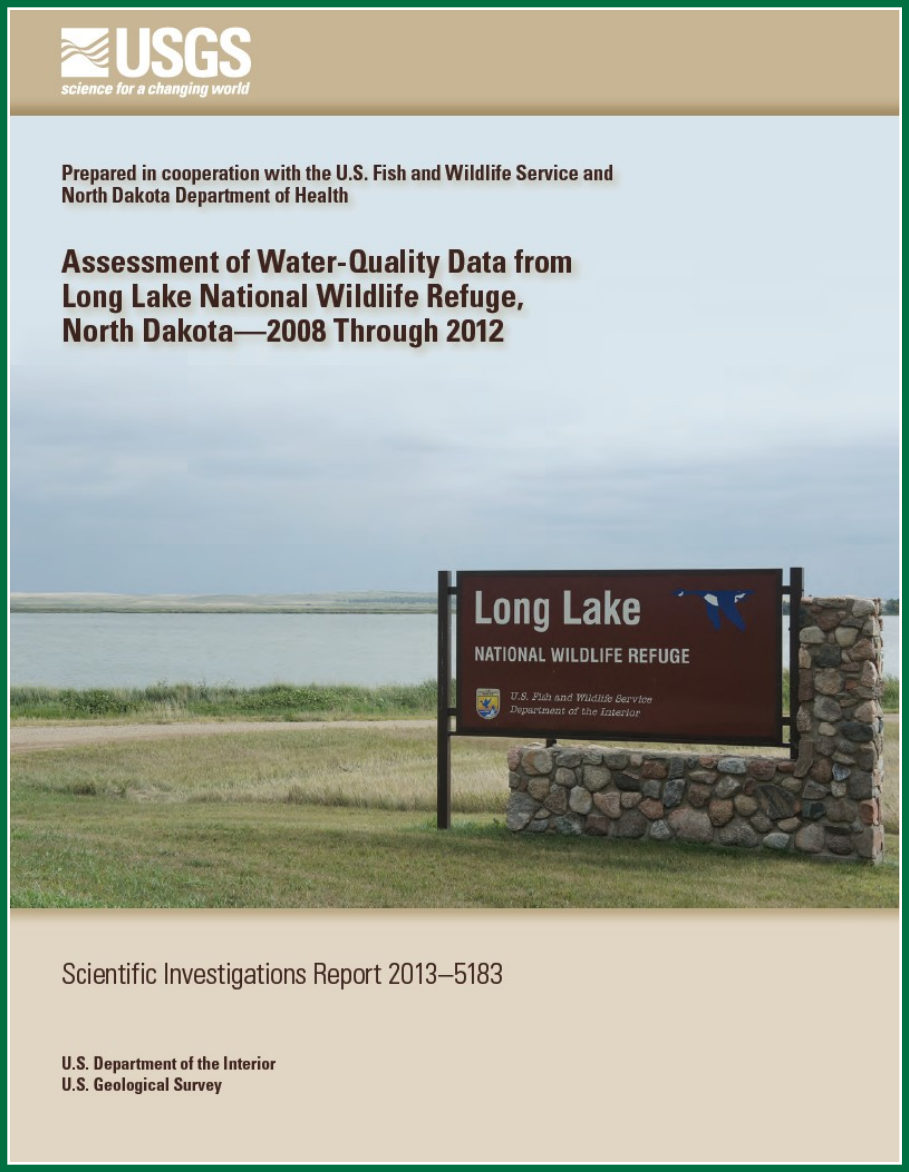
Long Lake
National
Wildlife
Refuge
U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR
U.S. Department of the Interior
U.S. Geological Survey

Water Quality Monitoring at Long Lake National Wildlife Refuge, North Dakota: 2008–2012

USGS, Northern Prairie Wildlife Research Center

U.S. Department of the Interior
U.S. Geological Survey



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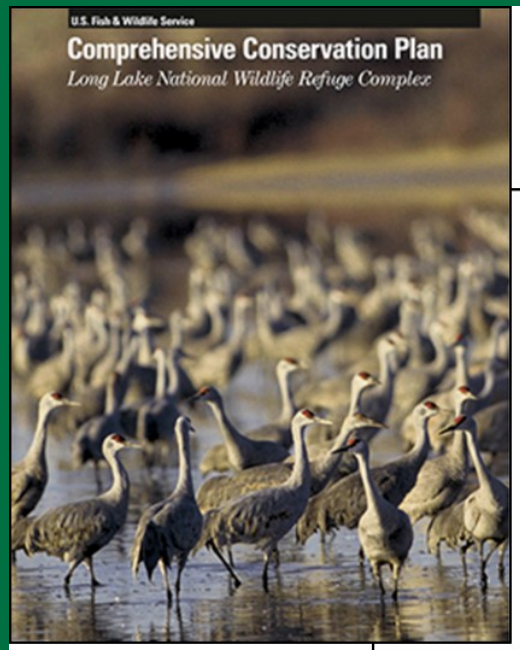
Partners

- **USFWS,** LLNWR staff
- **ND Dept. of Health,** Mike Ell
- **USGS Northern Prairie Wildlife Research Center,** Ray Finocchiaro, Charlie Dahl, Brian Tangen, Robert Gleason
- **USGS ND Water Science Center,** Steve Robinson, Bill Damschen

Background

- **Biologic assessment / CCP**
- Potential water-quality issues
- Evaporates and chemicals
- Impact to plants, aquatic invertebrates, and birds
- Research, inventory, and monitoring



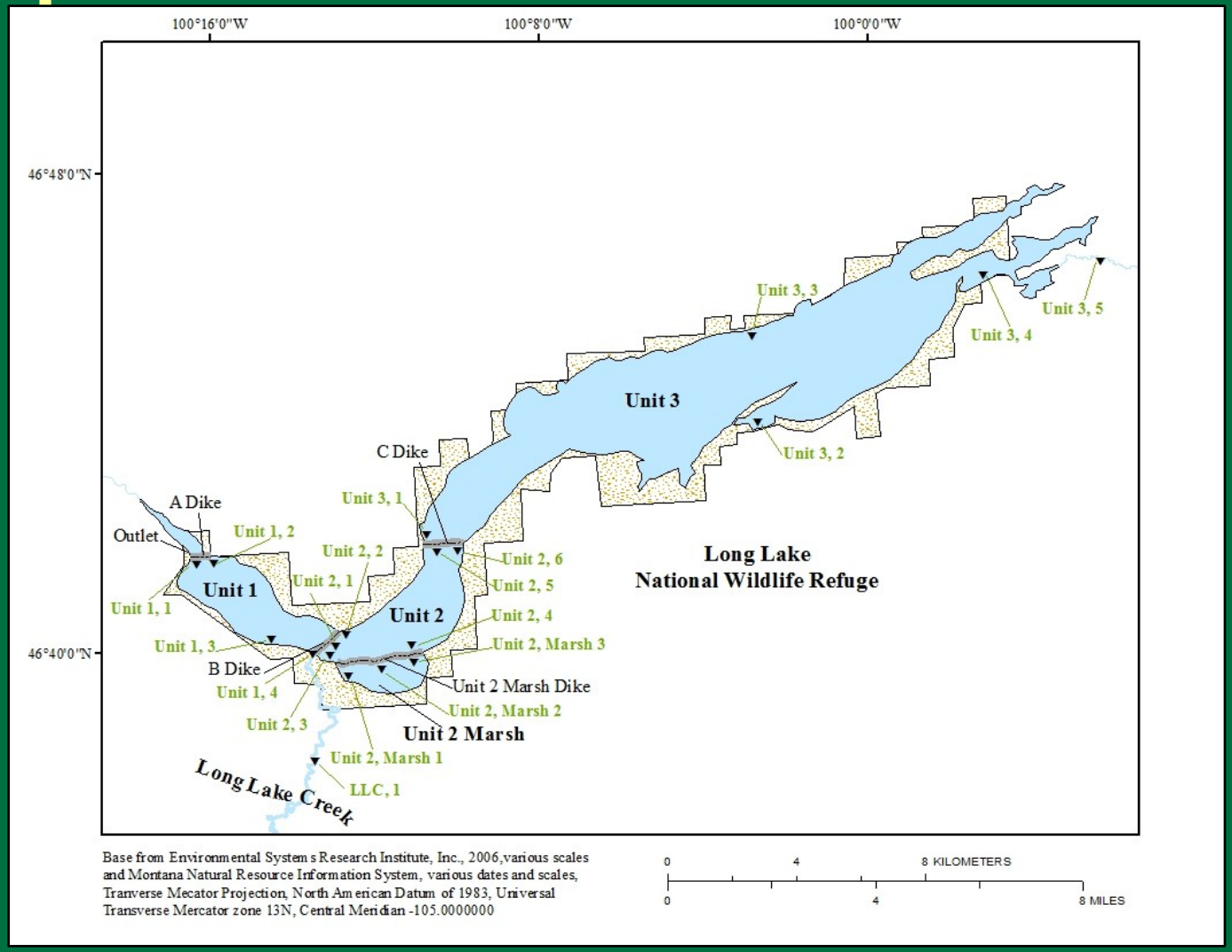
Monitoring program

- USGS, USFWS, NDDH
- Initiated in 2008
- Goals:
  - Protocol
  - Baseline data
  - Identify potential water quality issues
  - Support management decisions

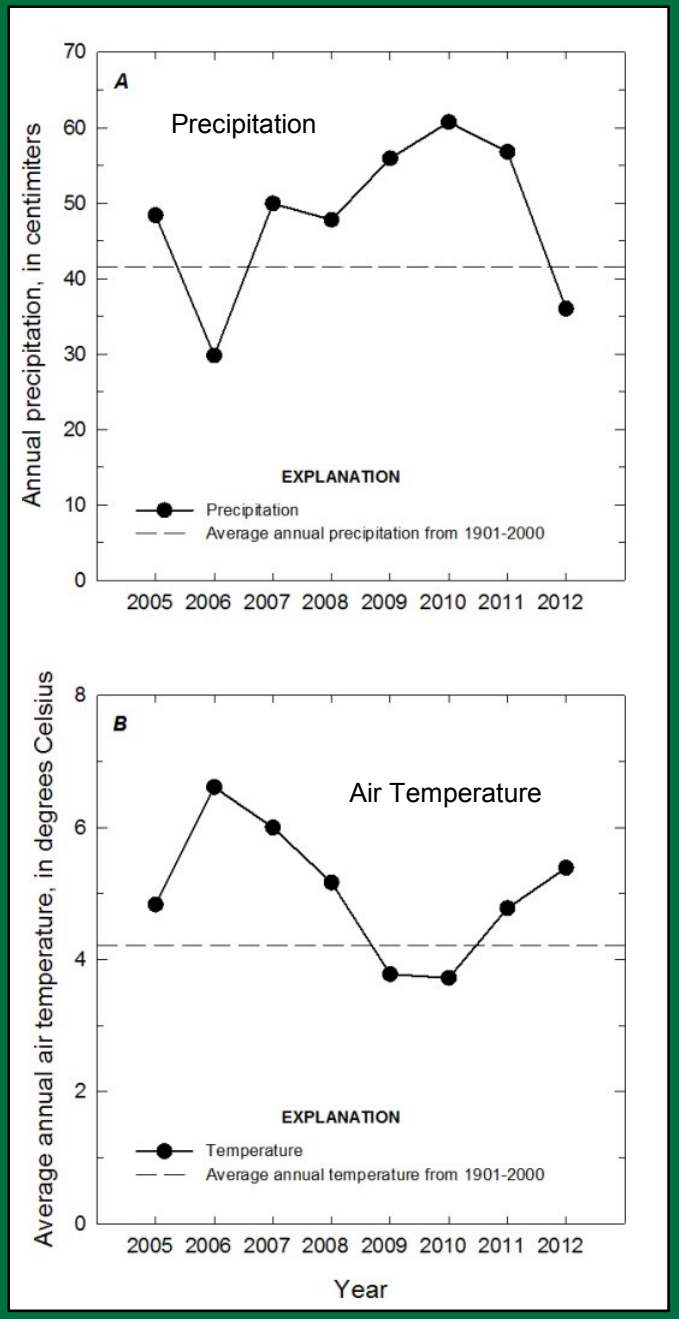
Water quality data

- Bi-monthly samples
  - Hand-held
  - Water samples
    - Major ions
    - Nutrients
    - Elements
    - SC / pH
- Automated loggers
  - Specific conductance
  - Water level

Sample locations



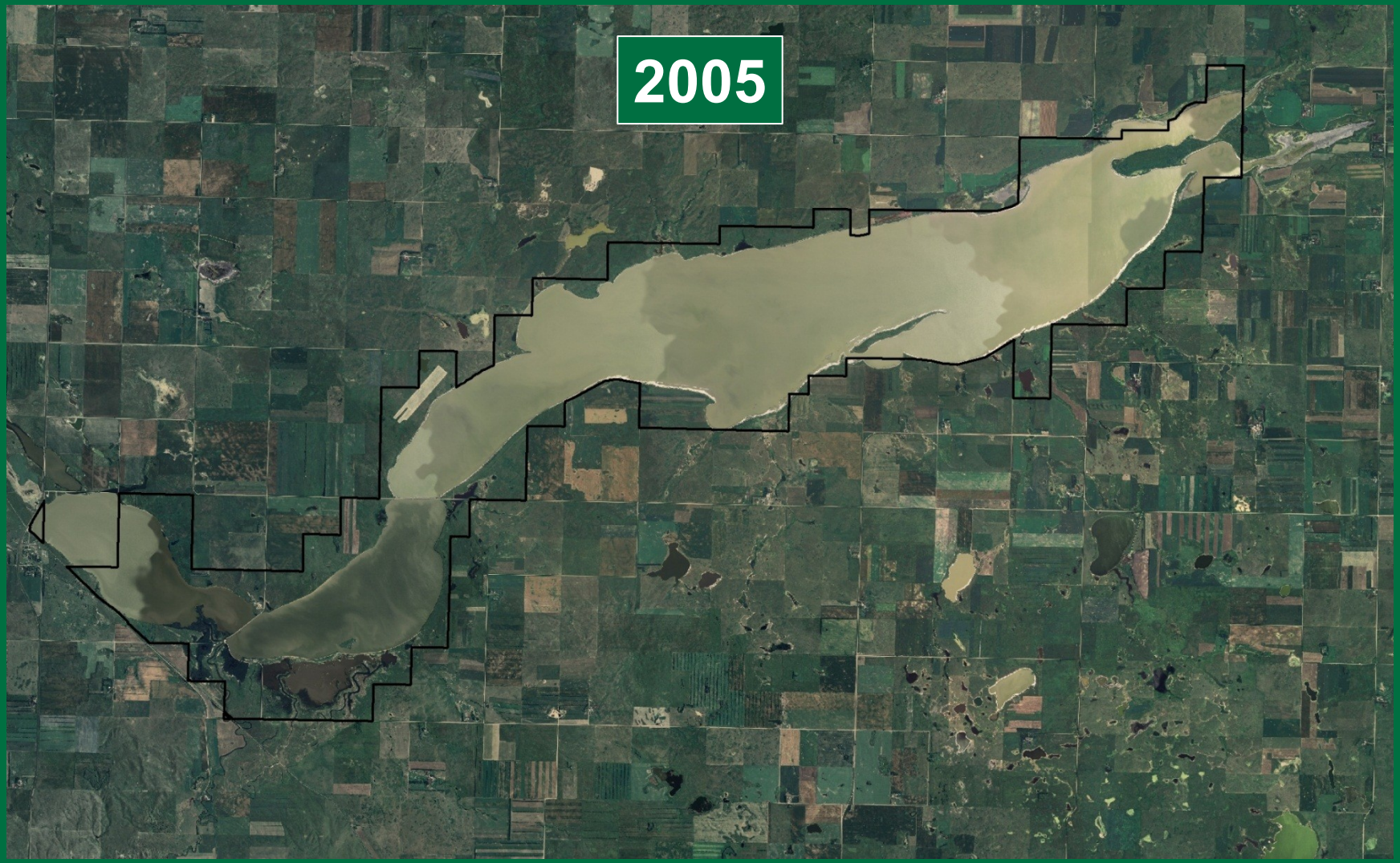
Setting: precipitation/temp



Setting: inflow/outflow

Year	Date range	n	Inflow, cfs	Outflow, cfs	Difference, cfs
2008	June 19—Oct. 17	107	8.48	0.00	-8.48
2009	June 18—Nov. 18	154	110.37	28.55	-81.82
2010	April 23—Nov. 19	211	59.91	94.42	34.51
2011	May 11—Oct. 26	169	143.72	193.63	49.91
2012	April 4—Nov. 13	223	18.53	31.18	12.66

Long Lake NWR, 2005–2009



Photos provided by USFWS: ~August-September

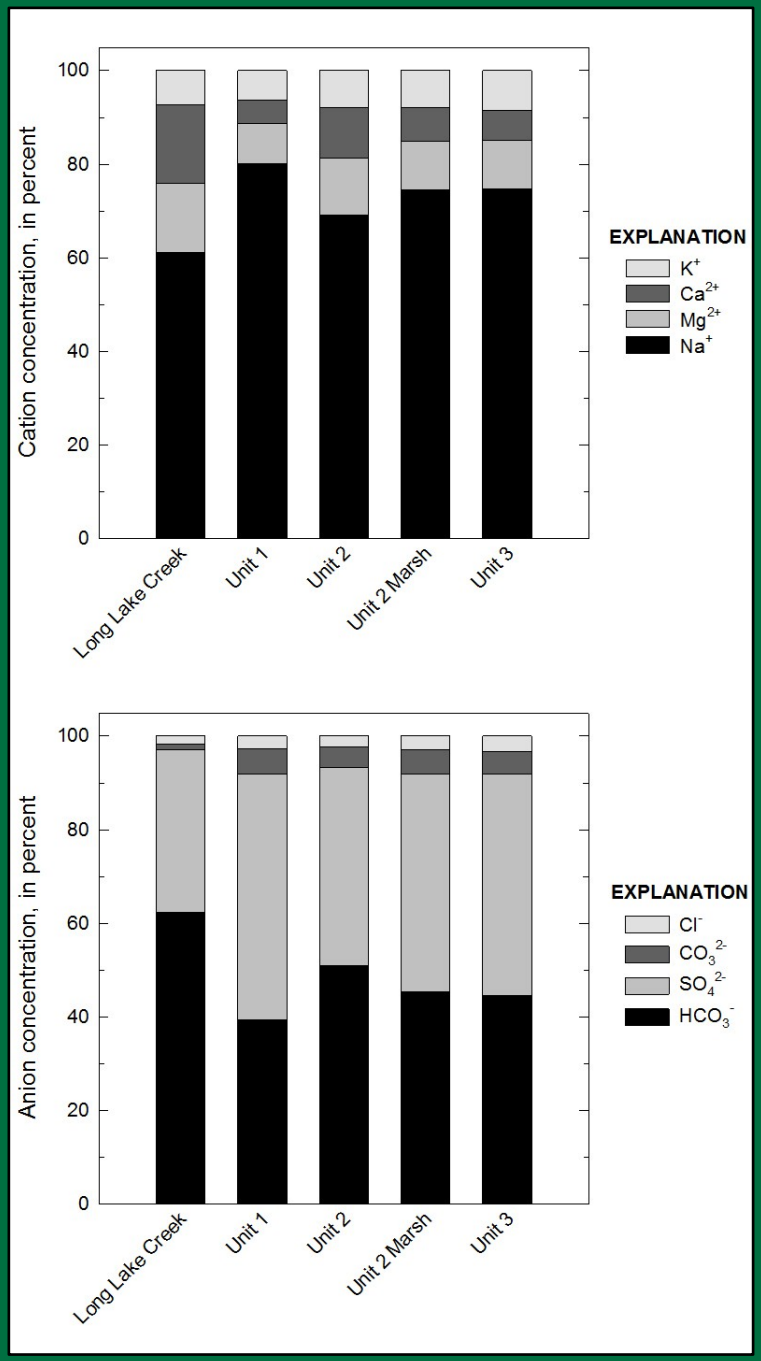
Sampling Season

	Date			
Year	Start	End	Number of sites	Sample periods
2008	July 1	Nov. 5	12	5–9
2009	April 2	Nov. 17	18	12–15
2010	Mar 23	Nov. 18	18	15–25
2011	April 28	Nov. 15	18	14–18
2012	April 2	Nov. 1	19	9–15

Results

- Ions
- Elements
- Nutrients
- Temporal trends
- Spatial variation

Ions


Cation concentration, in percent
100
80
60
40
20
0
Long Lake Creek
Unit 1
Unit 2
Unit 2 Marsh
Unit 3
EXPLANATION
K+
Ca2+
Mg2+
Na+
Anion concentration, in percent
100
80
60
40
20
0
Long Lake Creek
Unit 1
Unit 2
Unit 2 Marsh
Unit 3
EXPLANATION
Cl-
CO3 2-
SO4 2-
HCO3 -

Salinity, etc.

Specific conductance
- 2,400 µS/cm (<204–38,700)

TDS
- 1,755 mg/L (117–39,700)

Hardness
- 329 mg/L = very hard

Alkalinity
- 580 mg/L = alkaline

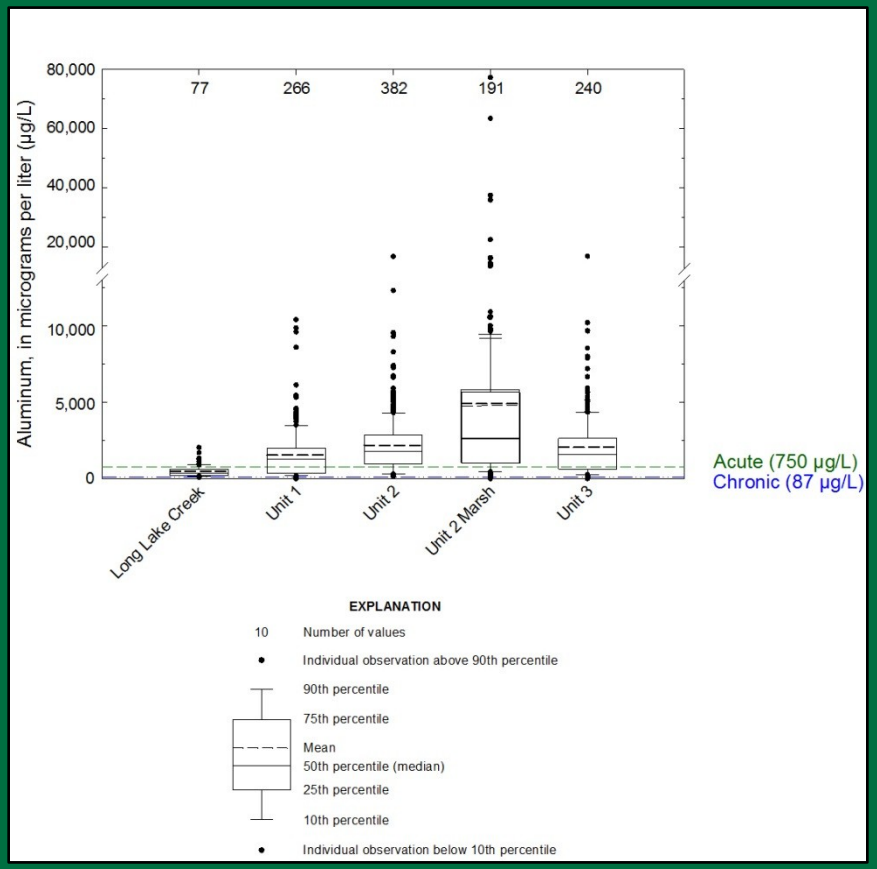
SAR
- 10

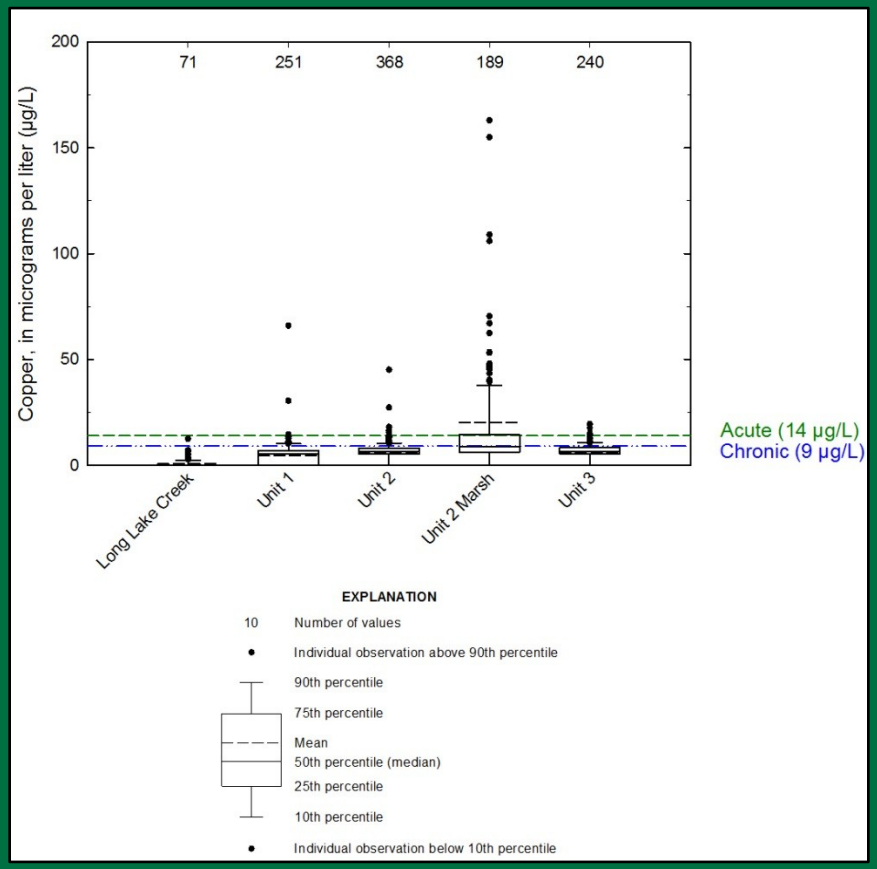
pH
- 8.8

Elements

- Ag, Al, As, B, Ba, Cr, Cu, Fe, Mn, Ni, Pb, Sb, Se, Zn
- WQ standards
  - Acute, chronic, HH, max
  - 12/14
- Al: 70 &100%
- Cu: 6 & 20%

Al & Cu


Aluminum, in micrograms per liter (µg/L)
80,000
60,000
40,000
20,000
10,000
5,000
0
77
266
382
191
240
Long Lake Creek
Unit 1
Unit 2
Unit 2 Marsh
Unit 3
Acute (750 µg/L)
Chronic (87 µg/L)
EXPLANATION
10 Number of values
Individual observation above 90th percentile
90th percentile
75th percentile
Mean
50th percentile (median)
25th percentile
10th percentile
Individual observation below 10th percentile

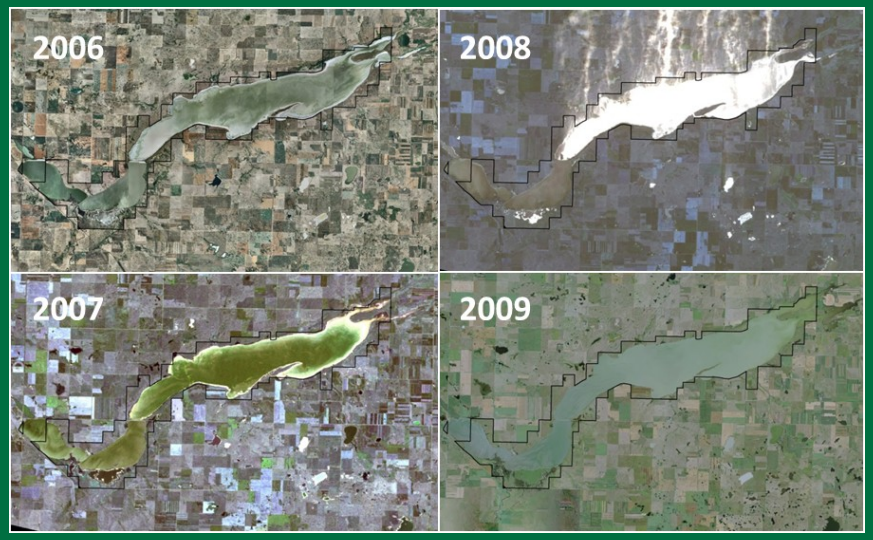

Copper, in micrograms per liter (µg/L)
200
150
100
50
0
71
251
368
189
240
Long Lake Creek
Unit 1
Unit 2
Unit 2 Marsh
Unit 3
Acute (14 µg/L)
Chronic (9 µg/L)
EXPLANATION
10 Number of values
Individual observation above 90th percentile
90th percentile
75th percentile
Mean
50th percentile (median)
25th percentile
10th percentile
Individual observation below 10th percentile

Nutrients

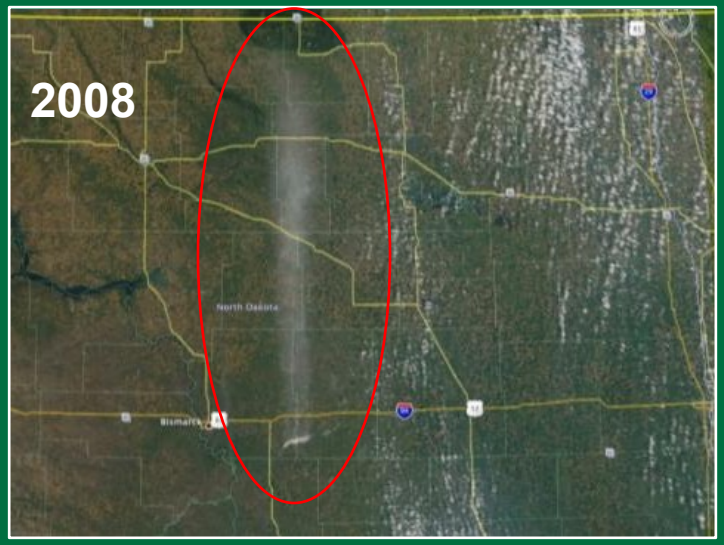
- Total N
- NH_4-N
- NO_3+NO_2
- Total P
- TKN

Temporal trends

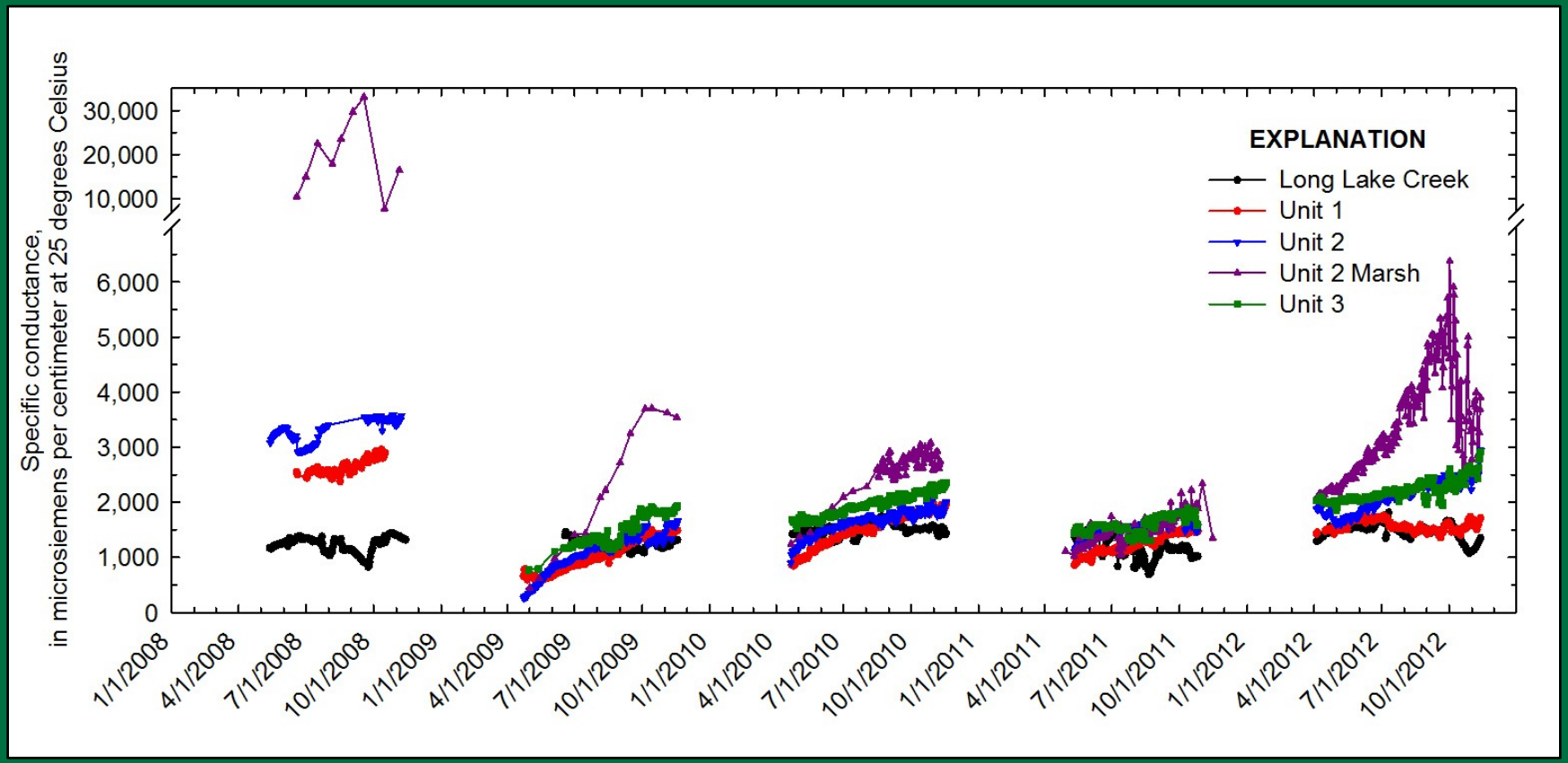
- Yearly
- Seasonal
- *In situ* loggers
  - Specific conductance
  - Water levels
- Salt import/export
- Concentration/dilution



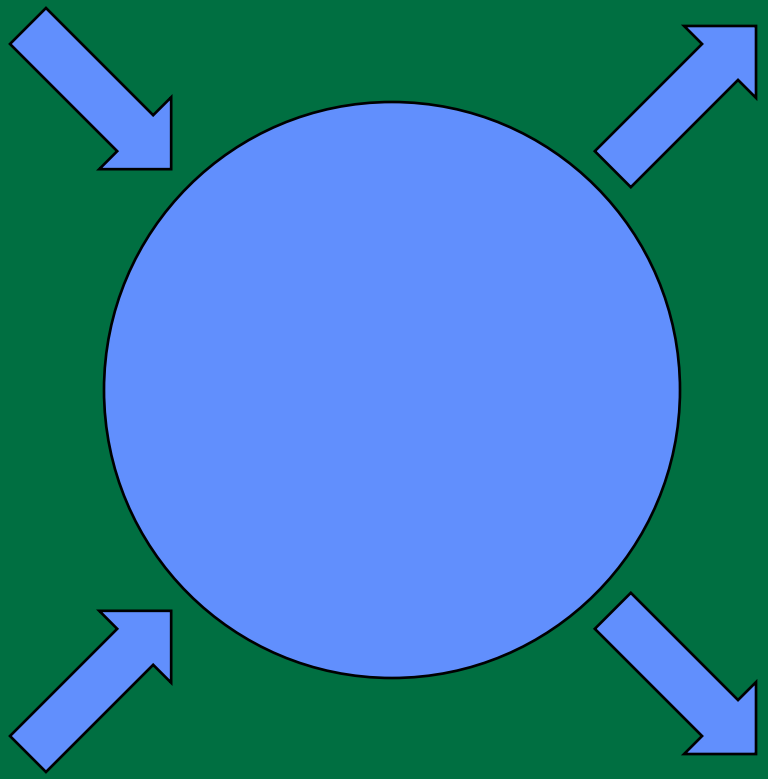
Interannual trends

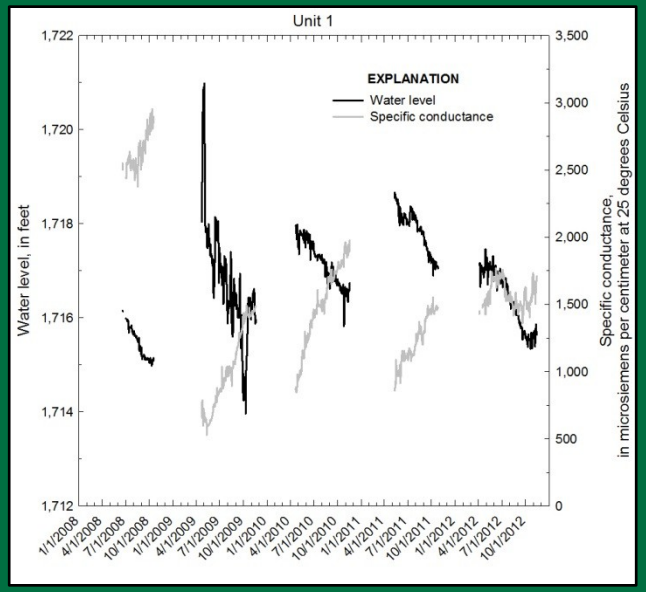


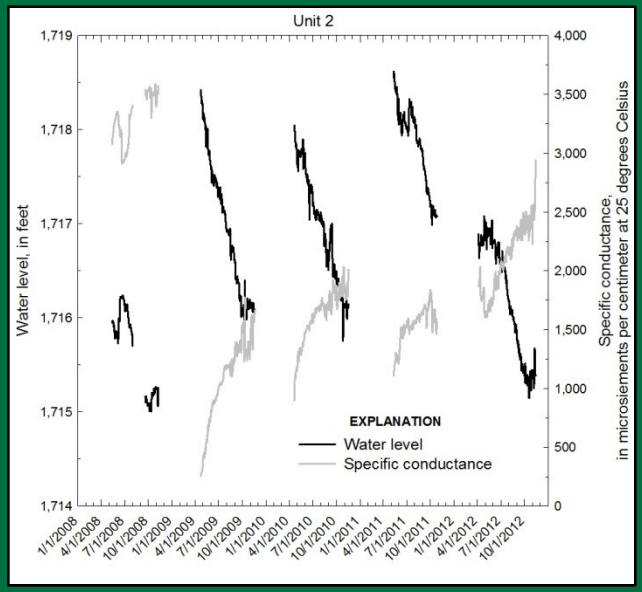
Specific conductance

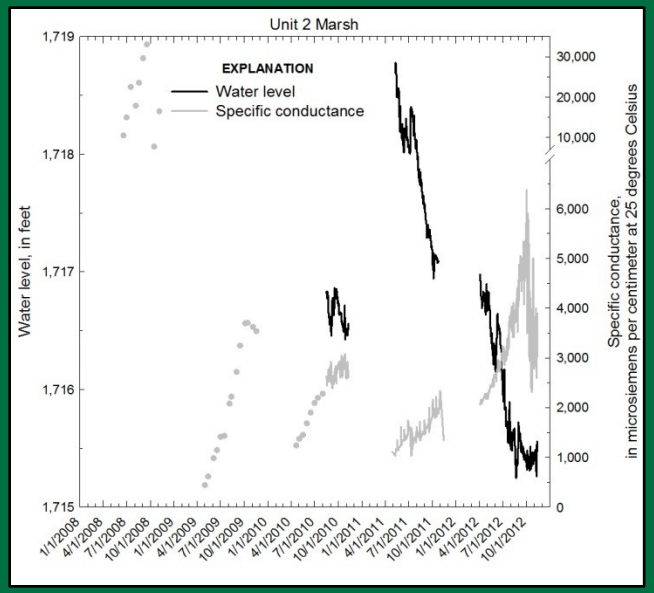


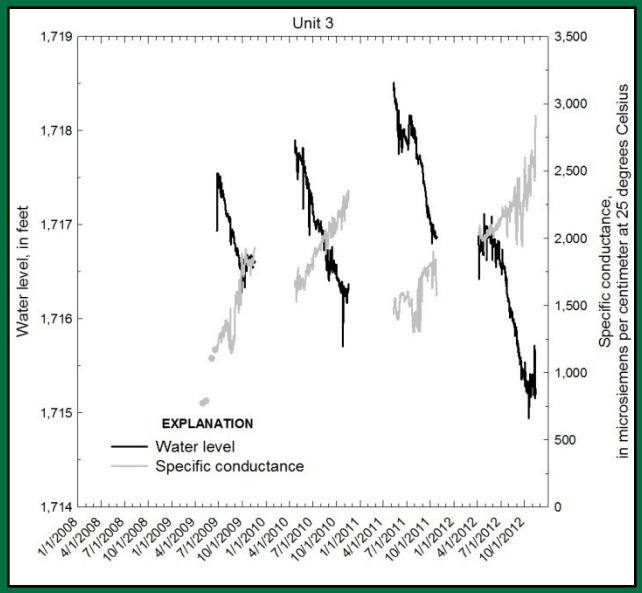
Seasonal trends




Unit 1
EXPLANATION
Water level
Specific conductance
Water level, in feet
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
1,722
1,720
1,718
1,716
1,714
1,712
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012

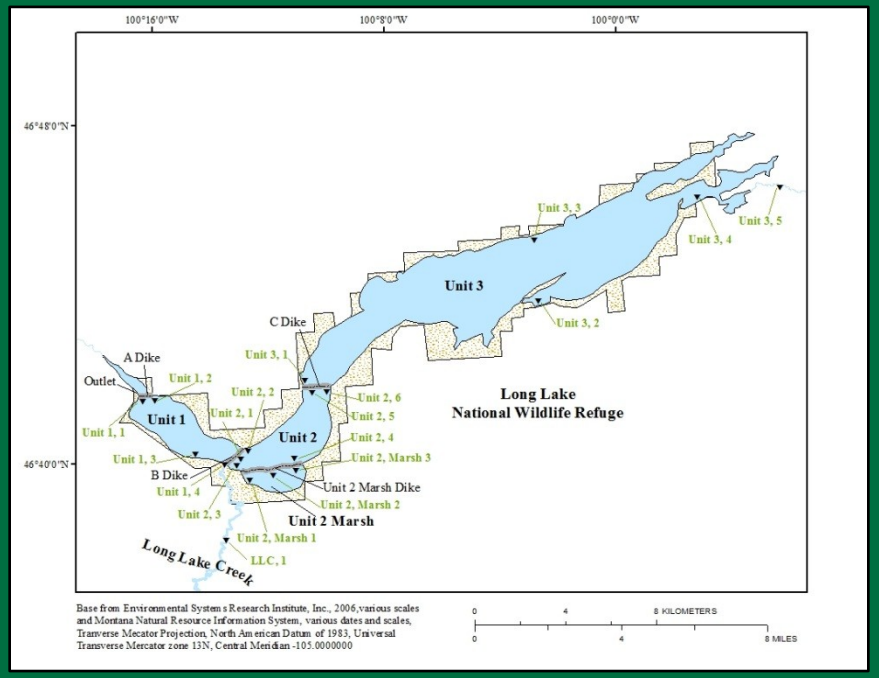

Unit 2
EXPLANATION
Water level
Specific conductance
Water level, in feet
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
1,719
1,718
1,717
1,716
1,715
1,714
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012

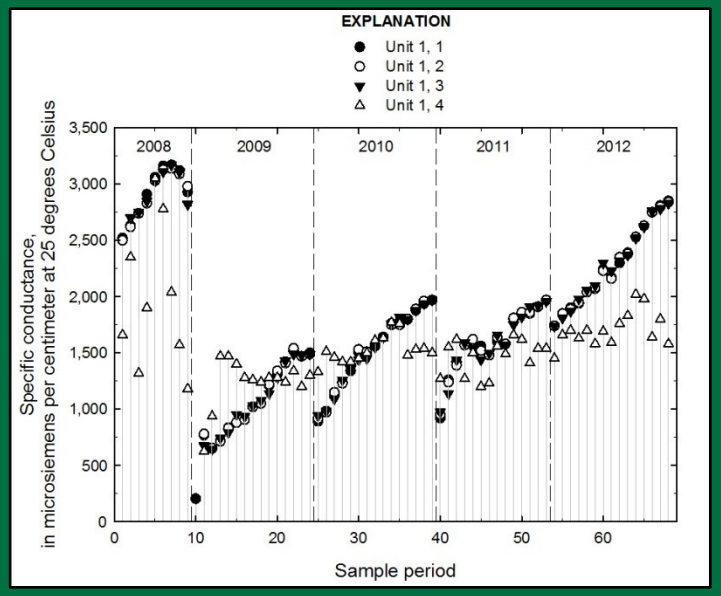

Unit 2 Marsh
EXPLANATION
Water level
Specific conductance
Water level, in feet
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
1,719
1,718
1,717
1,716
1,715
30,000
20,000
10,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012

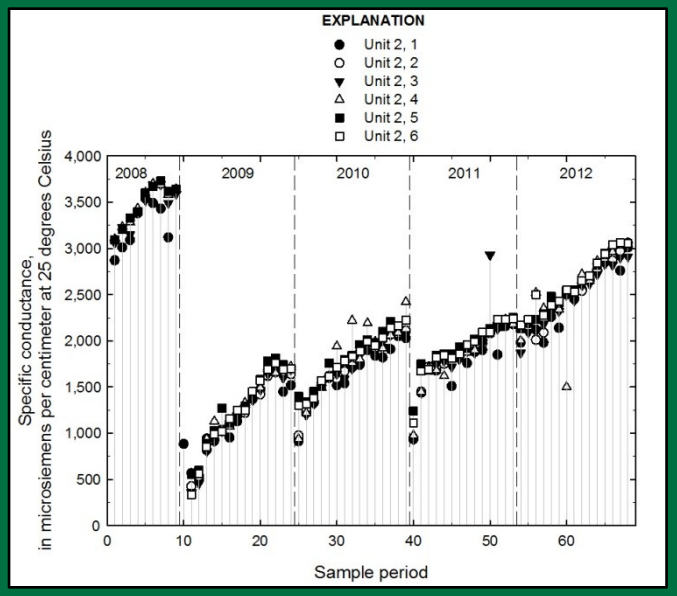

Unit 3
EXPLANATION
Water level
Specific conductance
Water level, in feet
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
1,719
1,718
1,717
1,716
1,715
1,714
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012

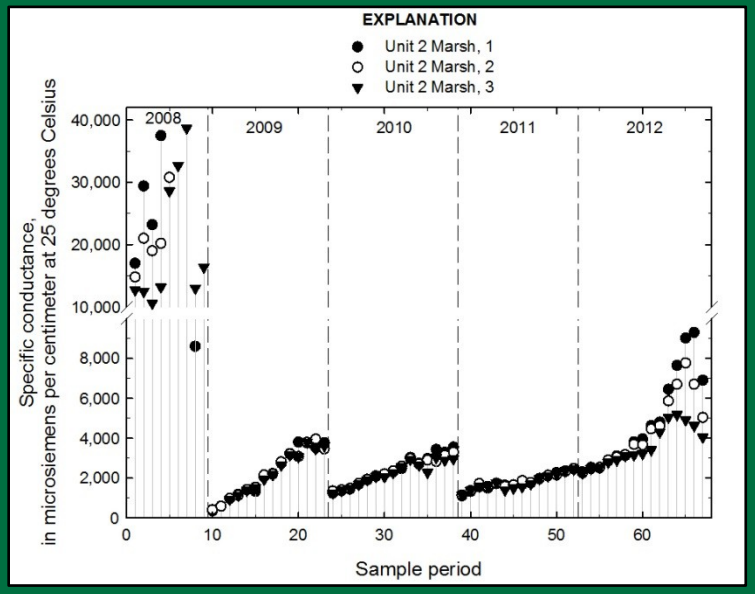
Among-unit variability

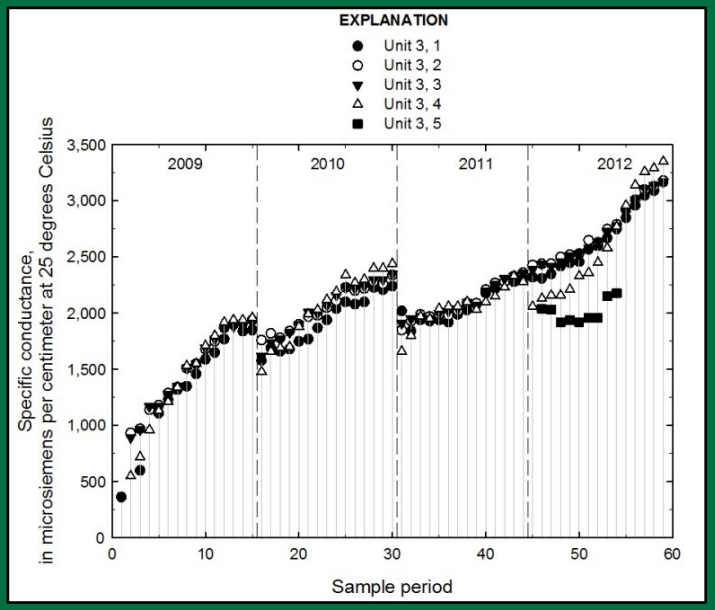
- Compare sites by Unit & date
- How well are units mixed?
- Can we modify study design?




EXPLANATION
Unit 1, 1
Unit 1, 2
Unit 1, 3
Unit 1, 4
2008
2009
2010
2011
2012
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
Sample period


EXPLANATION
Unit 2, 1
Unit 2, 2
Unit 2, 3
Unit 2, 4
Unit 2, 5
Unit 2, 6
2008
2009
2010
2011
2012
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
Sample period


EXPLANATION
Unit 2 Marsh, 1
Unit 2 Marsh, 2
Unit 2 Marsh, 3
2008
2009
2010
2011
2012
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
Sample period


EXPLANATION
Unit 3, 1
Unit 3, 2
Unit 3, 3
Unit 3, 4
Unit 3, 5
2009
2010
2011
2012
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
Sample period

Future Monitoring

- 2013
  - 1 sample site per unit
    - 2 in Unit 2 Marsh
  - 1 sample site Long Lake Creek
  - 1 time per month

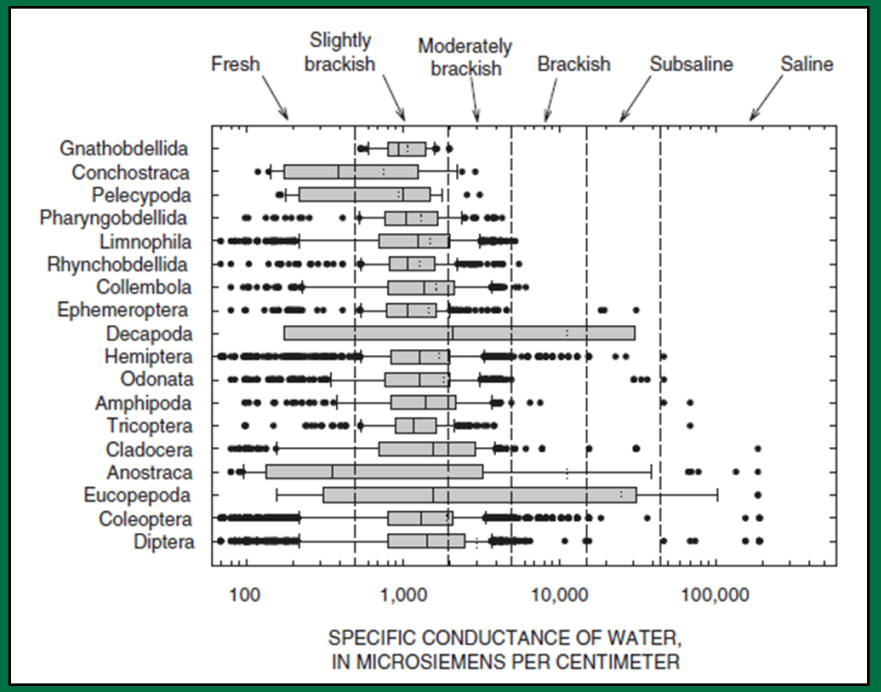
- With limited time and resources
  - Seasonal (e.g., spring, summer, fall)

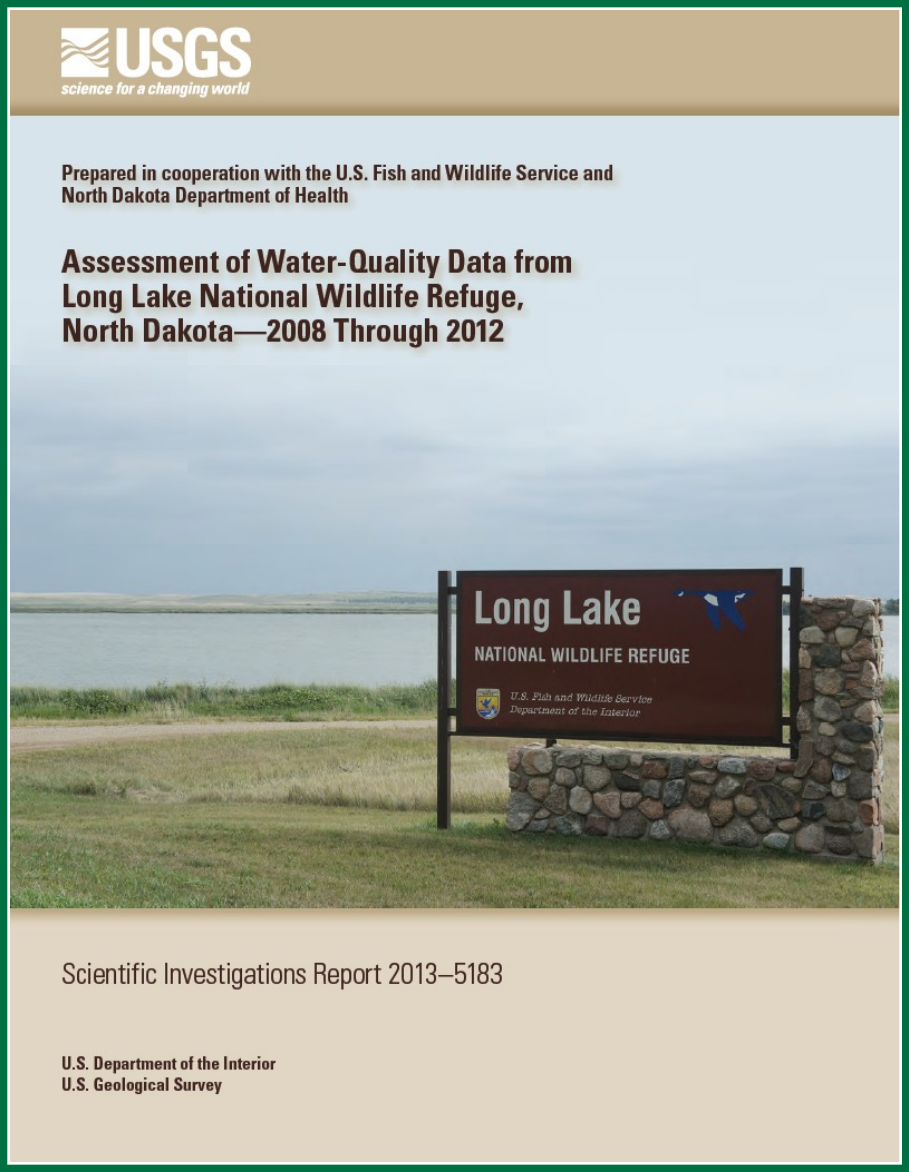
Summary

- Assess the state of the system
  - No major issues identified
  - High salinity during low water levels
- Identify noteworthy trends
- Establish baselines
  - Valid comparisons
- Provide information to support management decisions

Moving forward

- Continue monitoring
- Examine trends
- Additional data?
  - Soils
  - Biotic communities
- Evaluate management goals / objectives
- Modeling?
  - Water balance information





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