Lower Wisconsin State Riverway Floodplain Lakes - A Groundwater Study to Delineate Nutrient Contribution Areas

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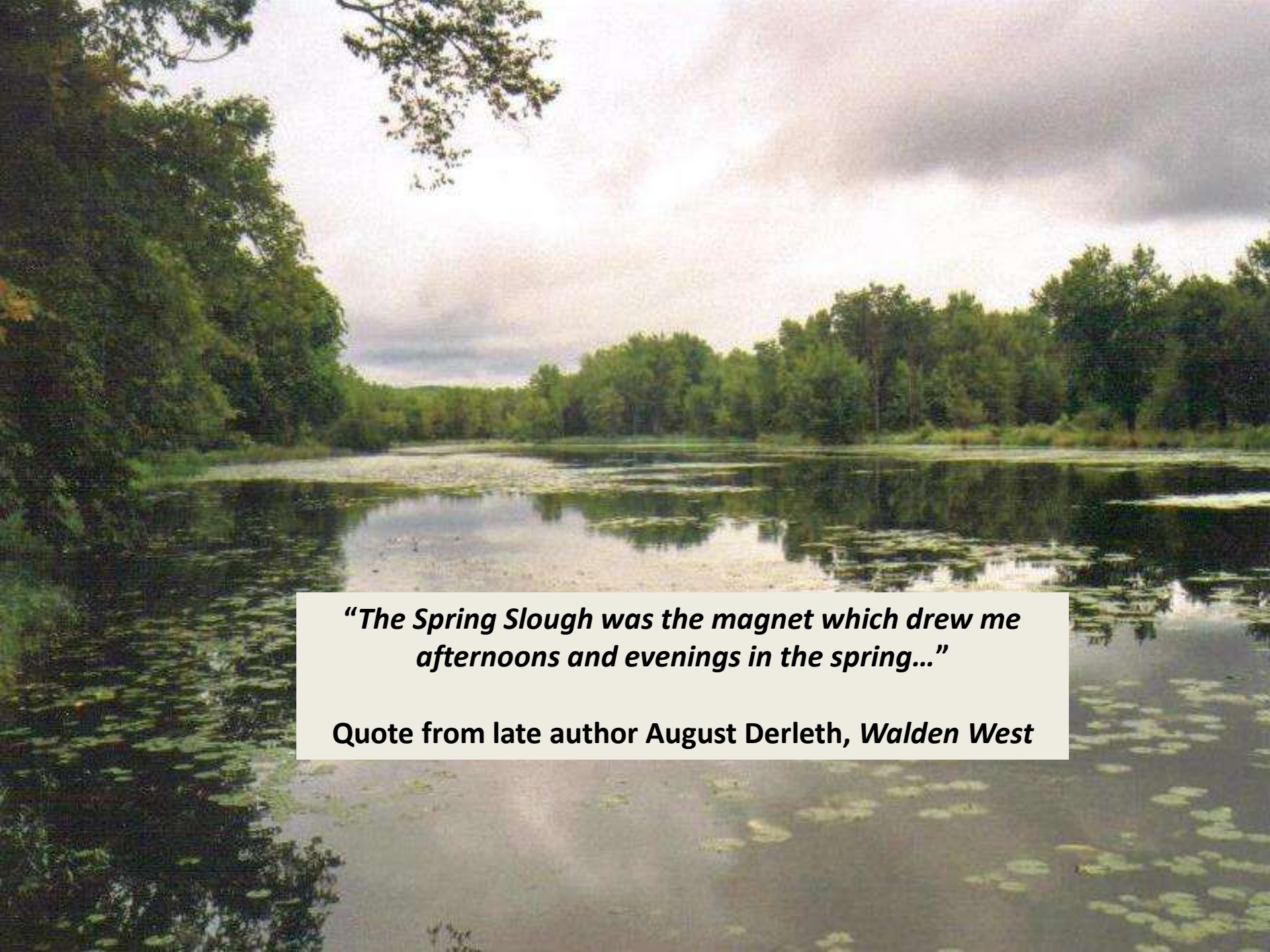
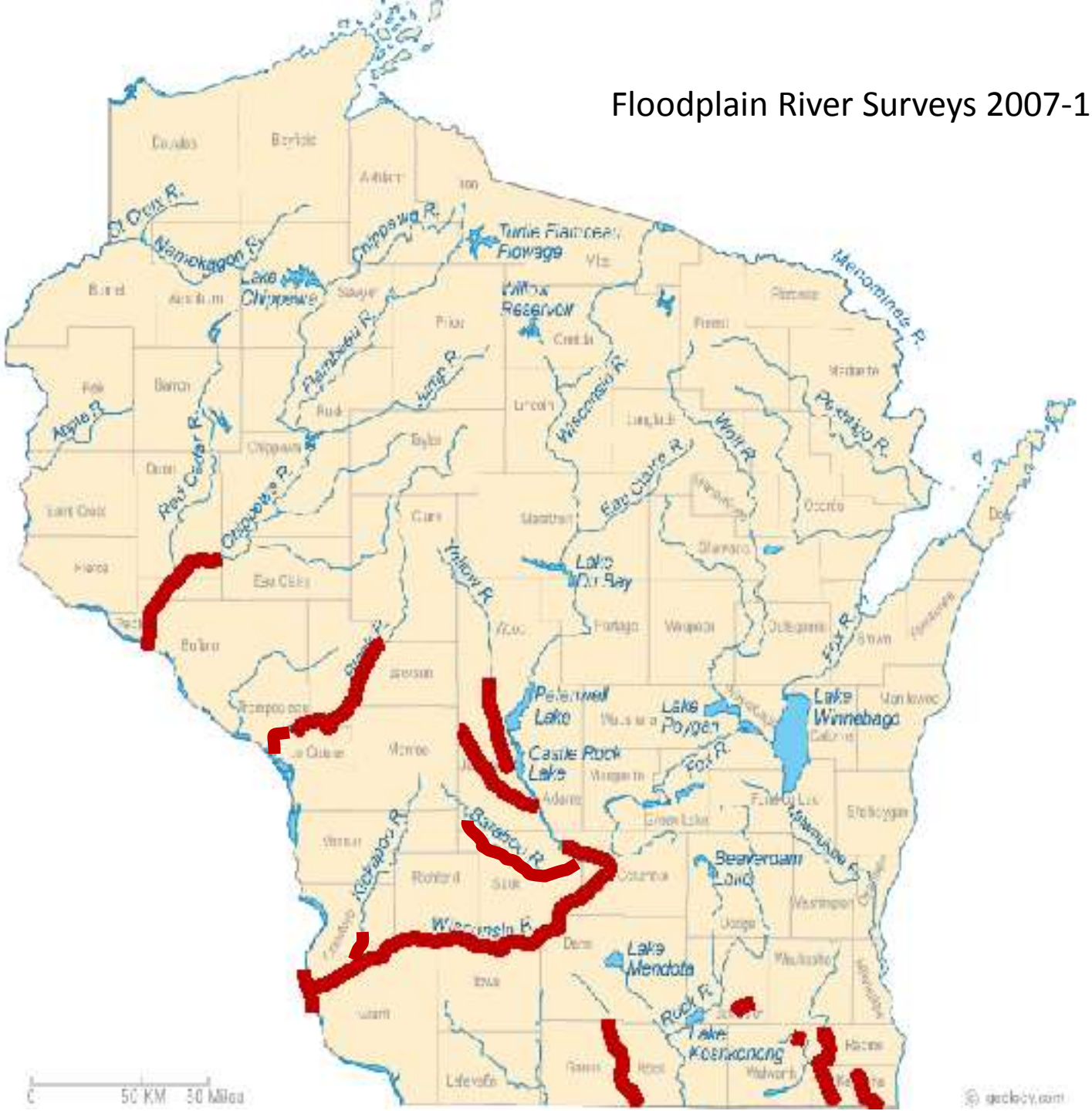


"The Spring Slough was the magnet which drew me afternoons and evenings in the spring…"

Quote from late author August Derleth, *Walden West*

Floodplain River Surveys 2007-12



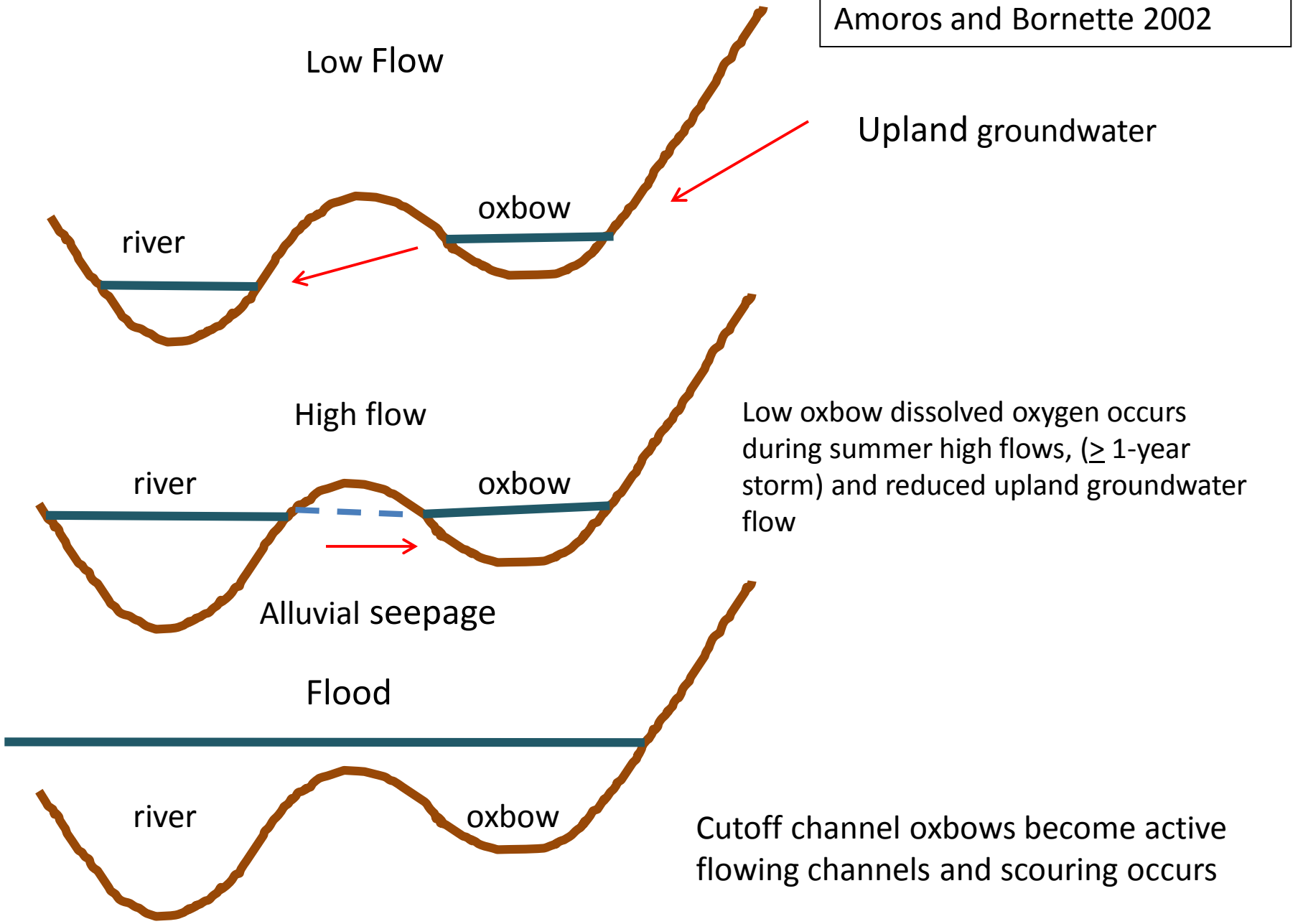
Floodplain lakes associate species

	2011	2012
1	Largemouth bass	Bluegill
2	Bluegill	Largemouth bass
3	Grass pickerel	Mudminnow
4	Mudminnow	Grass pickerel
5	Mud darter	Starhead t. m.
6	Starhead t. m.	Yellow bullhead
7	Warmouth	Mud darter
8	Yellow bullhead	Tadpole madtom
9	Green sunfish	Warmouth
10	Tadpole madtom	Green sunfish
1	Bluegill	Bluegill
2	Largemouth bass	Largemouth bass
3	Grass pickerel	Mudminnow
4	Pirate perch	Grass pickerel
5	Mudminnow	Green sunfish
6	Warmouth	Pirate perch
7	Starhead t. m.	Starhead t. m.
8	Green sunfish	Pumpkinseed
9	Warmouth	Yellow bullhead
10	Yellow bullhead	Brook silverside
1	Largemouth bass	Bluegill
2	Bluegill	Largemouth bass
3	Grass pickerel	Mudminnow
4	Pirate perch	Grass pickerel
5	Mudminnow	Pirate perch
6	Mud darter	Mud darter
7	Warmouth	Warmouth
8	Yellow bullhead	Green sunfish
9	Lake chubsucker	Yellow bullhead
10	Johnny darter	Lake chubsucker

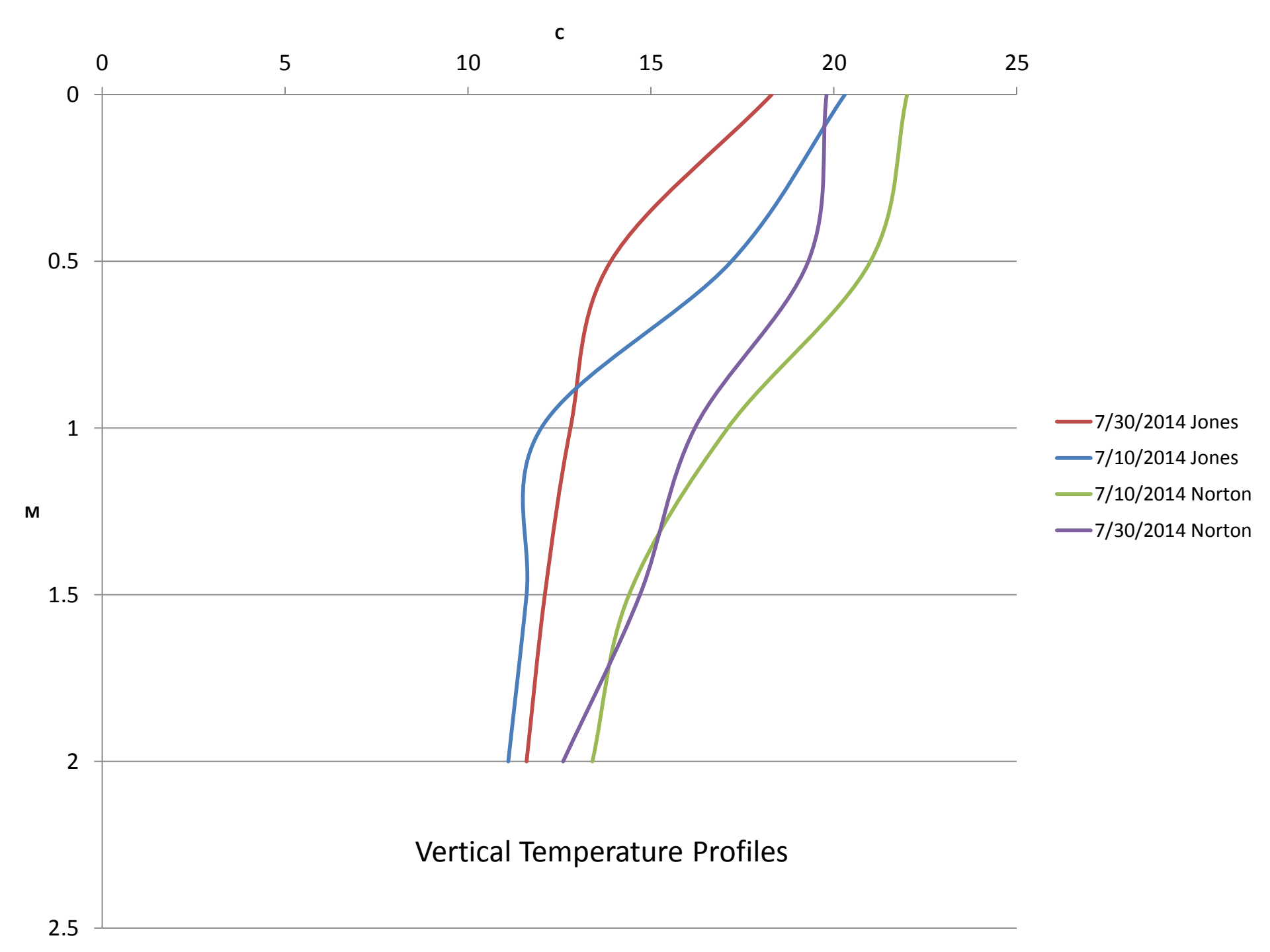
Pirate perch

Mud darter

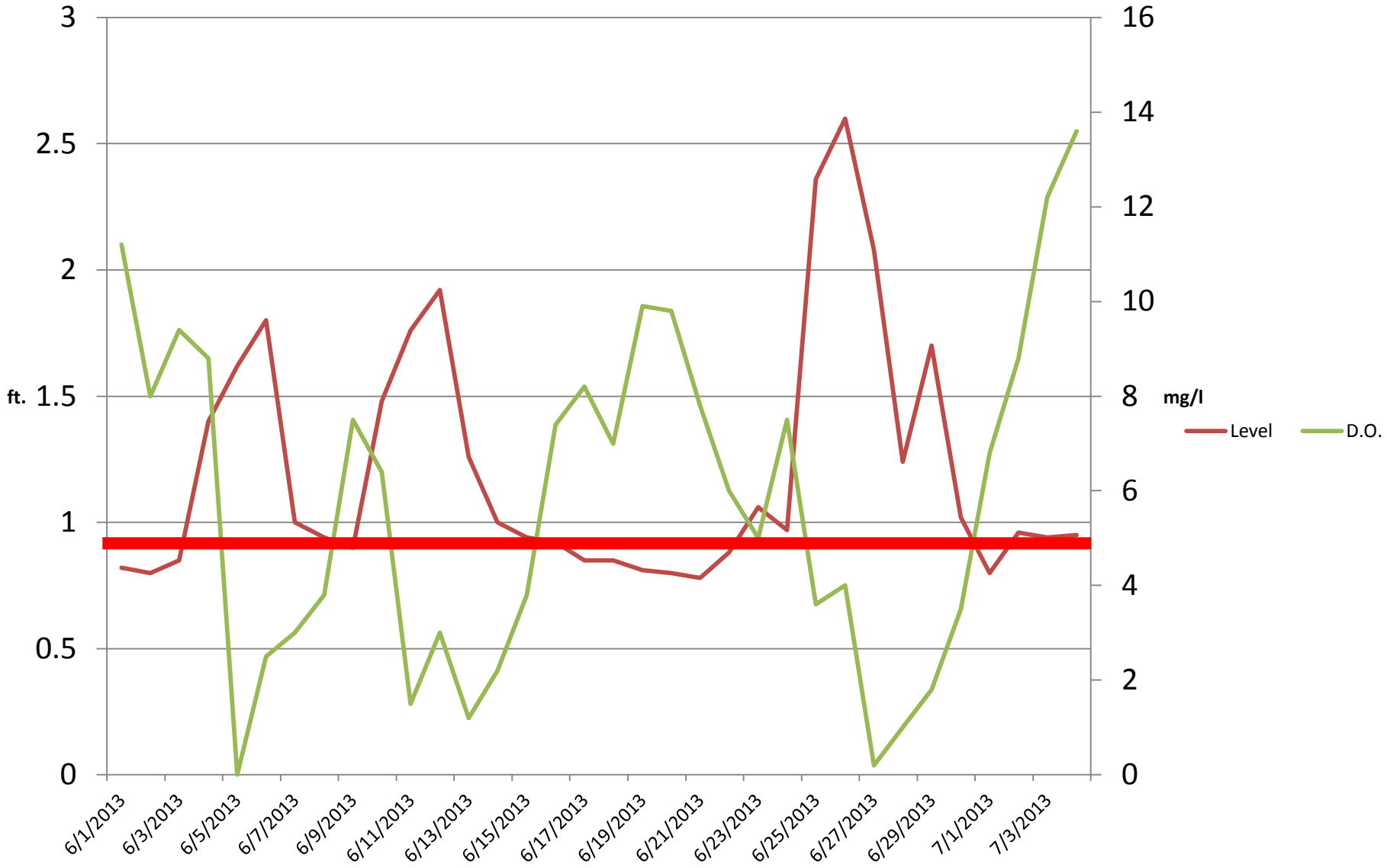
Starhead topminnow

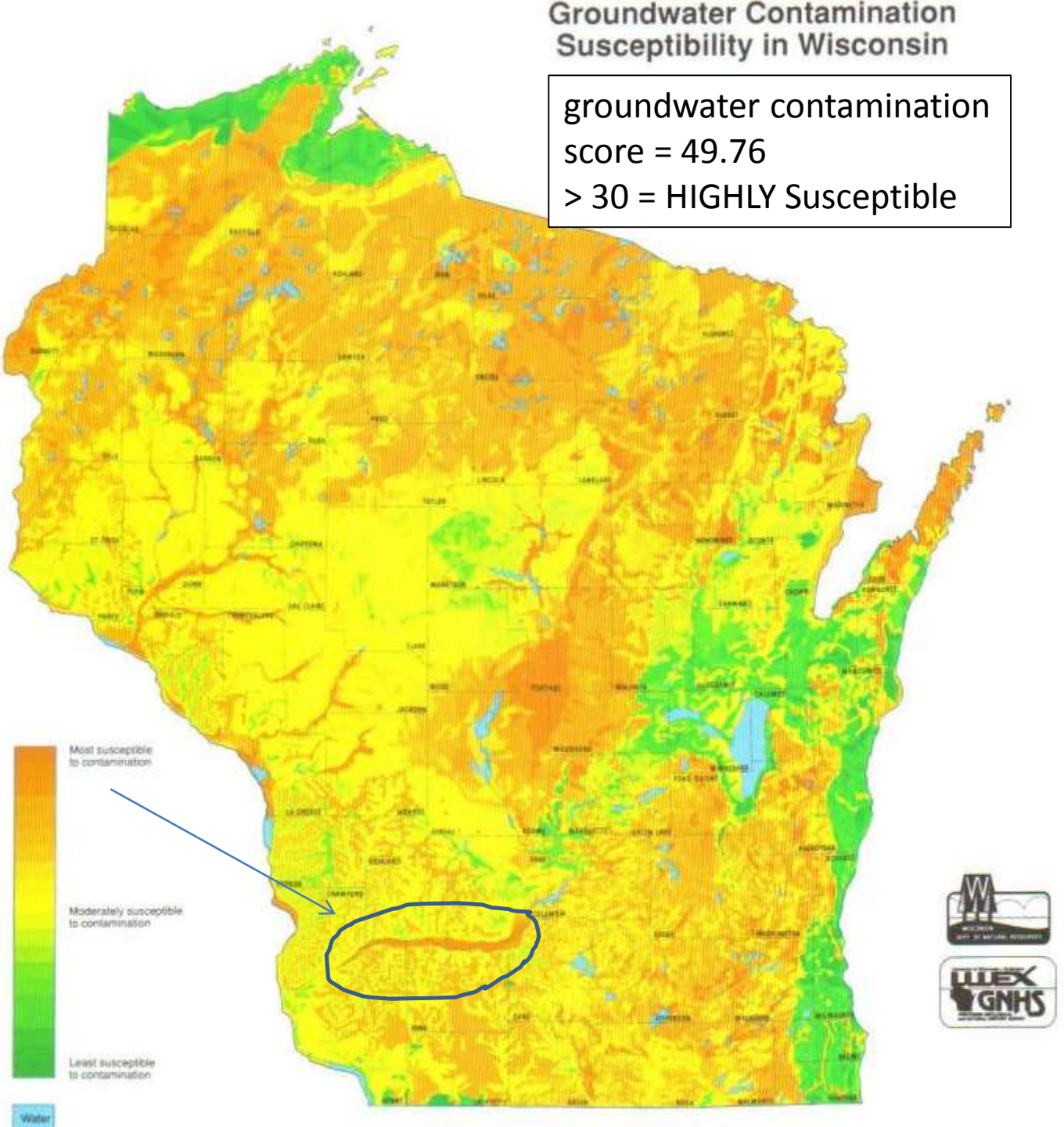

Modified from
Amoros and Bornette 2002
Low Flow
Upland groundwater
oxbow
river
High flow
river
oxbow
Low oxbow dissolved oxygen occurs during summer high flows, (≥ 1-year storm) and reduced upland groundwater flow
Alluvial seepage
Flood
river
oxbow
Cutoff channel oxbows become active flowing channels and scouring occurs

Sediment deposition was minimal, suggesting scouring during floods and no internal loading.


C
0
5
10
15
20
25
0
0.5
1
1.5
2
2.5
M
7/30/2014 Jones
7/10/2014 Jones
7/10/2014 Norton
7/30/2014 Norton
Vertical Temperature Profiles

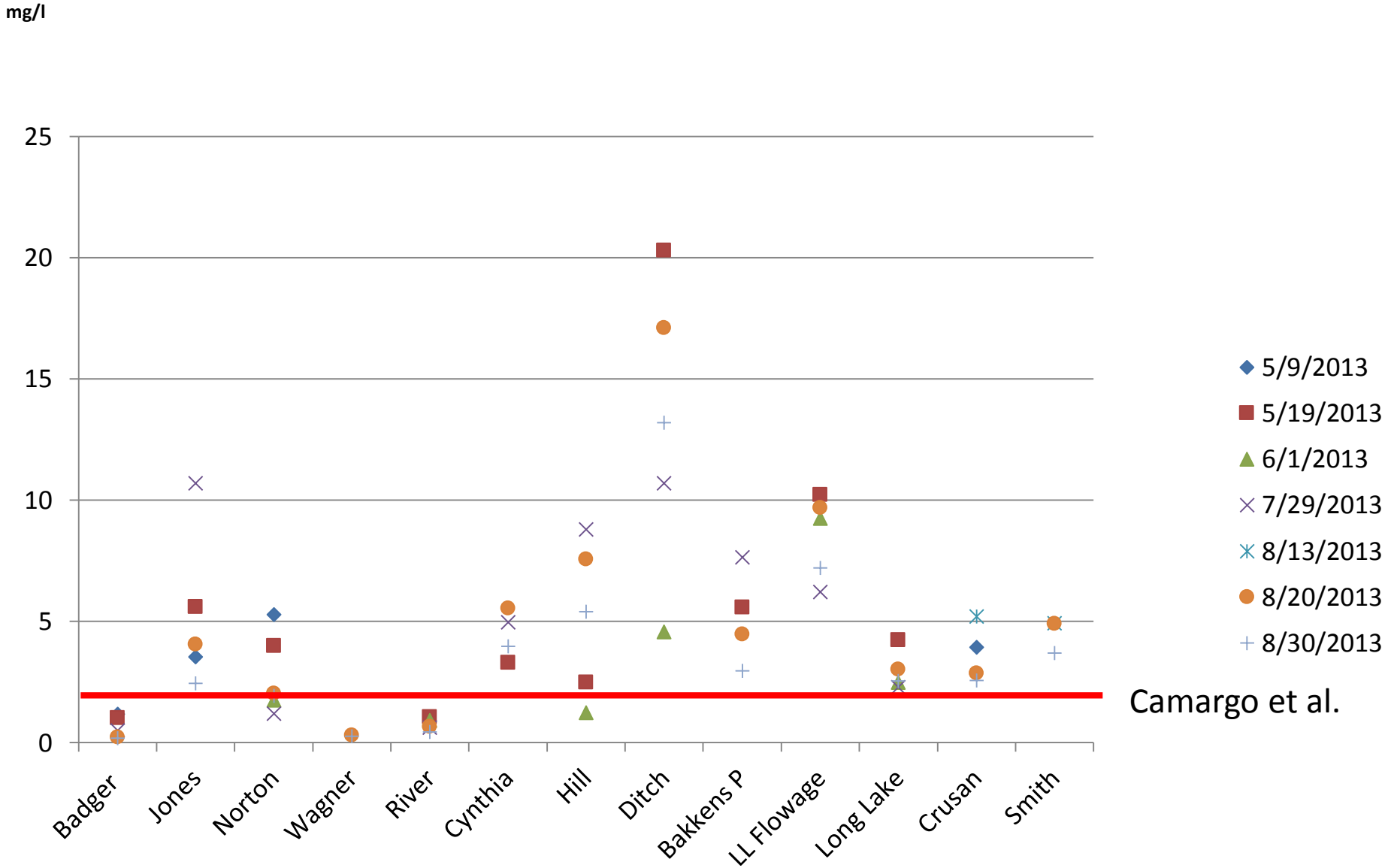
Norton Slough Water Levels Dissolved Oxygen Levels




Groundwater Contamination
Susceptibility in Wisconsin
groundwater contamination
score = 49.76
> 30 = HIGHLY Susceptible
Most susceptible
to contamination
Moderately susceptible
to contamination
Least susceptible
to contamination
Water
WEX
GNHS


9.19.37
FL. - 8.
WR - 10 - 756

NO_x Levels



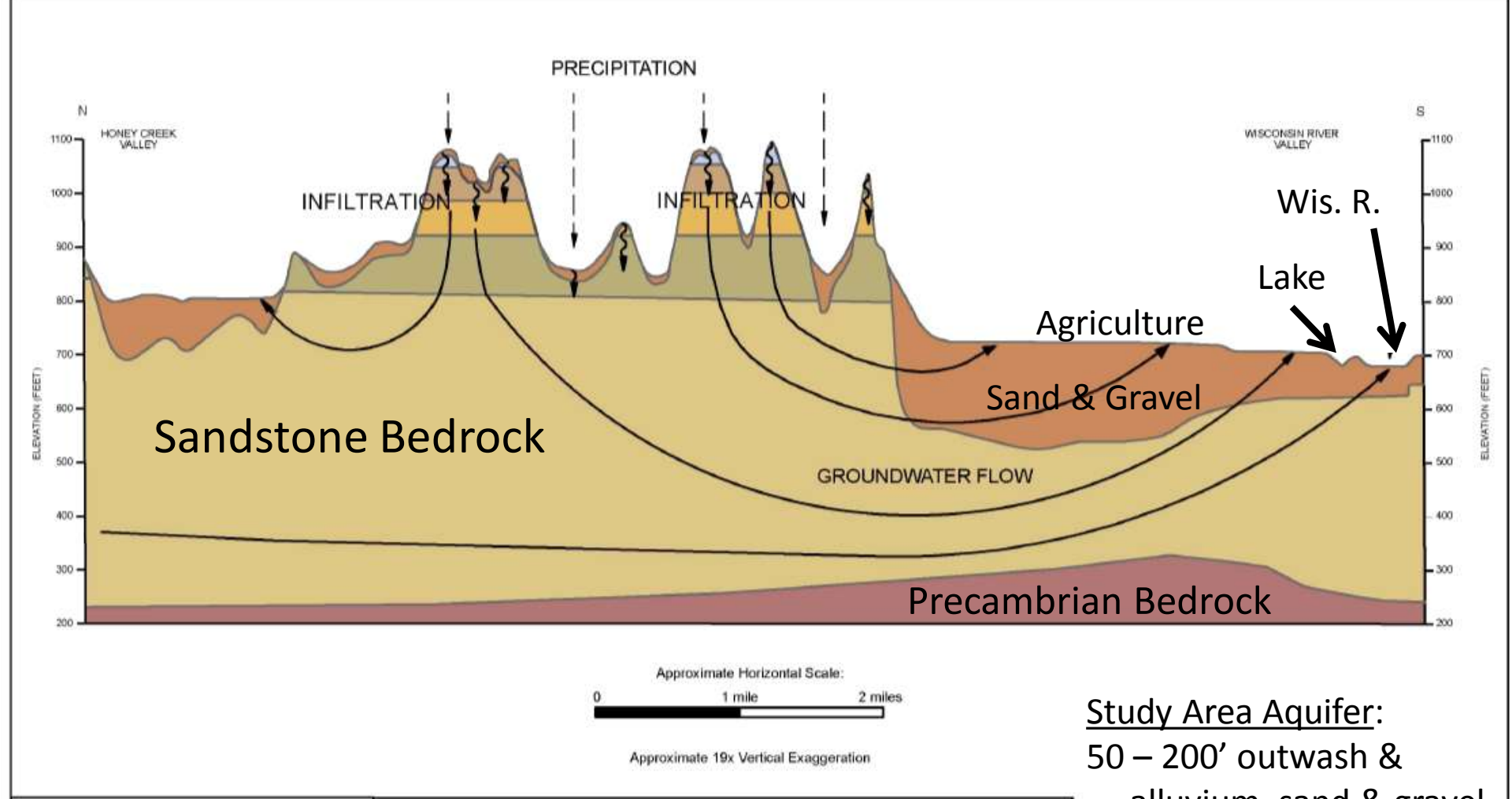
Camargo et al.

Groundwater Investigation

Groundwater Investigation

Goals:

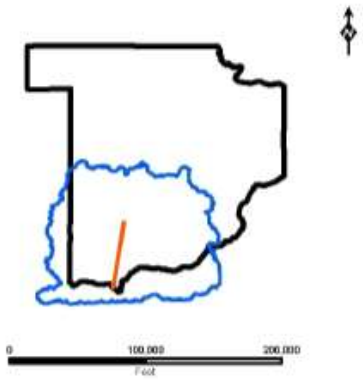
- Determine the Areas of Groundwater Recharge Providing Discharge to the Lakes
- Determine Quality of Groundwater Discharging to the Lakes



Approximate Horizontal Scale:

0 1 mile 2 miles

Approximate 19x Vertical Exaggeration



LEGEND

- CROSS SECTION LOCATION
- MODEL AREA WATERSHED BOUNDARY
- SAUK COUNTY BOUNDARY

Unlithified Aquifer

- Quaternary and Pliocene Unconsolidated Deposits

Sandstone Aquifer

- Ordovician Oneota Formation
- Cambrian Jordon Formation
- Cambrian St. Lawrence Formation
- Cambrian Tunnel City Formation
- Cambrian Elk Mound Group

Aquitard

- Precambrian Igneous and Metamorphic Rock

References

1. Adapted from Gotkowitz et al., 2002. Delineation of Zones of Contribution for Municipal Wells in Sauk County, Wisconsin, Open-File Report 2002-05, Wisconsin Geological and Natural History Survey, Figure 6.
2. Clayton and Attig, 1990, Geology of Sauk County, Wisconsin, Wisconsin Geological and Natural History Survey, Information Circular 67.

Study Area Aquifer:

50 – 200’ outwash & alluvium sand & gravel

200 – 350’ sandstone BR

FIGURE 6
CONCEPTUAL MODEL DIAGRAM
GROUNDWATER INUNDATION STUDY
SPRING GREEN, WISCONSIN

AECOM

MAY 2011

60176866

Aquifer Properties

- Outwash & Alluvium Sand & Gravel
  - Hydraulic Conductivity – 162 ft/day
  - Annual Recharge – 10.2 in/yr.
- Sandstone Bedrock
  - Hydraulic Conductivity – 8 ft/day
  - Annual Recharge – 5.2 in/yr.
- (from Hydrogeology and Simulation of Groundwater Flow in Sauk County, WI, WG&NHS Bulletin 102, 2005)

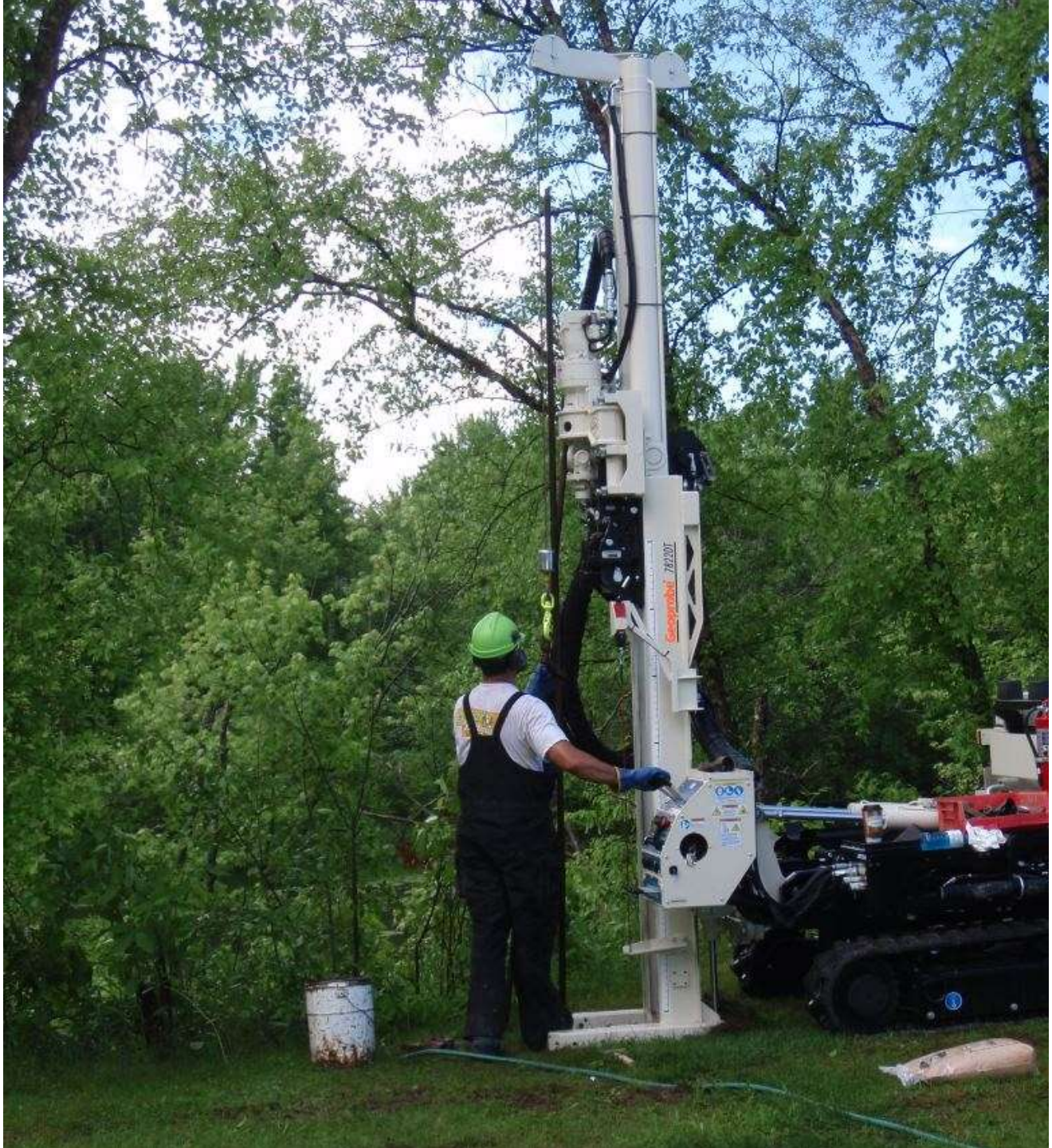
Methods

- Install Water Table Wells & Multi-level Piezometers
- Install Staff Gauges
- Water Level &Temperature Data Loggers
- Measure Water Quality Parameters
  - NO3, NH3, DO, Cl, Sp. Cond., pH

Well Installation

- Geoprobes
- Hand-driven Wellpoints

Geoprobe 7822DT – Onsite Environmental Services, Sun Prairie, WI


Geoprobe 7822DT


Soil Sampling Tube

Wis. River Terrace Sands & Gravels

Well Casing Installation


Long Lake Well Cluster


Rowing to Norton Slough Floodplain Drivepoint Site


Driving
Wellpoint at
Norton Slough
Floodplain

Well Points Driven at Norton Slough Floodplain

Lower Wisconsin River Floodplain Lake Recharge Delineation Project

Long Lake - Bakken's Pond

Norton & Jones Sloughs

☆ = Town Flood Study Well ☆ = Private Water Supply Well ☆ = Project Well Location

Study Monitoring Points

- 27 Geoprobe water table wells & piezometers
- 3 two-inch ID drive points
- 4 lake staff gages
- 2 Town of Spring Green drive points
- 6 private wells

Study Results

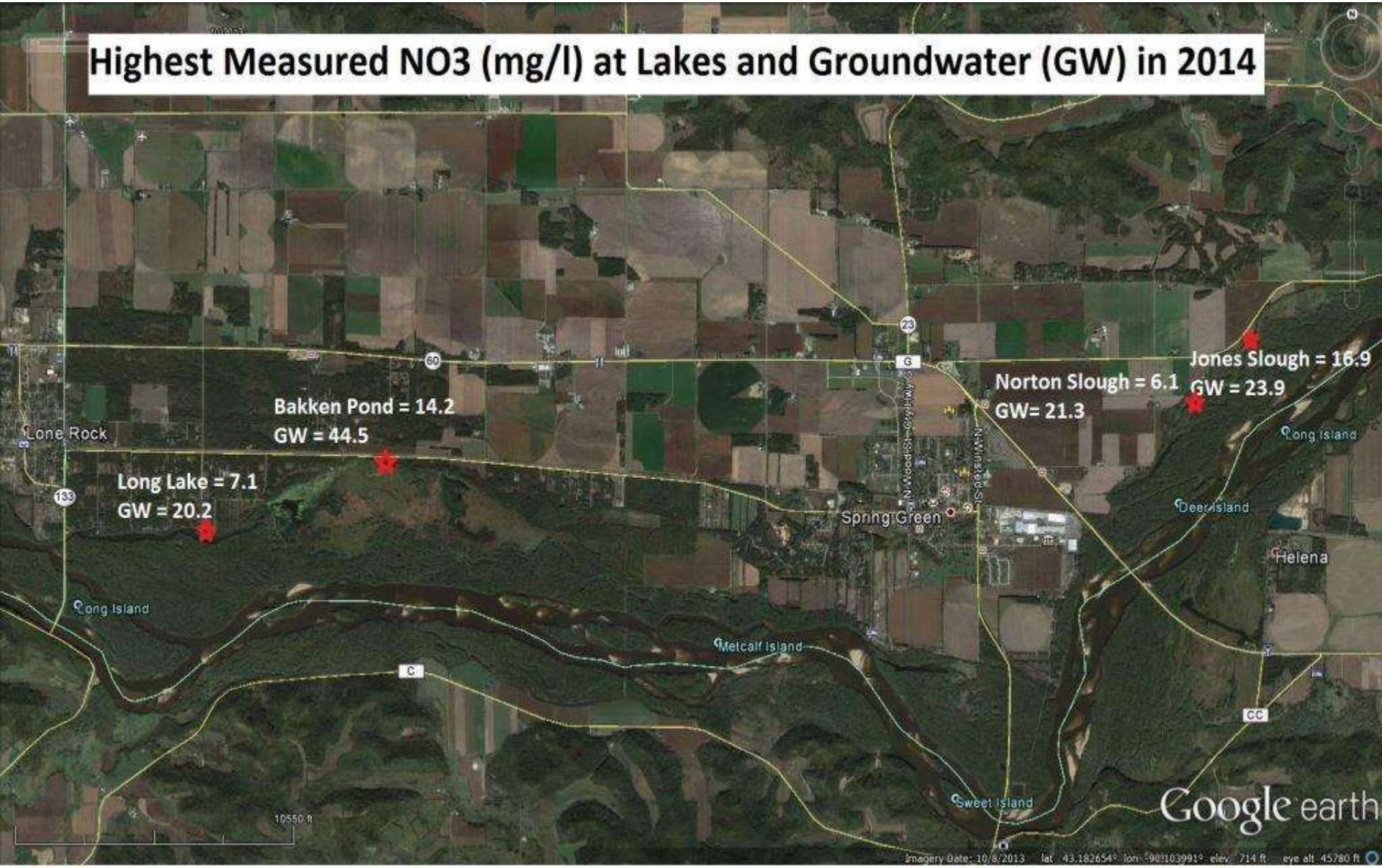
- Hydraulic Gradients
  - Norton Slough Terrace – 0.0014 to 0.0016 ft/ft (Vs = 0.91 to 1.04 ft/day)
  - Bakken Pond Terrace – 0.003 ft/ft (Vs = 1.94 ft/d)
  - Long Lake Terrace – 0.002 ft/ft (Vs = 1.3 ft/d)

  Note lower gradients at Norton Slough terrace due to radial groundwater flow at bend in Wis. River

  (Assuming Wis. Rr. Terrace aquifer K = 162 ft/d & Porosity = 0.25)

2014 Nitrate Measurements

Site Area	Highest Lake/Slough NO3, mg/l	Highest Adjacent Groundwater NO3, mg/l
Jones Slough	16.9	23.9
Norton Slough	6.1	21.3
Bakken's Pond	14.4	44.5
Long Lake	7.1	20.2


Highest Measured NO3 (mg/l) at Lakes and Groundwater (GW) in 2014
Jones Slough = 16.9
GW = 23.9
Norton Slough = 6.1
GW= 21.3
Bakken Pond = 14.2
GW = 44.5
Long Lake = 7.1
GW = 20.2
Lone Rock
Spring Green
Deer Island
Helena
Long Island
Metcalf Island
Sweet Island
Google earth

Ice Cover & Groundwater Discharge at the Lakes & Sloughs

- December 2014 Observations
- Variations in Extent of Ice Cover
- Correlation with NO3 Concentration?

Bakken's Pond, 12/12/2014
Most Open Water – Highest NO3

Jones Slough 12/12/2014
Significant Open Water – High NO3

Norton Slough 12/12/2014
Moderate Open Water – Less NO3

Long Lake – 12/12/2014
Least Open Water – Lowest NO3

Investigation of Discharge Variation Needed

- Seepage Meter Transects Across Lakes
- Monitor Discharge Flux
- Monitor Discharge Water Quality

Delineating Lake Recharge Areas

- Upper portion of aquifer adjacent lakes have lower NO3 due to non-ag land use
- Lower portion of aquifer show higher NO3 representing agricultural contributions
- WDNR River Planning Grant for 2015 – 2016 will allow for numerical groundwater modeling to more precisely determine groundwater recharge areas

Study Policy Applications

- Delineation of Lake/Slough Recharge Areas:
  - Determine extent of buffer areas needed to insure quality of discharge to the lakes & sloughs
  - Use to prioritize Lower Wis. acquisition areas
  - Use to prioritize areas for land use conservation easements. E.g. conservation easement for nutrient restriction & prairie restoration adjacent to Norton Slough
  - Town & county land use planning, education & outreach

Acknowledgement

- This study is made possible through 2014 and 2015 Wisconsin Department of Natural Resources Lake Planning Grants.

Questions?