Continuous Water-Quality Monitoring for Estimating Concentrations and Loads in the Red River

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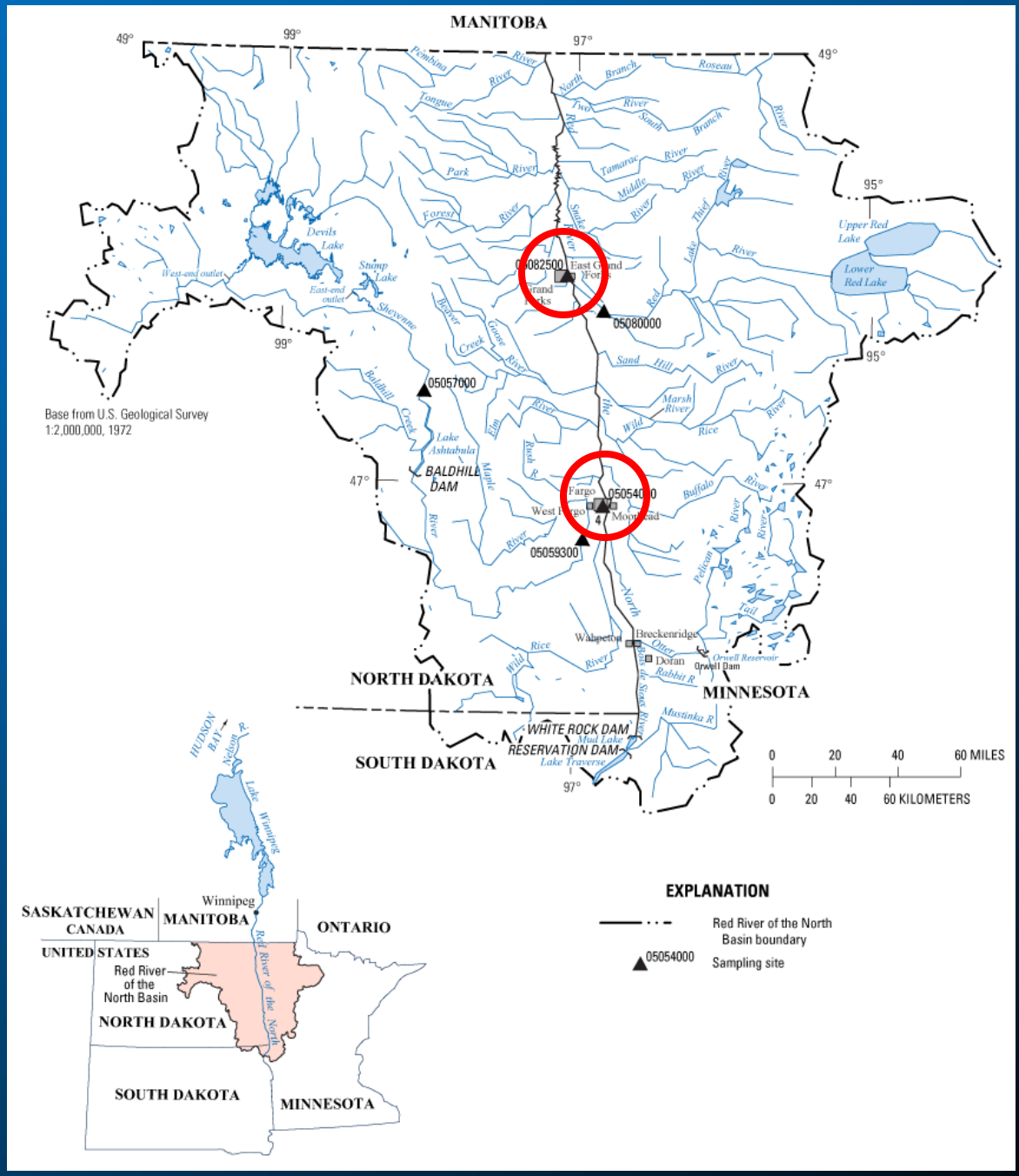
U.S. Department of the Interior
U.S. Geological Survey

Background

Red River Basin is an important water resource for the region. There are many water quality concerns including:

- Nutrient loading to the International border/Lake Winnipeg
- Effects of Devils Lake outlet discharges
- Effects of drainage tile
- Maintaining an adequate drinking water supply



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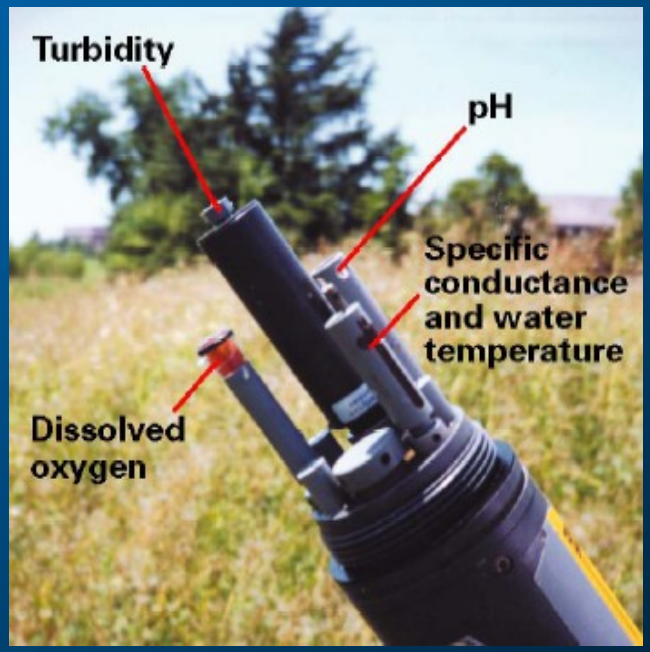
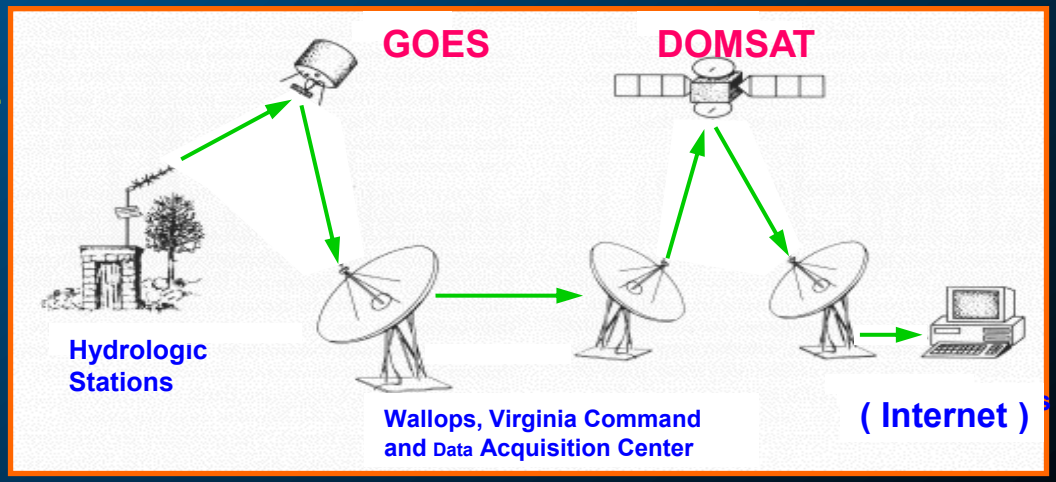
Continuous Real-time Water Quality for the Red River

- Continuous WQ data collected at Fargo since 2003 and from Grand Forks since 2007
- Data is collected every 15 minutes and updated to the web every hour



- Water temperature
- Dissolved oxygen
- Specific conductance
- pH
- Turbidity



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Background

- ***Why Continuous Water-Quality Data?***
  - Water-supply/wastewater management
    - Tracking changes in water-quality in near real time – can adjust treatment
    - Emergency response
  - Can assess water-quality dynamics better than can be done efficiently/affordability with discrete samples
    - For example - diurnal fluctuations of dissolved oxygen
  - Can be used to estimate continuous constituent concentrations
  - Load computation

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USGS Current Conditions for USGS 05054000 RED RIVER OF THE NORTH AT FARGO, ND - Windows Internet Explorer

http://waterdata.usgs.gov/nd/nwis/uv?cb_00060=on&cb_00300=on&cb_00095=on&cb_00400=on&cb_63680=on&cb_00060=on&format=gif_default&per

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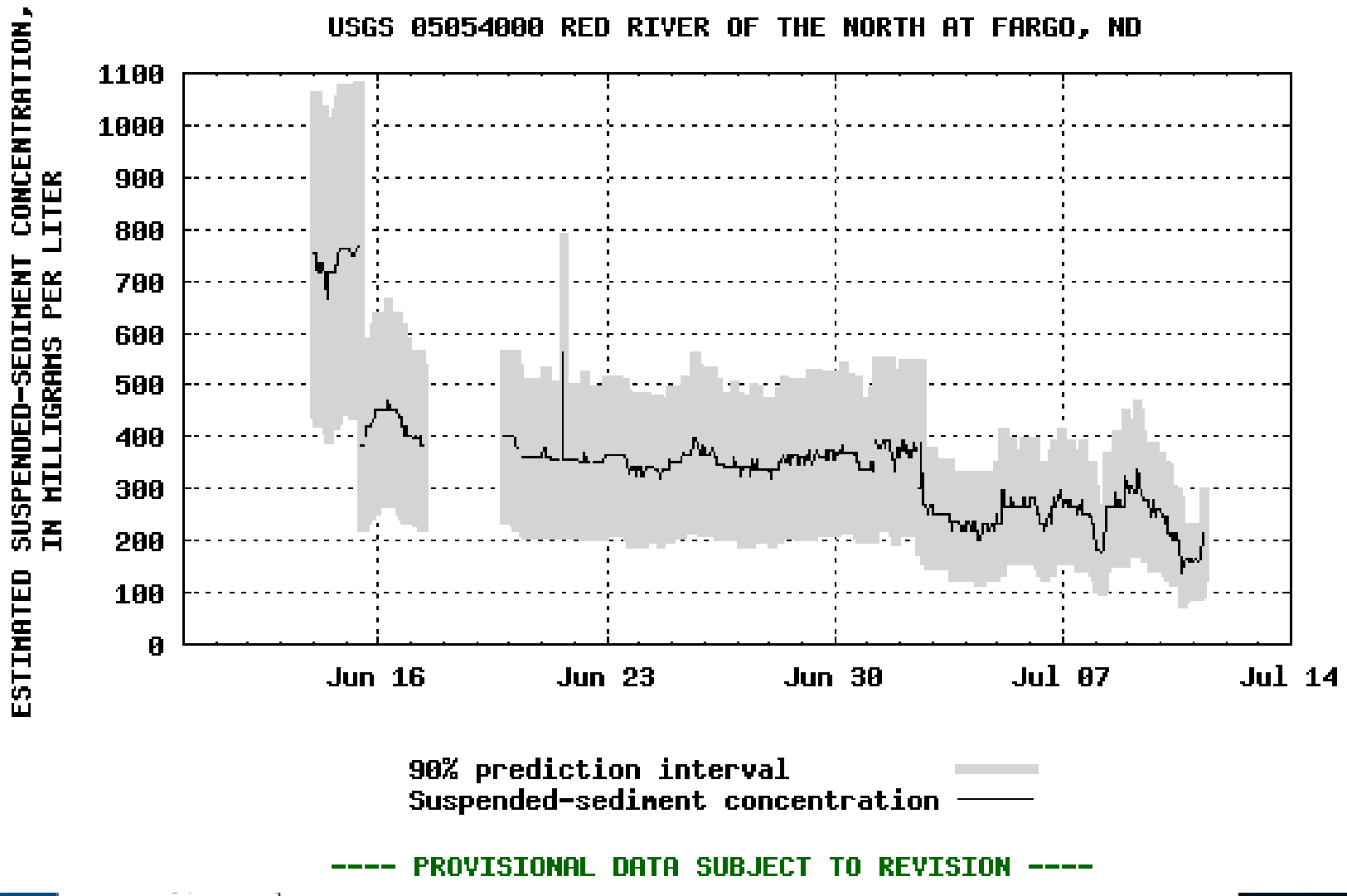
http://nd.water.usgs.gov/

USGS Current Conditions for USGS 05054000 RED RIV...

Click to hide state-specific text



---- Provisional Data Subject to Revision ----

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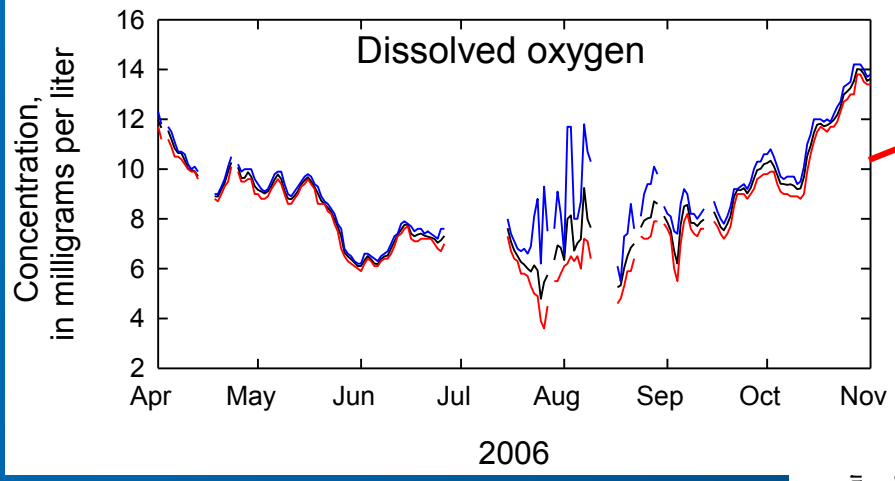
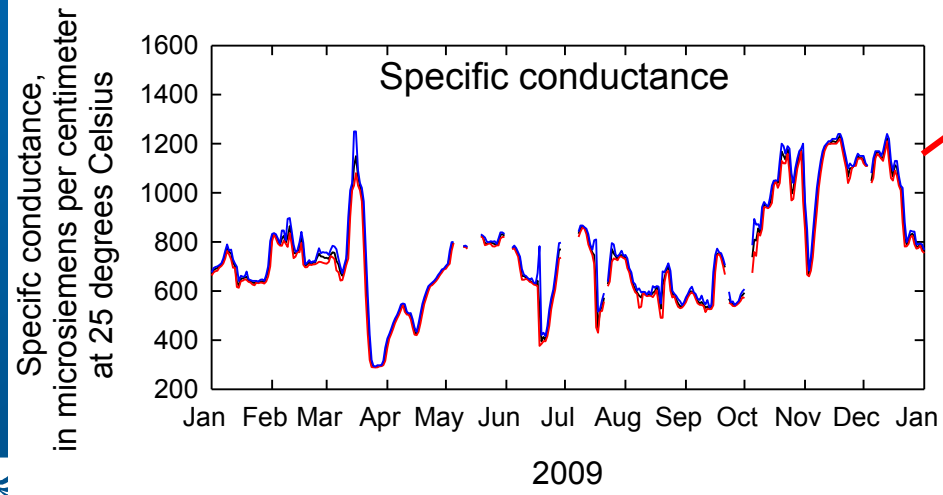
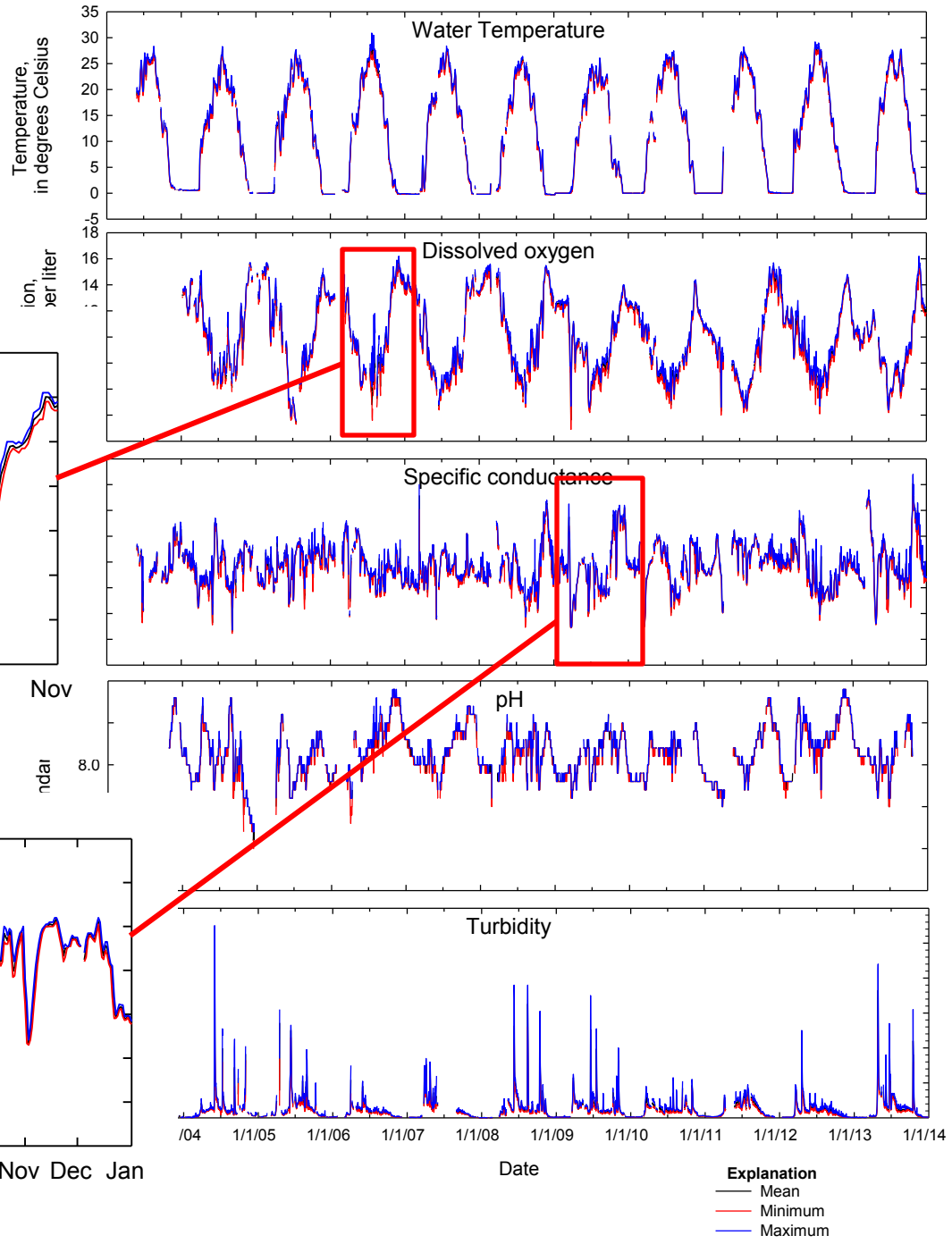
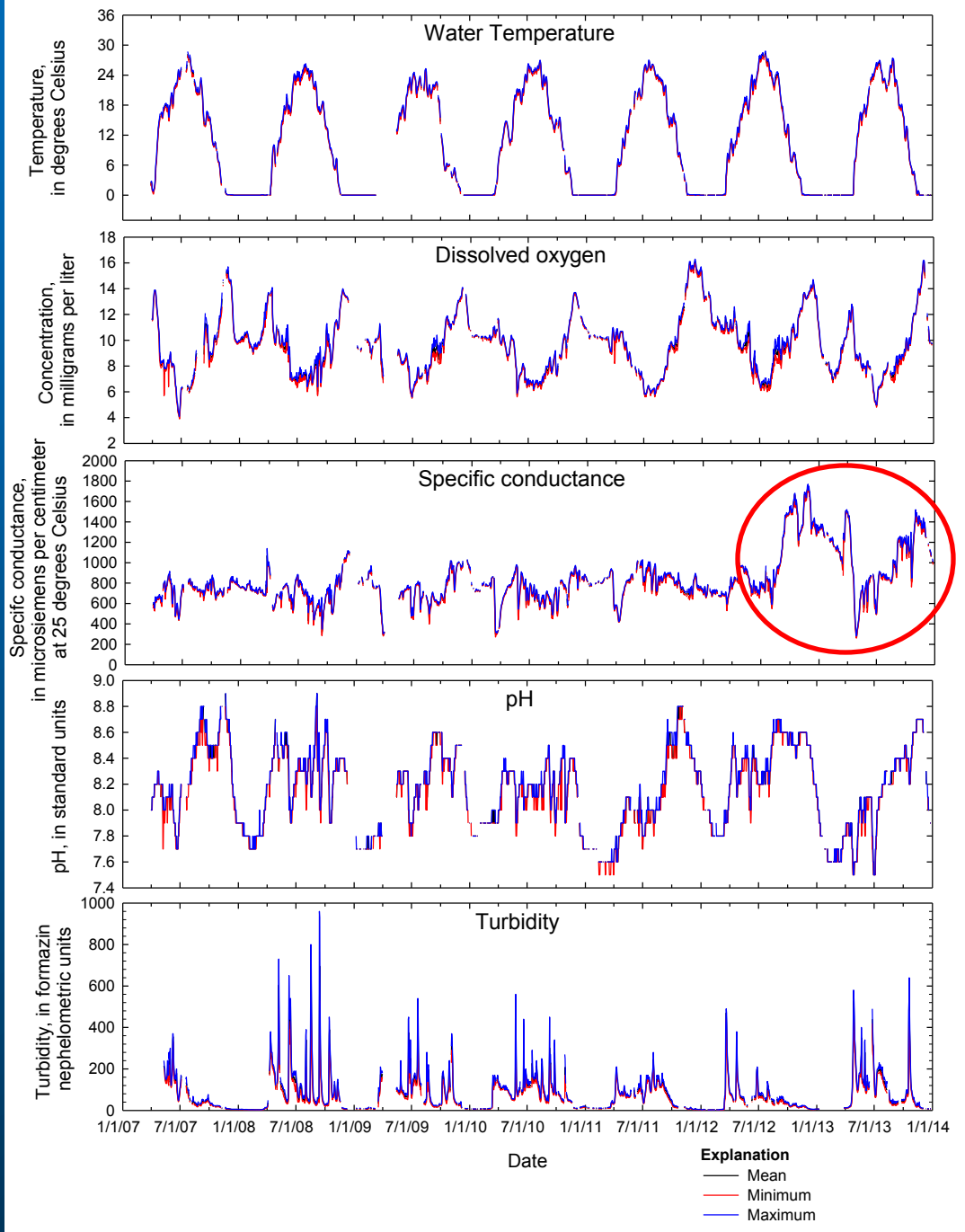
Red River at Fargo







Red River at Grand Forks



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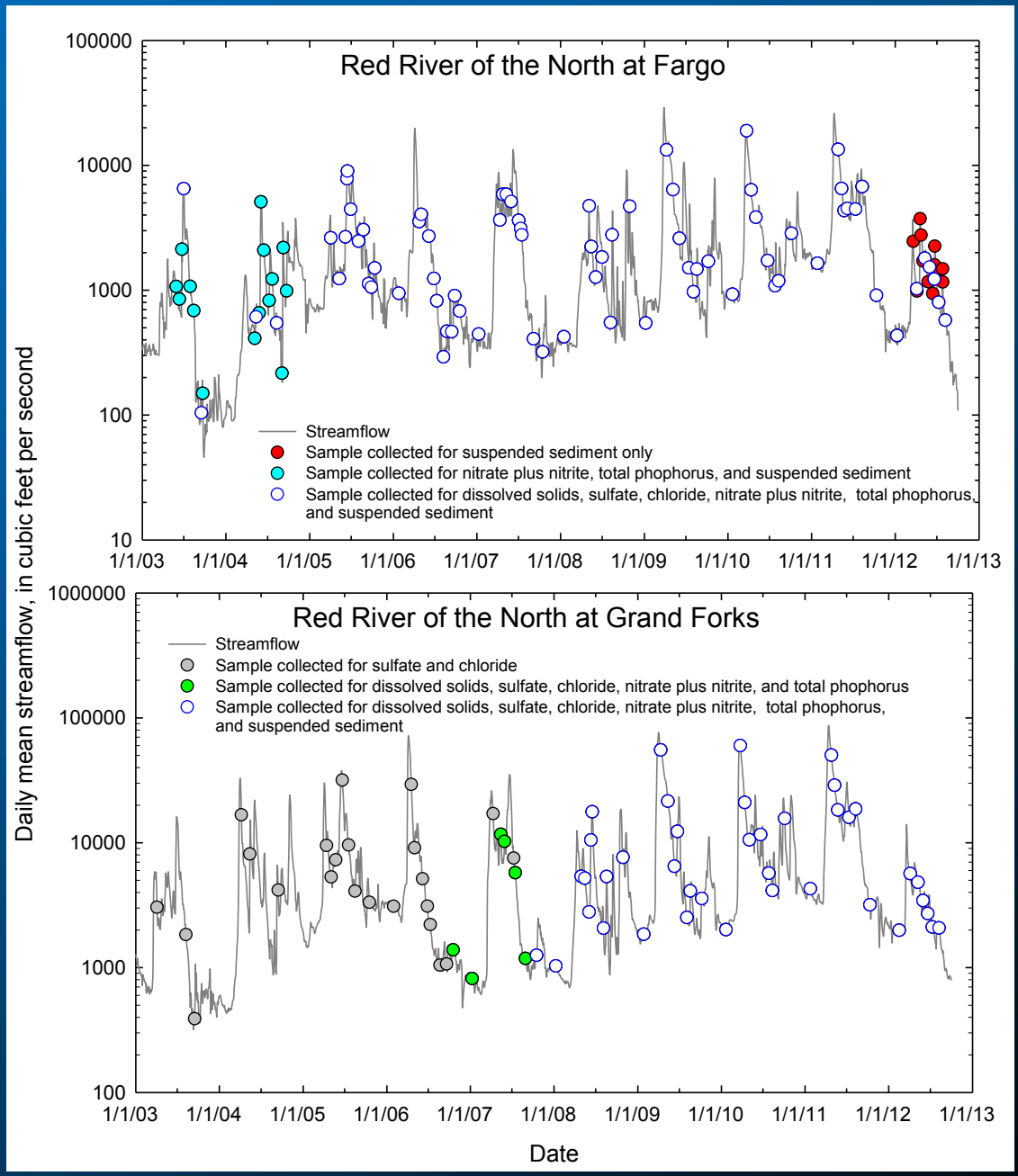
Discrete Sample Collection

- Samples mainly collected as part of the NDDH Ambient Sampling program and NDSWC High-Low Sampling Program
- Samples collected approx. 8 times/yr
- Sample constituents varied with time – Major ions, trace metals, nutrients, suspended sediment



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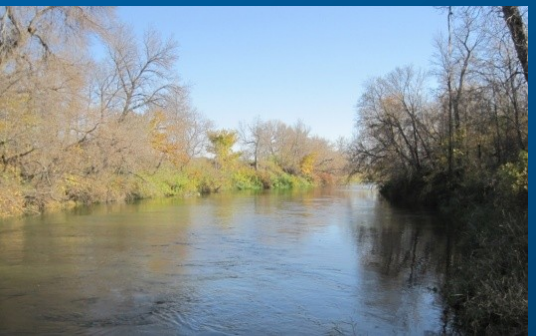
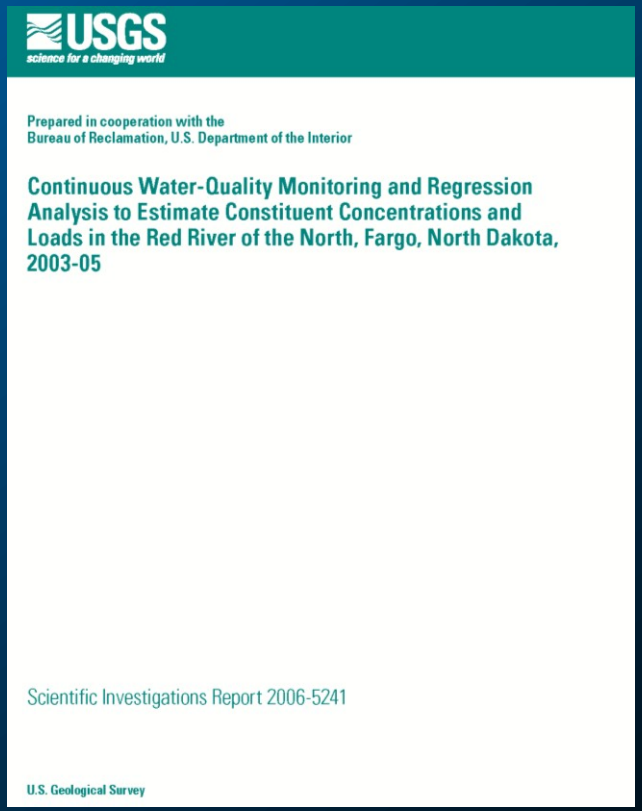
Estimating Constituent Concentrations - Regression Analysis

- Equations were previously developed for Fargo using data from 2003-05 by Ryberg (2006), and equations were not yet developed for Grand Forks

- Regression equations were updated for Fargo and created for Grand Forks using data collected from 2003-2012





http://pubs.usgs.gov/sir/2006/5241/

Regression Analysis

- Developed concentration estimates of
  - Total dissolved solids (TDS)
  - Sulfate (SO4)
  - Chloride (Cl)
  - Nitrate plus nitrite (NO2NO3)
  - Total phosphorus (TP)
  - Suspended sediment (SSC)

- Although evaluated many different variables, the most used explanatory variables included – Flow (Q), specific conductance (SC), turbidity (turb), time (t)
- Some variables needed log transformation
  - non-normality and heteroscedasticity, or non-constant variance
  - Determined bias correction factor to retransform result back to "real space"

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Red River at Fargo

Major Ions

TDS = 0.655SC -21.695

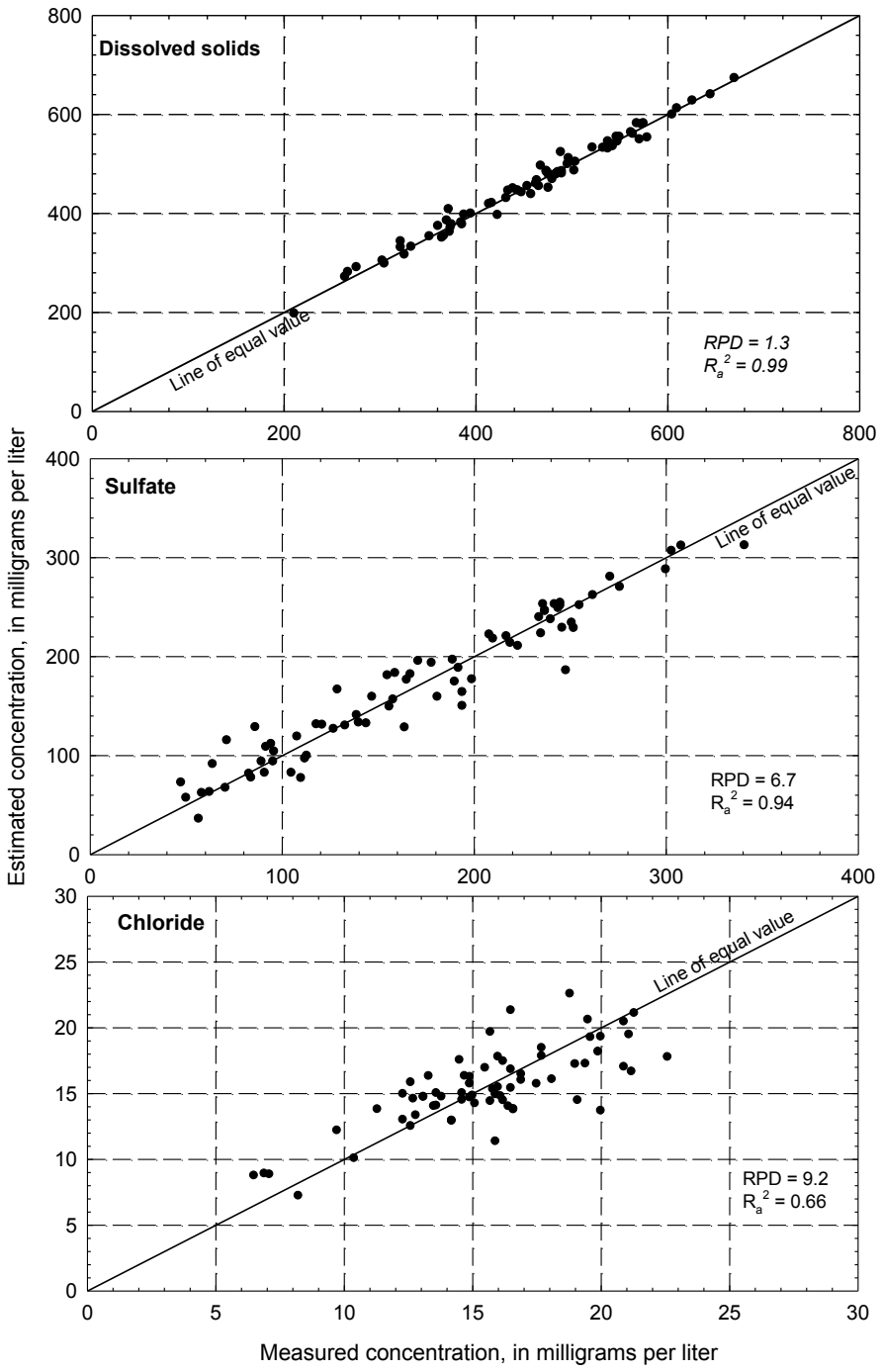
Range of TDS: 211 – 670 mg/L
# of samples used: 75
R_a^2= 0.99

SO4 = 0.426SC + 56.52 log(Q) – 7.248 cos(4πt/365) - 5.918sin(4πt/365) - 324.158

Range of SO4: 48 – 341 mg/L
# of samples used: 75
R_a^2= 0.94

log(Cl) = 0.609log(SC) + 0.160log(Q) – 0.0359cos(4πt/365) – 0.00734sin(4πt/365) – 0.0264

Range of Cl: 6.5 – 45.5 mg/L
# of samples used: 69
R_a^2= 0.66



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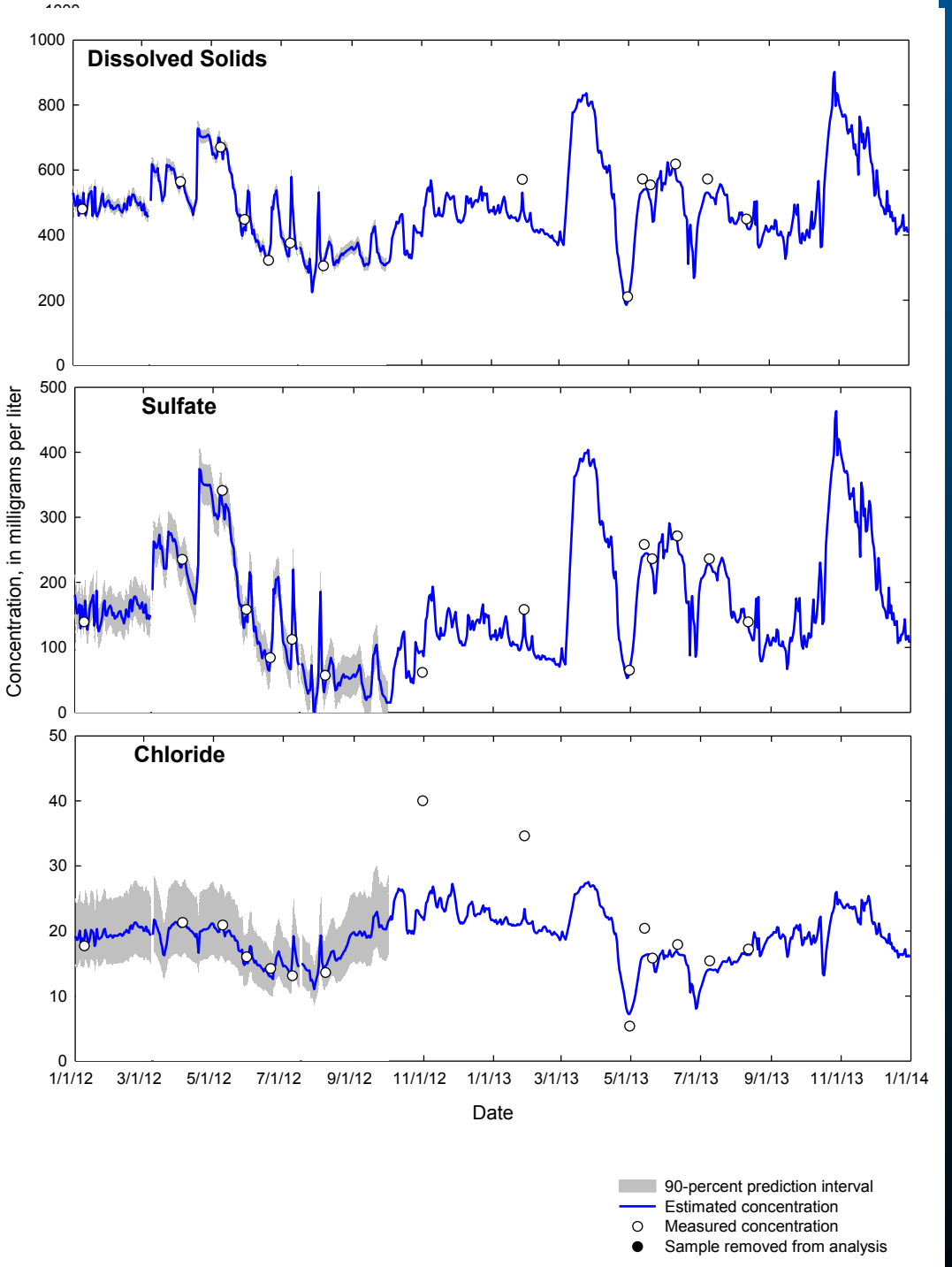
Red River at Fargo

Estimated Concentrations

Major Ions



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Red River at Grand Forks

Major Ions

TDS = 0.642SC -13.701

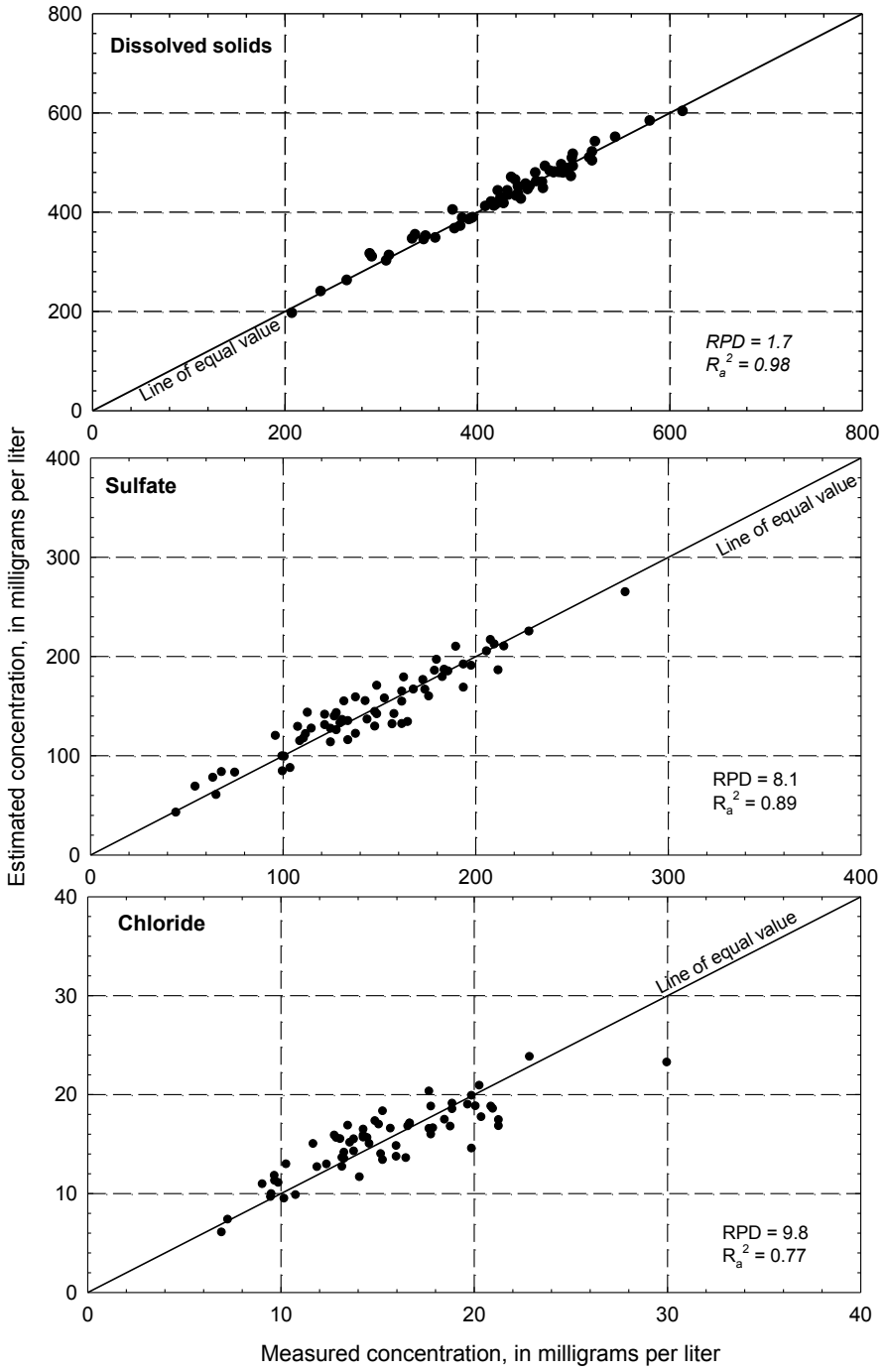
Range of TDS: 208 – 614 mg/L
# of samples used: 66
R_a^2= 0.98

SO4 = 0.353SC + 36.406log(Q) -
11.011cos(2πt/365) - 6.178sin(2πt/365) - 239.31

Range of SO4: 45 – 278 mg/L
# of samples used: 65
R_a^2= 0.89

log(Cl) = 0.911log(SC) + 0.141log(Q) –
0.0391cos(4πt/365)
– 0.0209sin(4πt/365) – 0.0000229t – 0.928

Range of Cl: 7.0 – 30.0 mg/L
# of samples used: 64
R_a^2= 0.77



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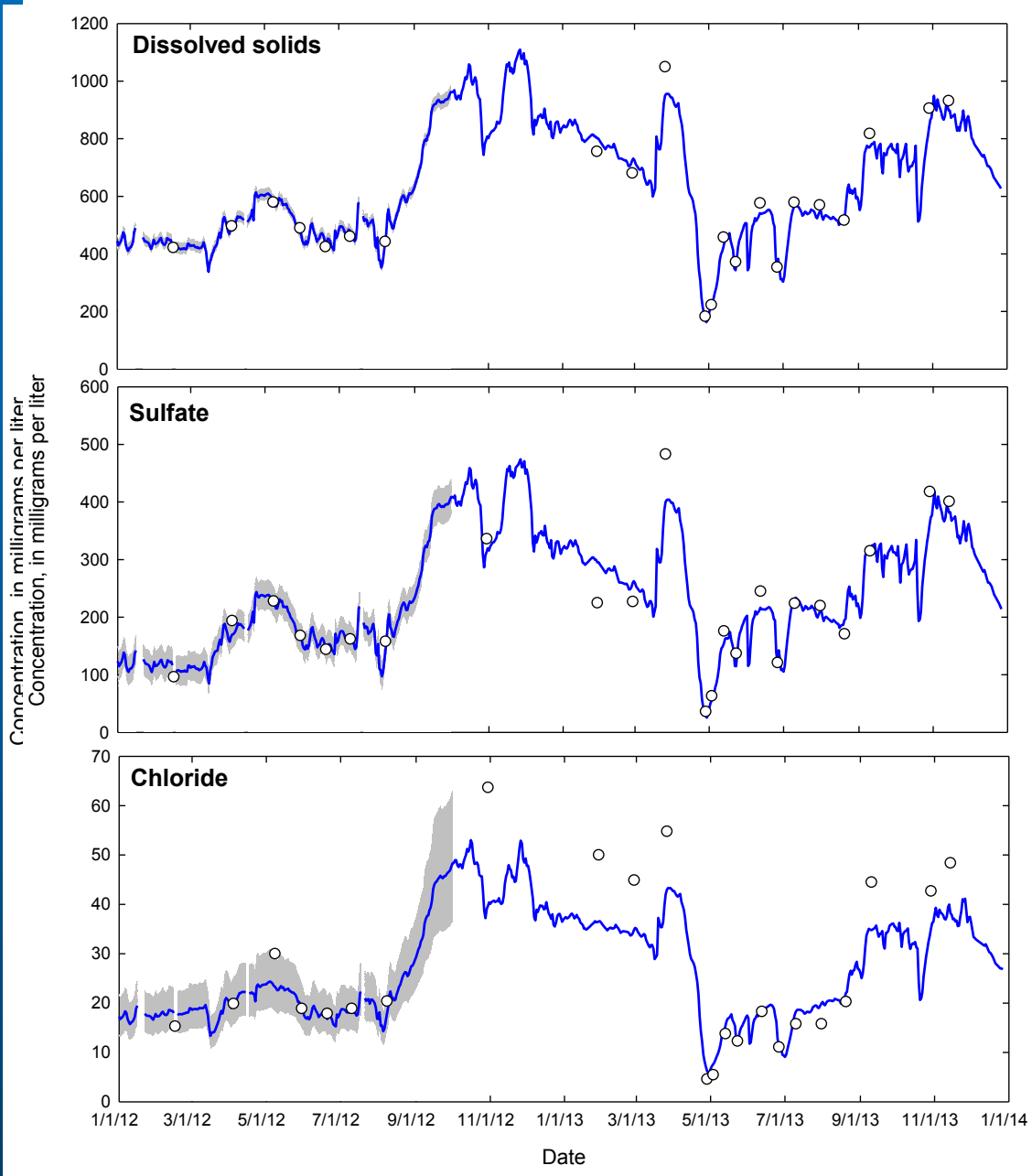
Red River at Grand Forks

Estimated Concentrations

Major Ions



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Red River at Fargo
Nutrients and Sediment

log(NO2NO3) = 0.578log(turb) + 0.418log(Q) – 3.146

Range of NO2NO3: 0.03 – 2.14 mg/L as N
# of samples used: 84
R_a^2= 0.46

log(TP) = 0.468log(turb) + 0.217log(Q)+ 0.00881cos(2πt/365) – 0.137sin(2πt/365) – 2.253

Range of TP: 0.07 – 1.28 mg/L as P
# of samples used: 84
R_a^2= 0.74

log(SSC) = 0.947log(turb) + 0.128log(Q) – 0.0656

Range of SSC: 3 – 1,160 mg/L
# of samples used: 96
R_a^2= 0.95

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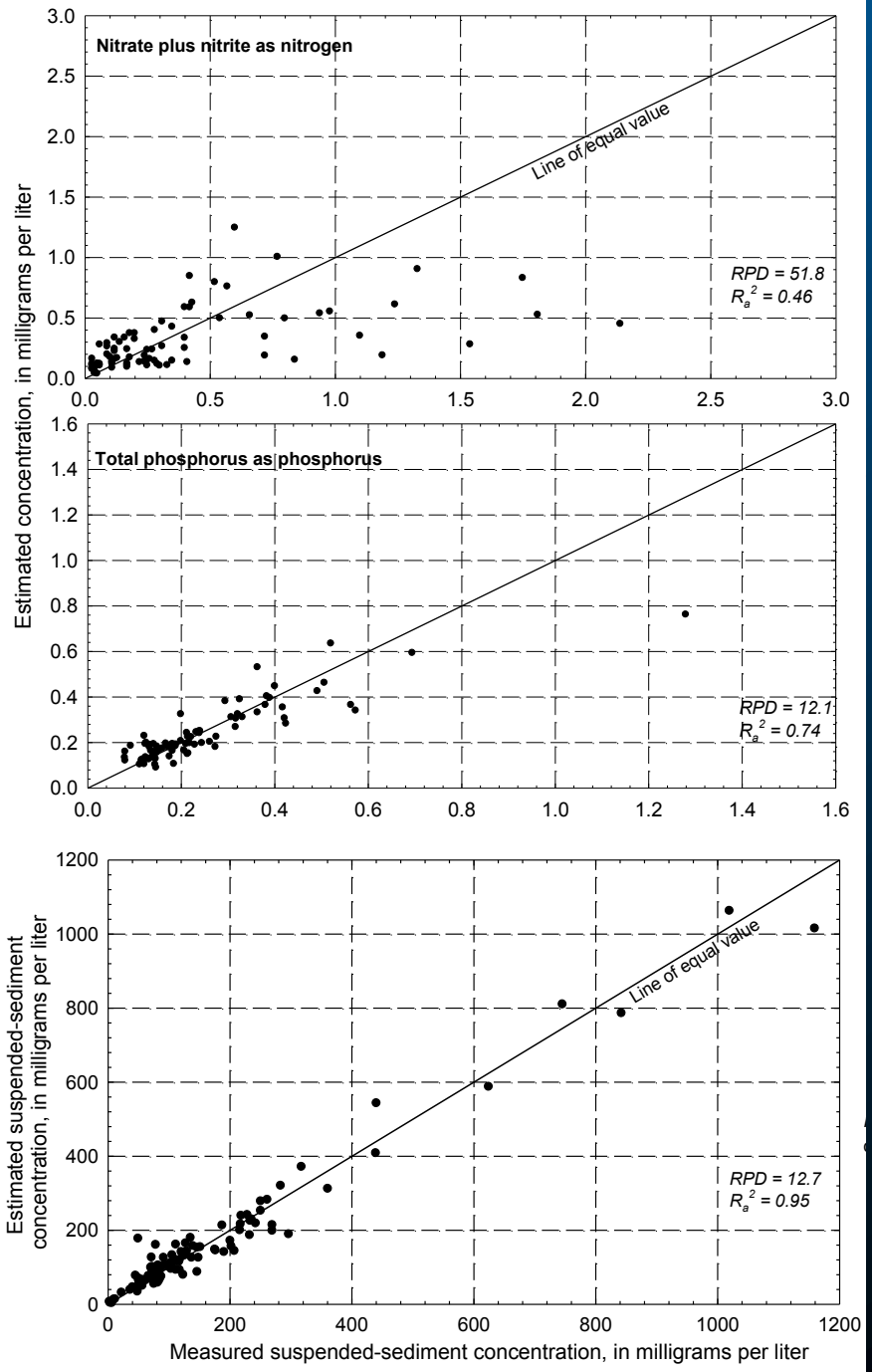
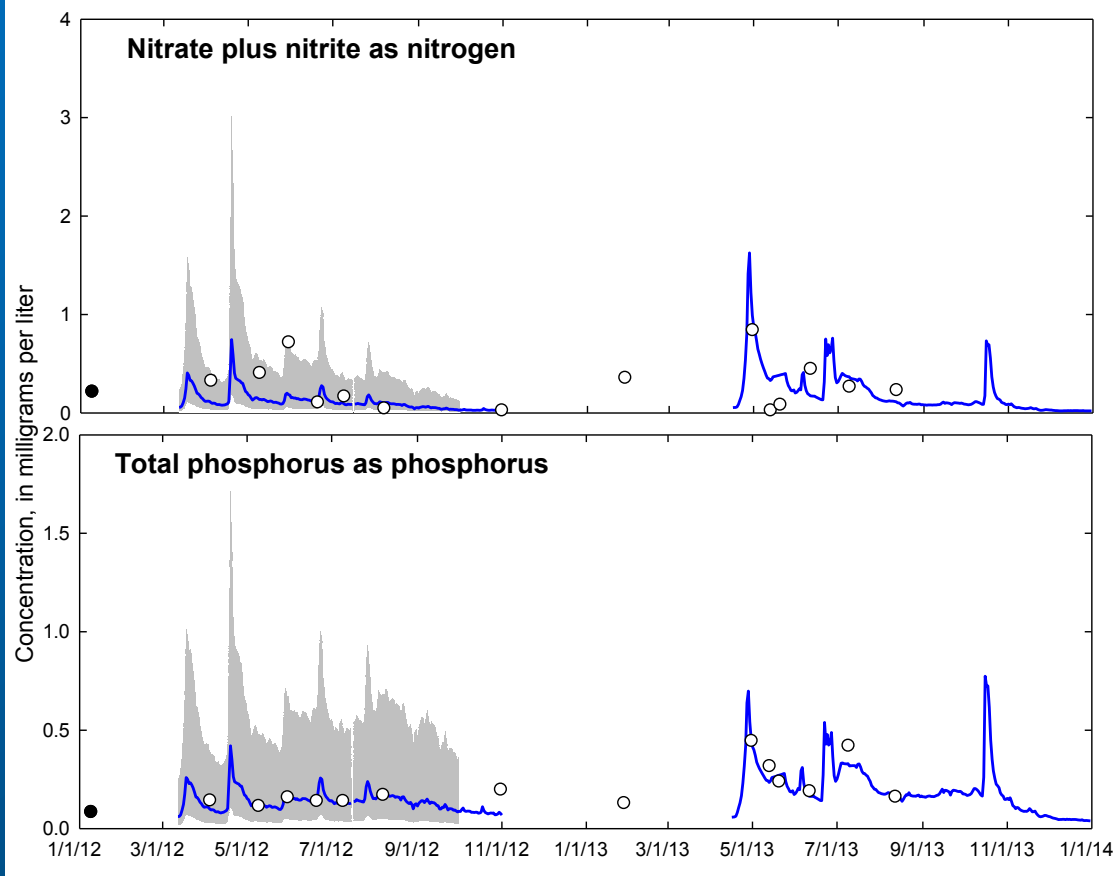
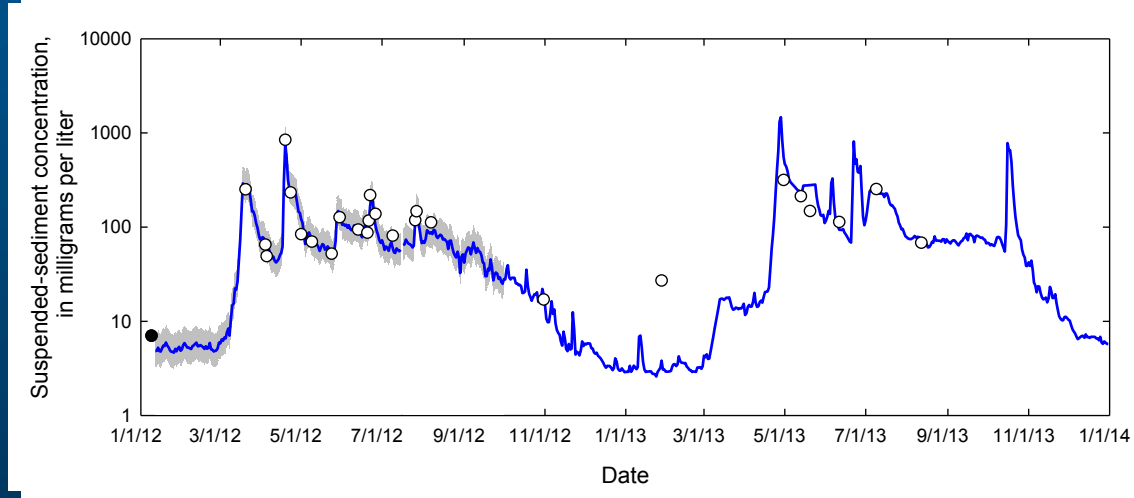


Red River at Fargo

Estimated Concentrations

Nutrients and Sediment





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Red River at Grand Forks
Nutrients and Sediment

NO2NO3 = 0.00655Turb – 0.133

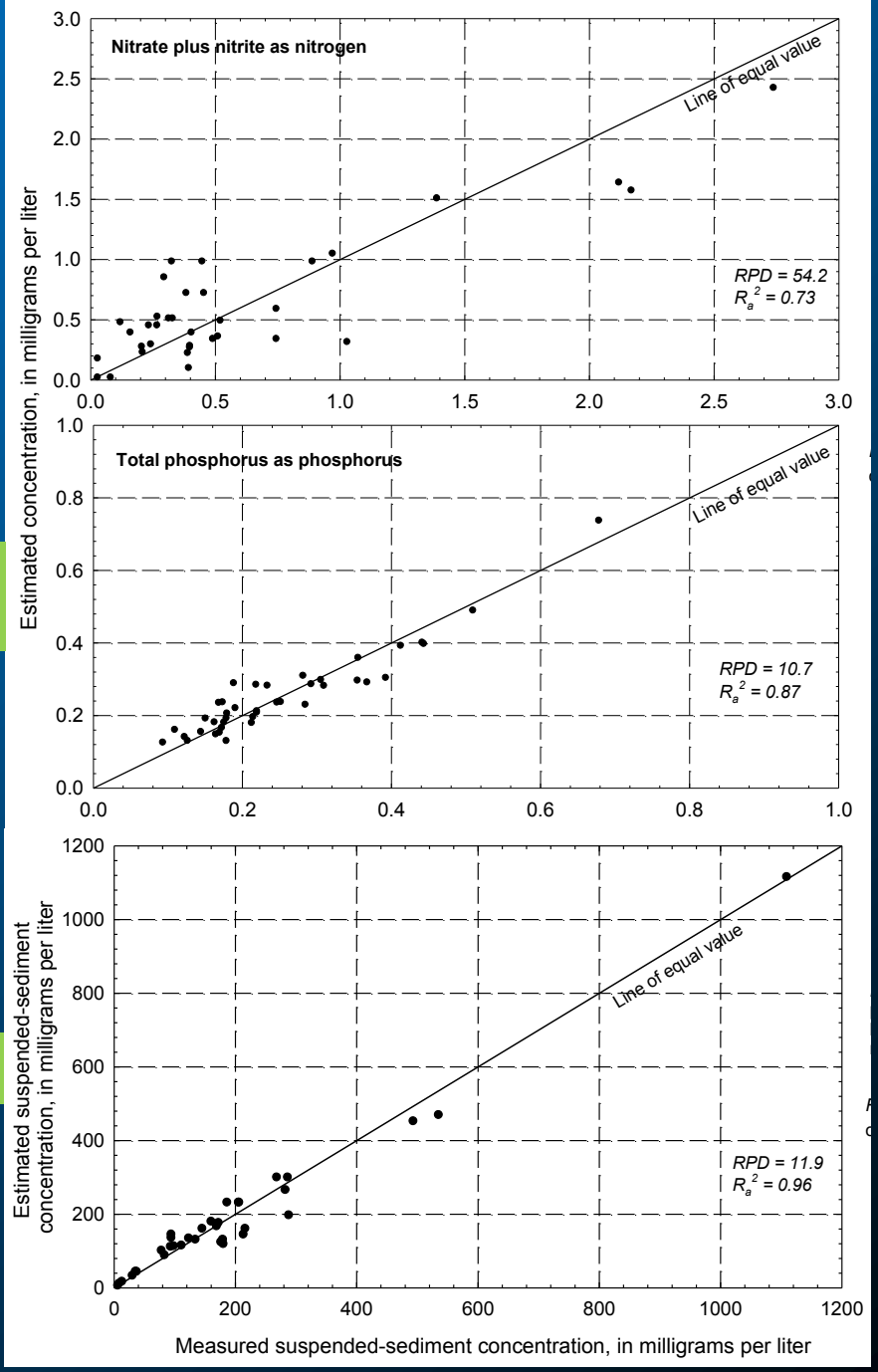
Range of NO2NO3: 0.03 – 3.15 mg/L as N
# of samples used: 37
R_a^2= 0.73

TP = 0.000859Turb + 0.0824log(Q) + 0.0182cos(2πt/365) – 0.0413sin(2πt/365) – 0.181

Range of TP: 0.08 – 0.68 mg/L as P
# of samples used: 40
R_a^2= 0.87

log(SSC) = 0.970log(Turb) + 0.312

Range of SSC: 4 – 1,110 mg/L
# of samples used: 35
R_a^2= 0.96



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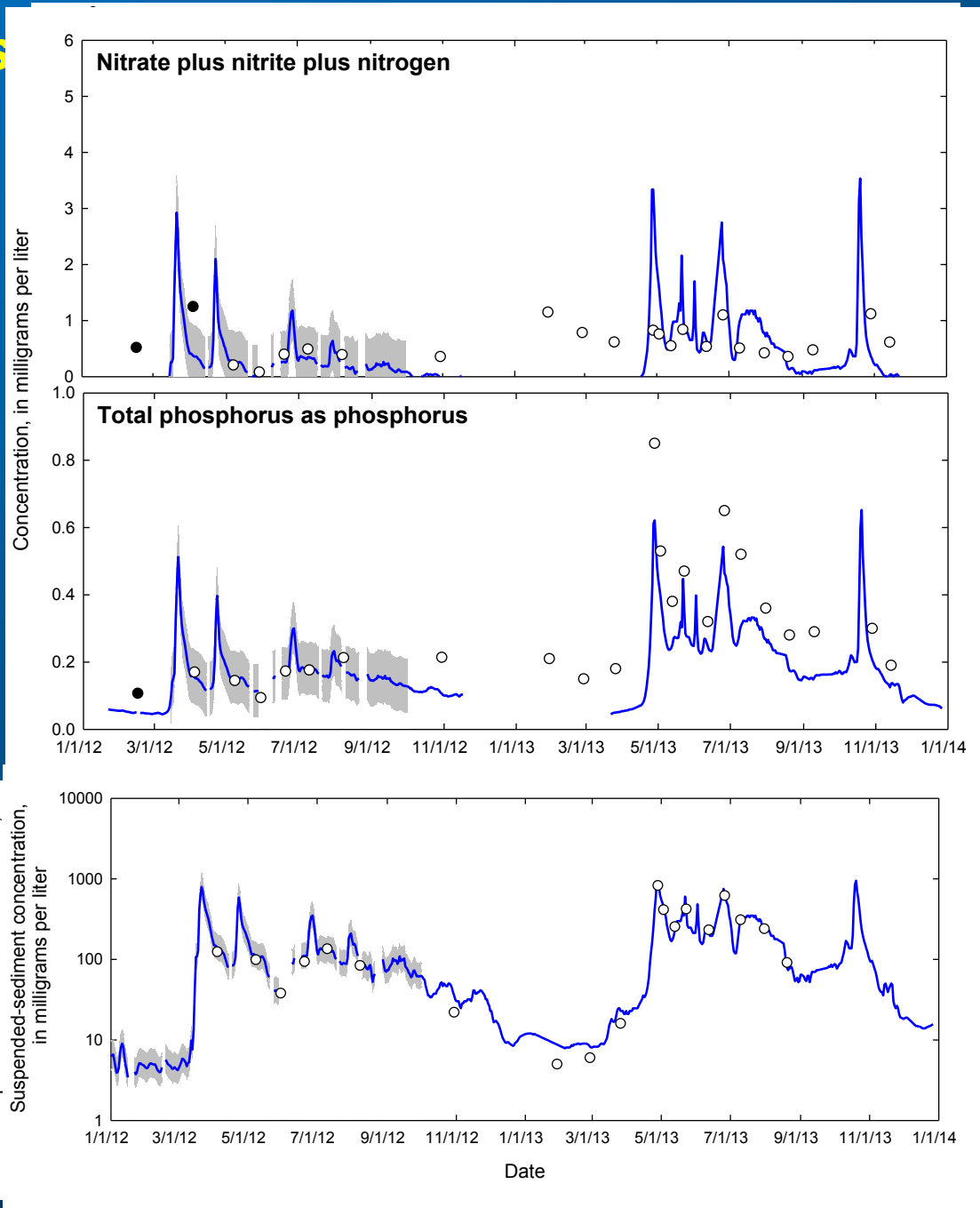
Red River at Grand Forks

Estimated Concentrations

Nutrients and Sediment



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Load Estimation

Daily Load (tons/d) =

(Estimated Daily mean Conc) X (Daily mean Flow)

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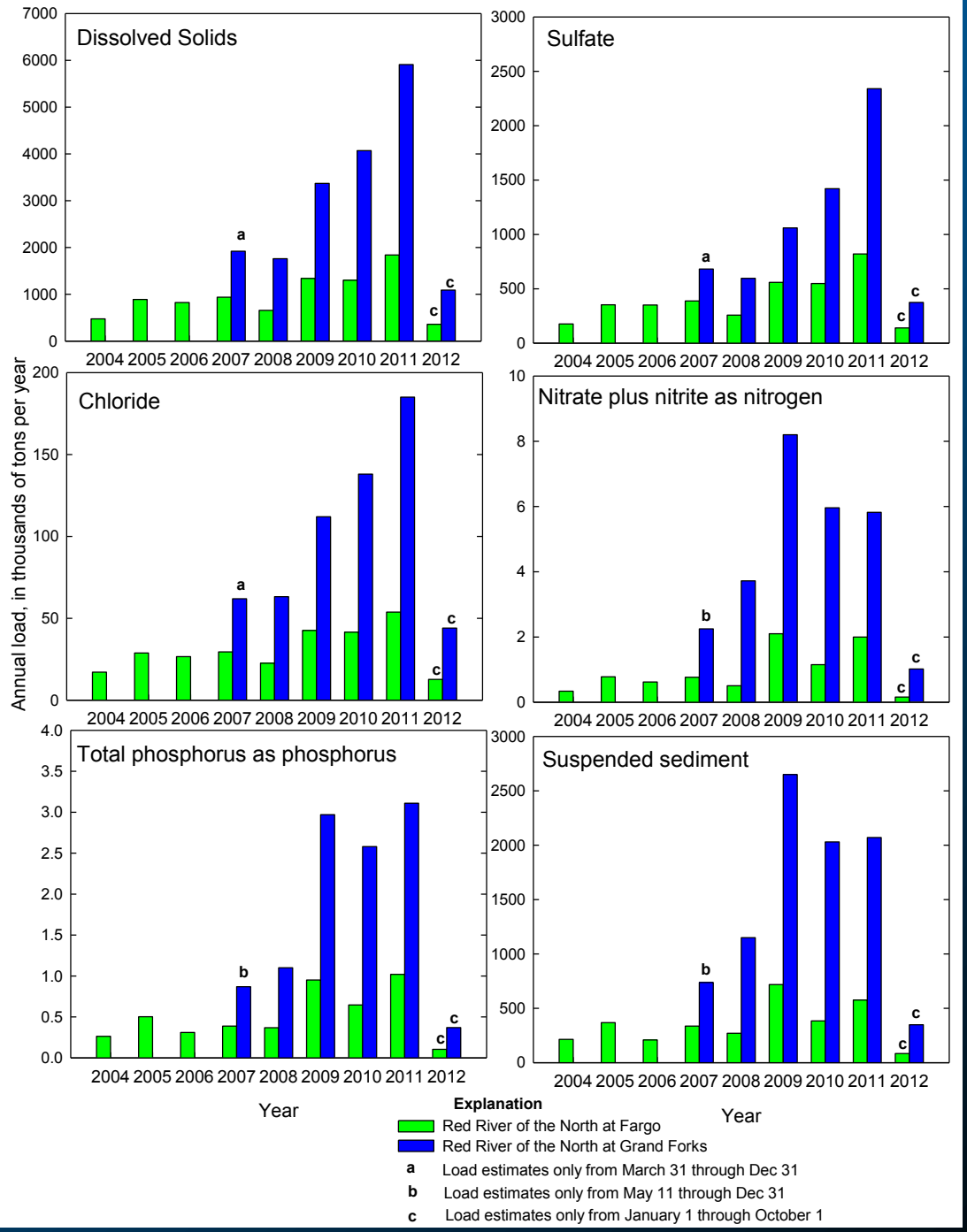
Annual Loads

- Greatest TDS, Cl, TP, and SO4 annual loads in 2011
- Greatest NO2NO3 and SSC annual loads in 2009



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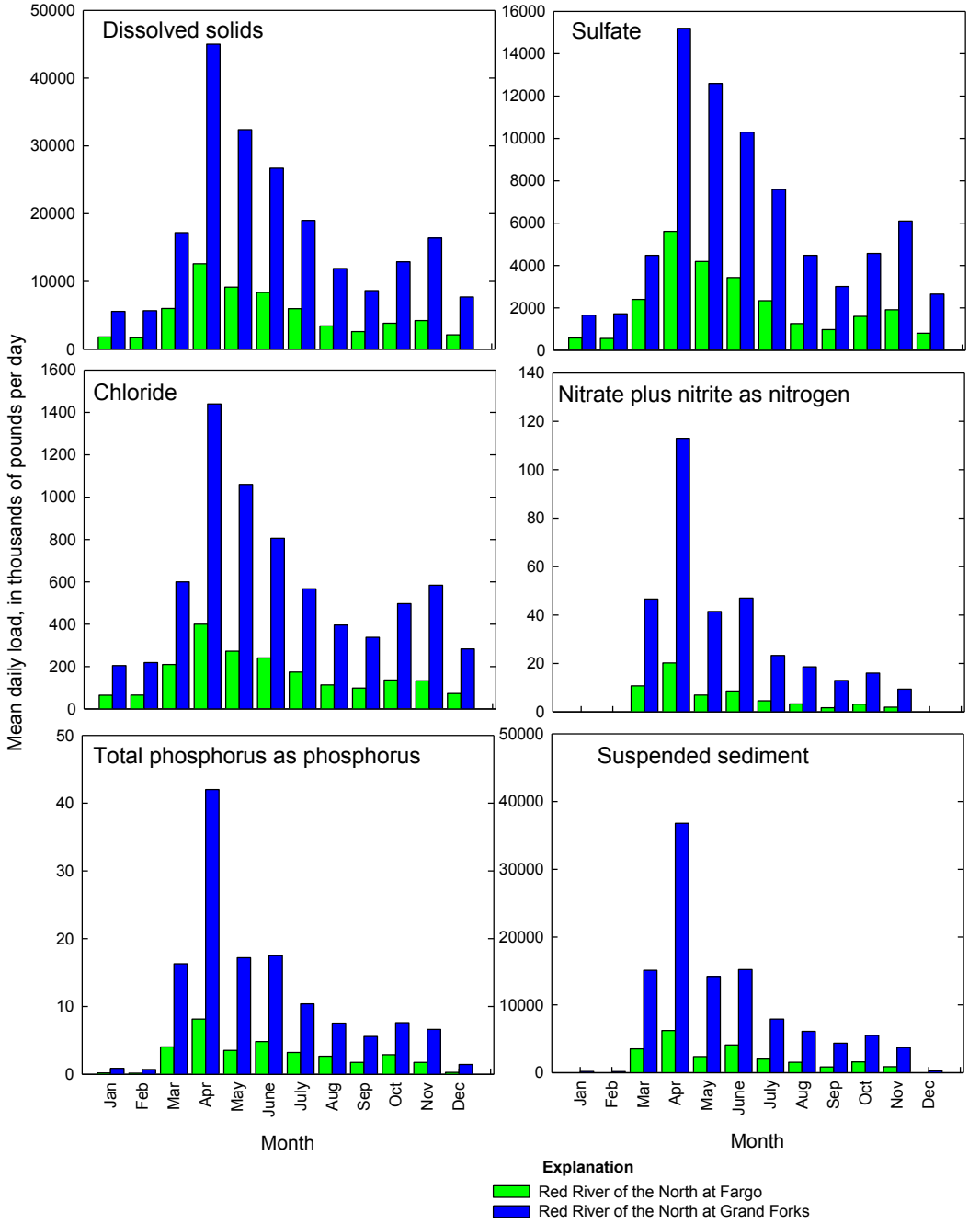
Monthly Loads

- Most of the annual loads generally delivered in March through June at both sites



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Summary

- Regression used to estimate constituent concentrations from discrete and continuous data
  - Generally good estimates for TDS, SO4, TP, SSC
  - Fair estimates for Cl and for NO2NO3 at GF
  - Poor estimates of Cl and NO2NO3 for Fargo
- Constituent loads computed from estimated concentrations and streamflow
  - Greatest TDS, Cl, TP, and SO4 annual loads in 2011, least in 2012
  - Greatest NO2NO3 and SSC annual loads in 2009, least in 2012
  - Most of the annual loads delivered in March through June at both sites
- Continuous real-time water-quality can be useful for water-resource management
    - Treatment management/emergency response
    - Water-quality dynamics
    - Load estimation

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ANY QUESTIONS?

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