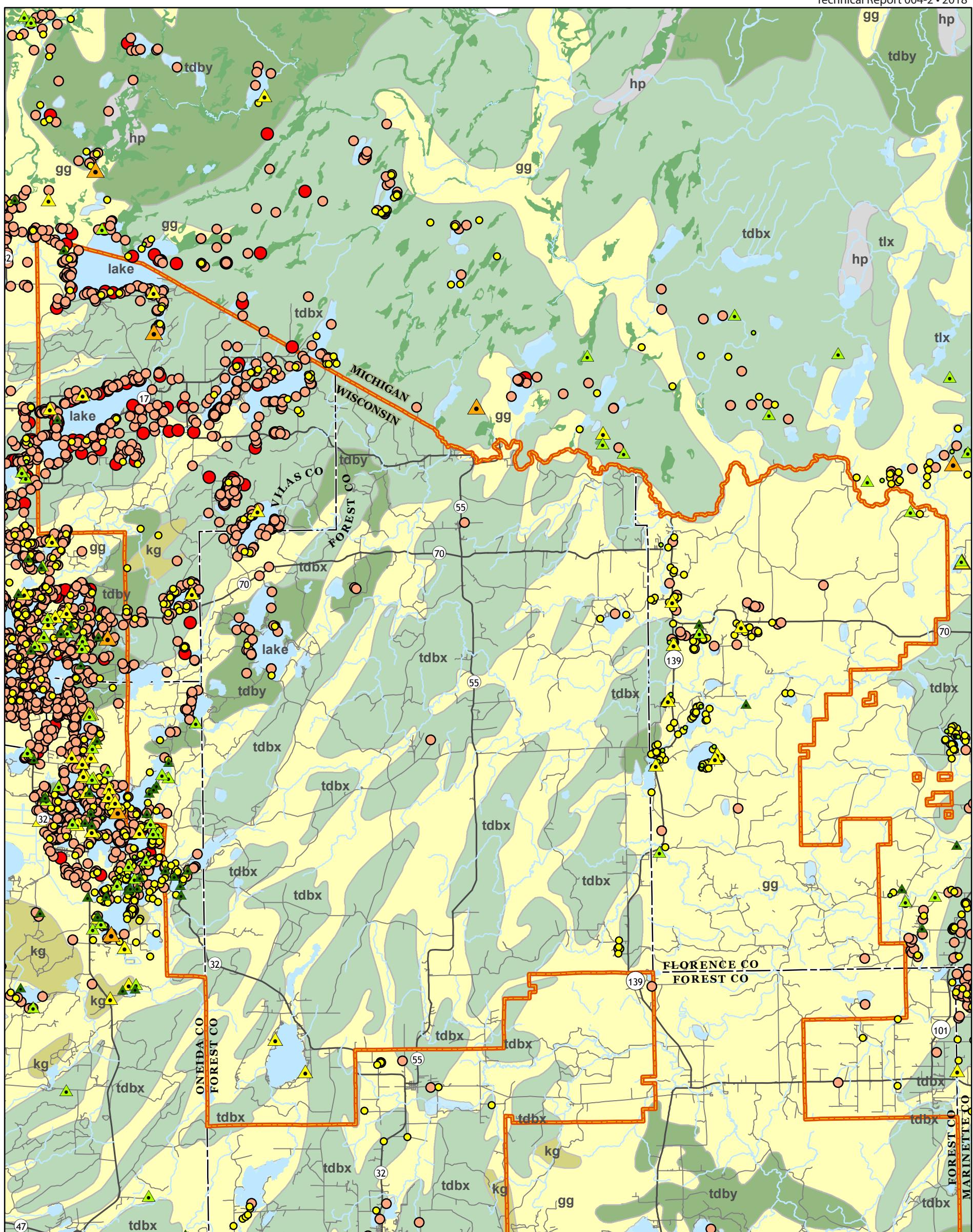


**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 1a
Transmissivity
Northern Nicolet Unit
Wisconsin Geological and Natural History Survey
Technical Report 004-2 • 2018



Glacial T, log ft²/day Bedrock T, log ft²/day

- ≤2 ▲ ≤1
- >2-3 ▲ >1-2
- >3-4 ▲ >2-3
- >4-5 ▲ >3-4

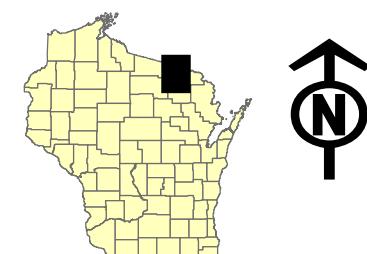
Quaternary map units

water	gg	tlx	tdby
hp	kg	tdbx	

Refer to Table 1 for unit descriptions.

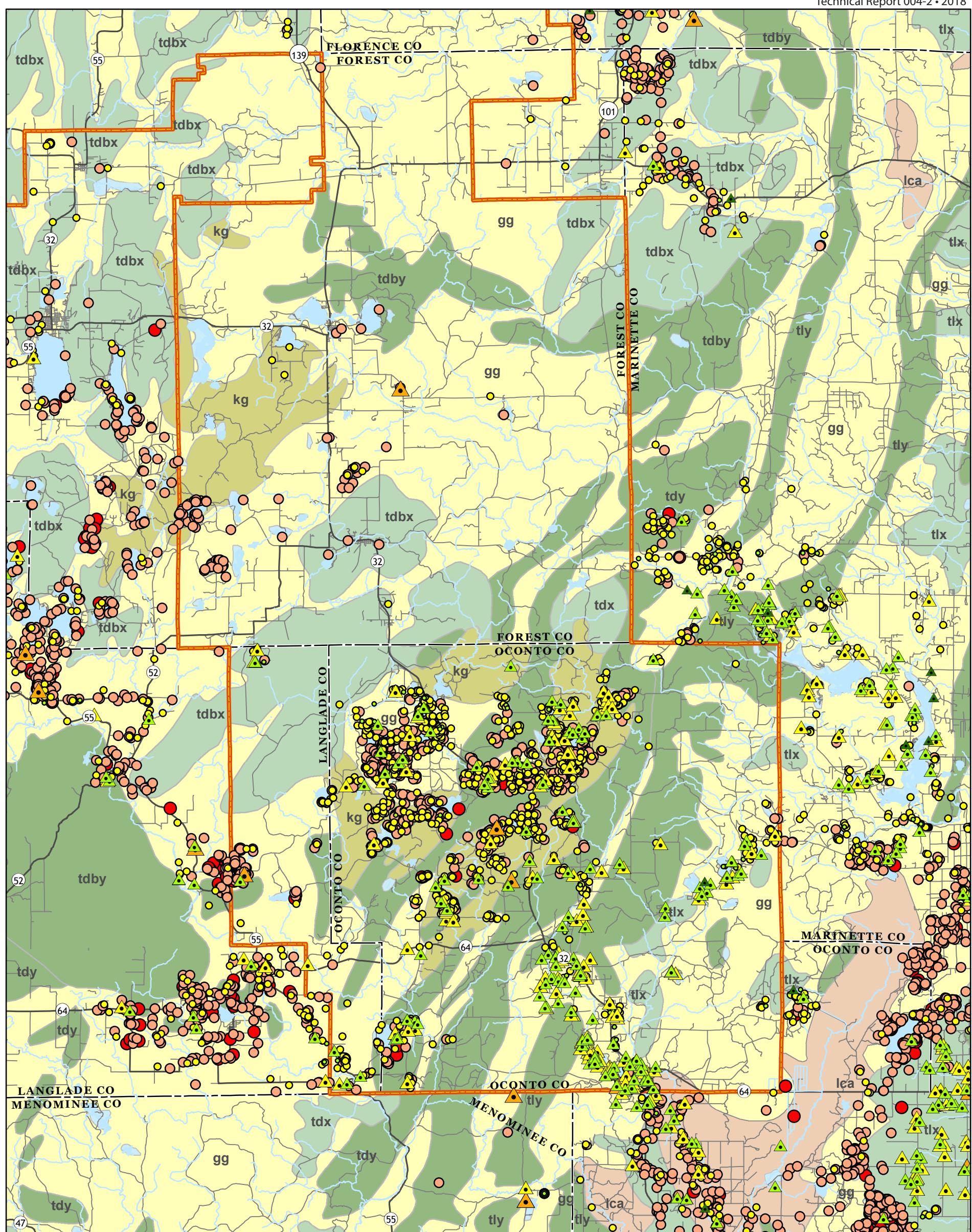


0 4 Miles



**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 1b
Transmissivity
Southern Nicolet Unit
Wisconsin Geological and Natural History Survey
Technical Report 004-2 • 2018



Glacial T, log ft²/day

Bedrock T, log ft²/day

Quaternary map units

0 4 Miles

- | | |
|--------|--------|
| • <=2 | ▲ <=1 |
| ○ >2-3 | △ >1-2 |
| ● >3-4 | ◆ >2-3 |
| ■ >4-5 | ◆ >3-4 |

water	lca	tdx	tdby
gg	tlx	tdy	
kg	tly	tdbx	

Refer to Table 1 for unit descriptions.

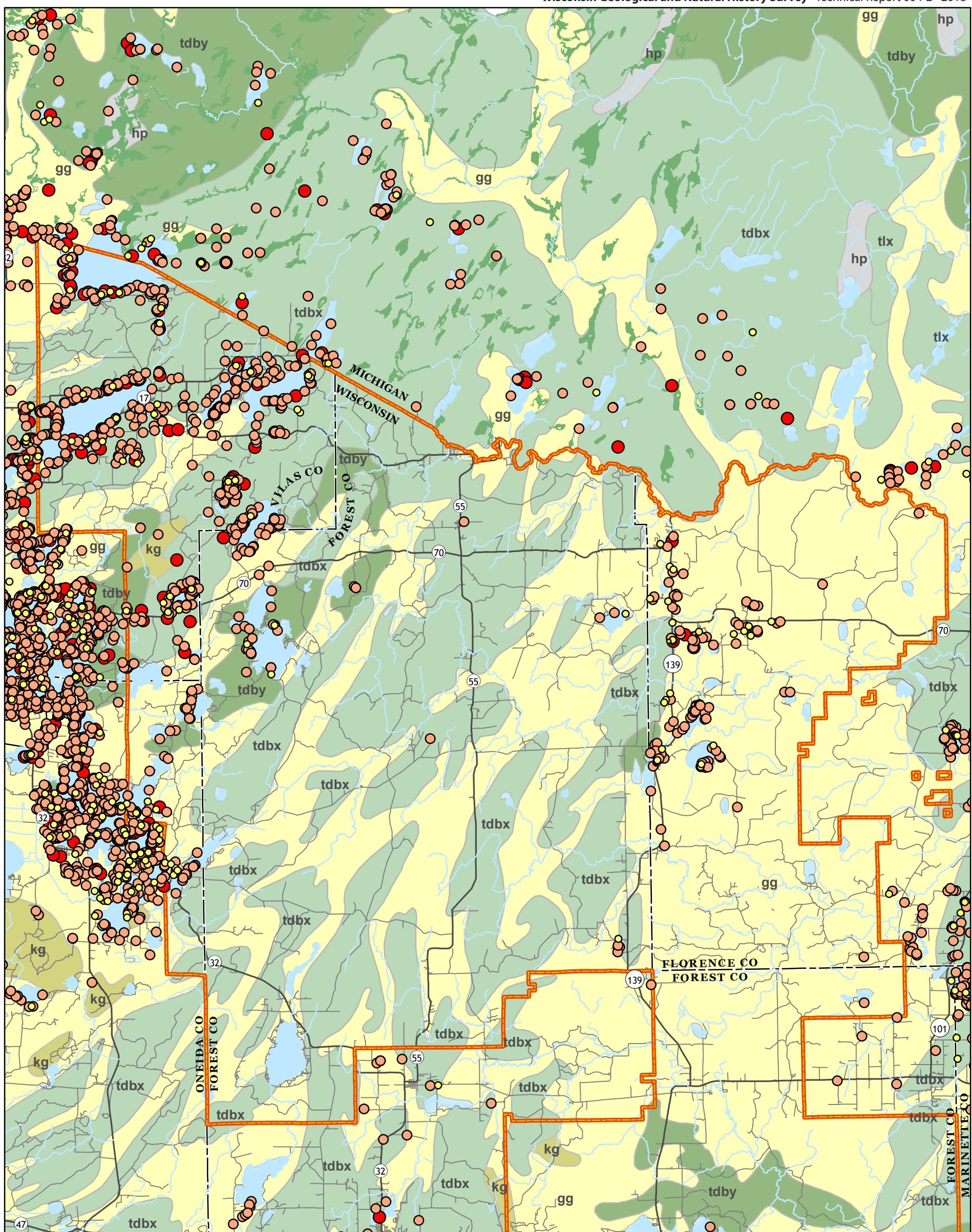
Nicolet Unit



**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 2a
**Hydraulic Conductivity of
Unlithified Materials
Northern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



**Glacial hydraulic conductivity,
log ft/day**

- <0
- >0-1
- >1-2
- >2

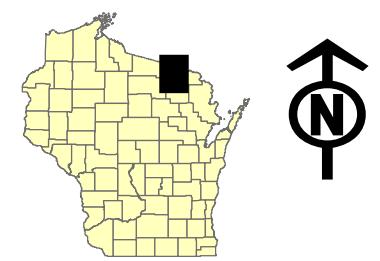
Quaternary geology

water	gg	tlx	tdby
hp	kg	tdbx	

Refer to Table 1 for unit descriptions.

Nicolet Unit

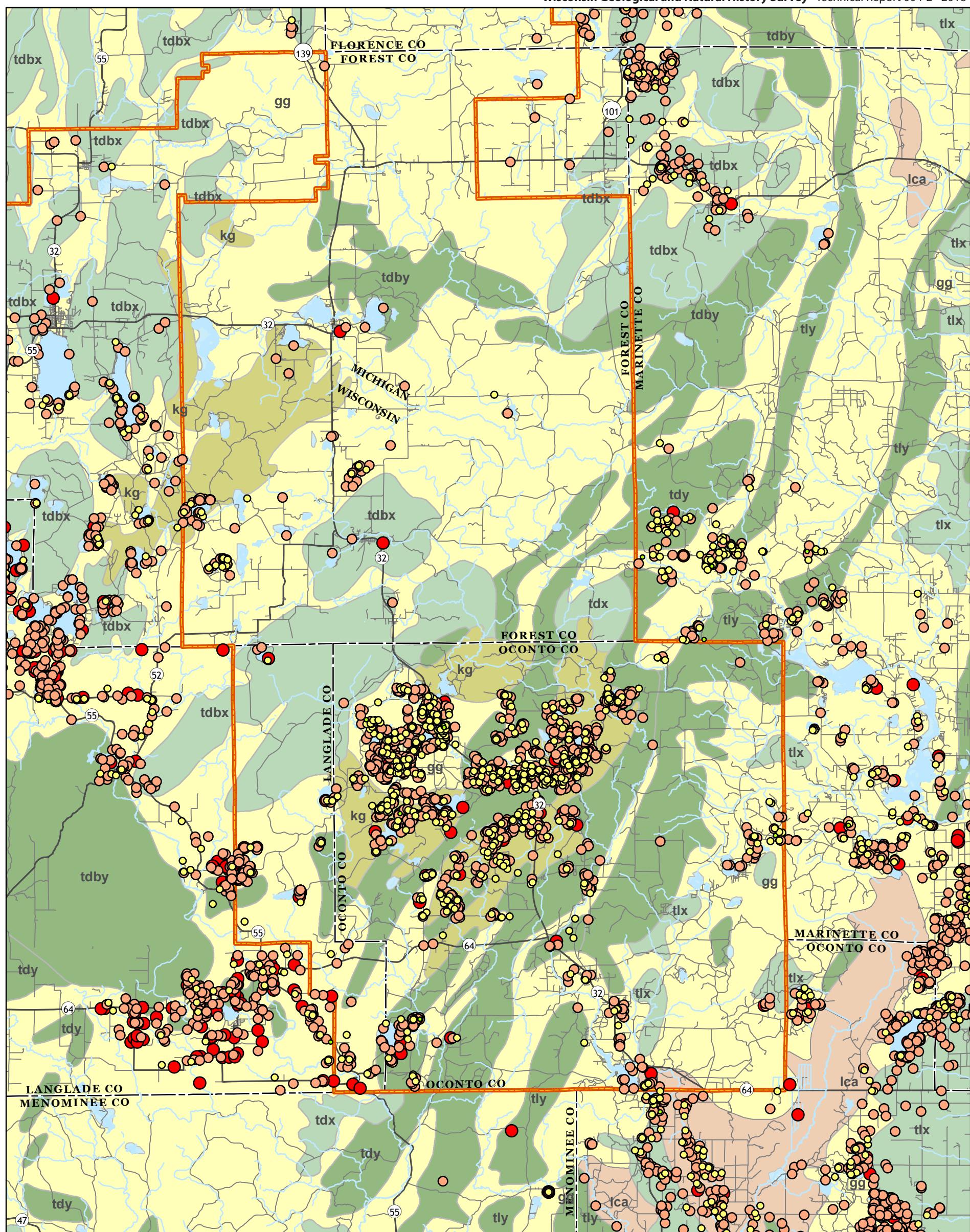
0 4 Miles



**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 2b
**Hydraulic Conductivity of
Unlithified Materials
Southern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



**Glacial hydraulic conductivity,
log ft/day**

- <0
- >0-1
- >1-2
- >2

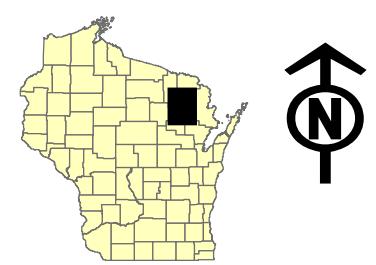
Quaternary geology

water	lca	tdx	tdby
gg	tlx	tdy	
kg	tly	tly	tdbx

Refer to Table 1 for unit descriptions.

Nicolet Unit

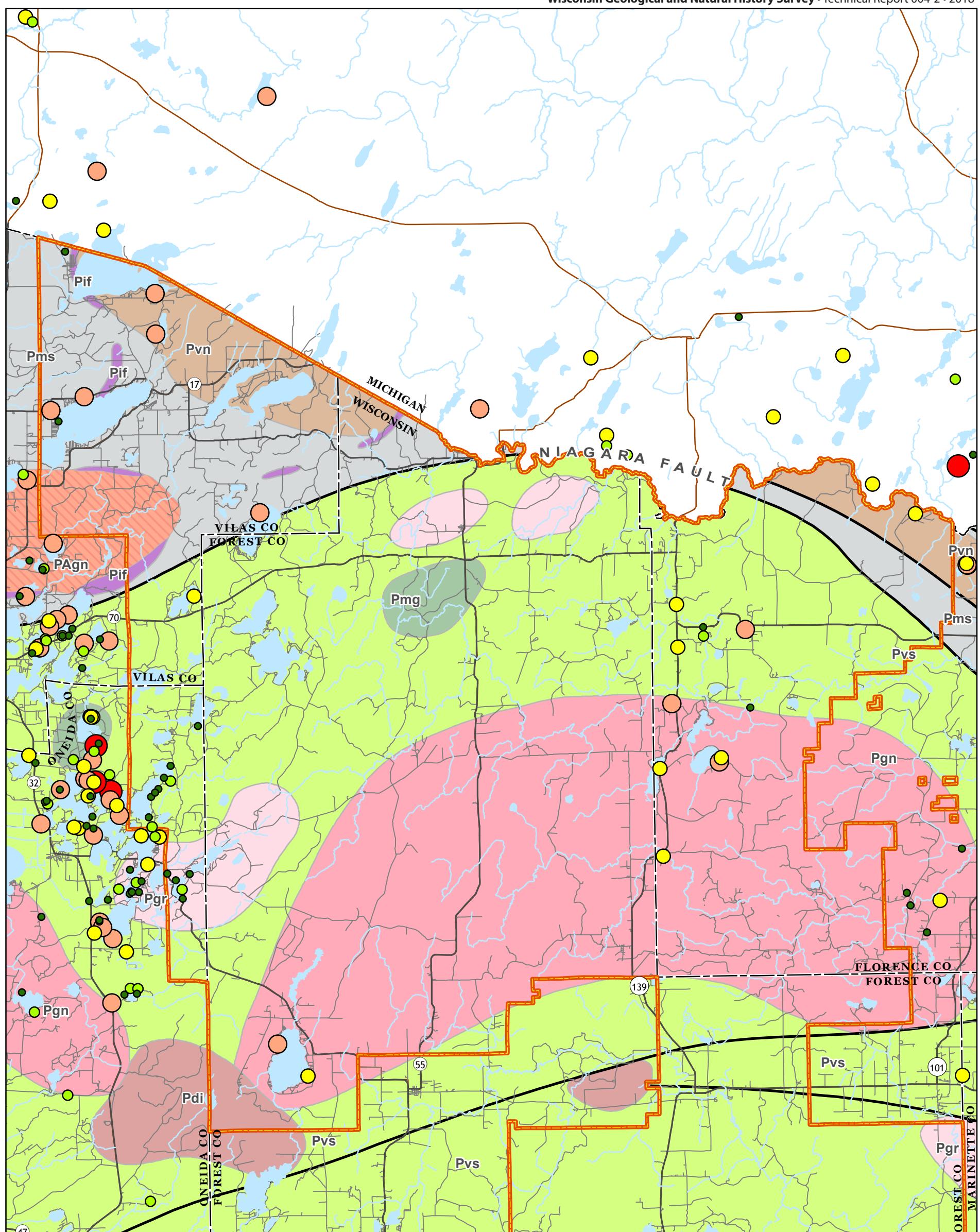
0 4 Miles



**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 3a
Hydraulic Conductivity of Bedrock
Northern Nicolet Unit

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



Bedrock hydraulic conductivity,
log ft/day

- <-1
- >-1 to 0
- >0 to 1
- >1 to 2
- >2 to 3

Bedrock geology

Pgr	Pgn	Pms	Pvn	PAgn
Pdi	Pmg	Pif	Pvs	

Refer to Table 2 for unit descriptions.

0 4 Miles

— fault
□ Nicolet Unit

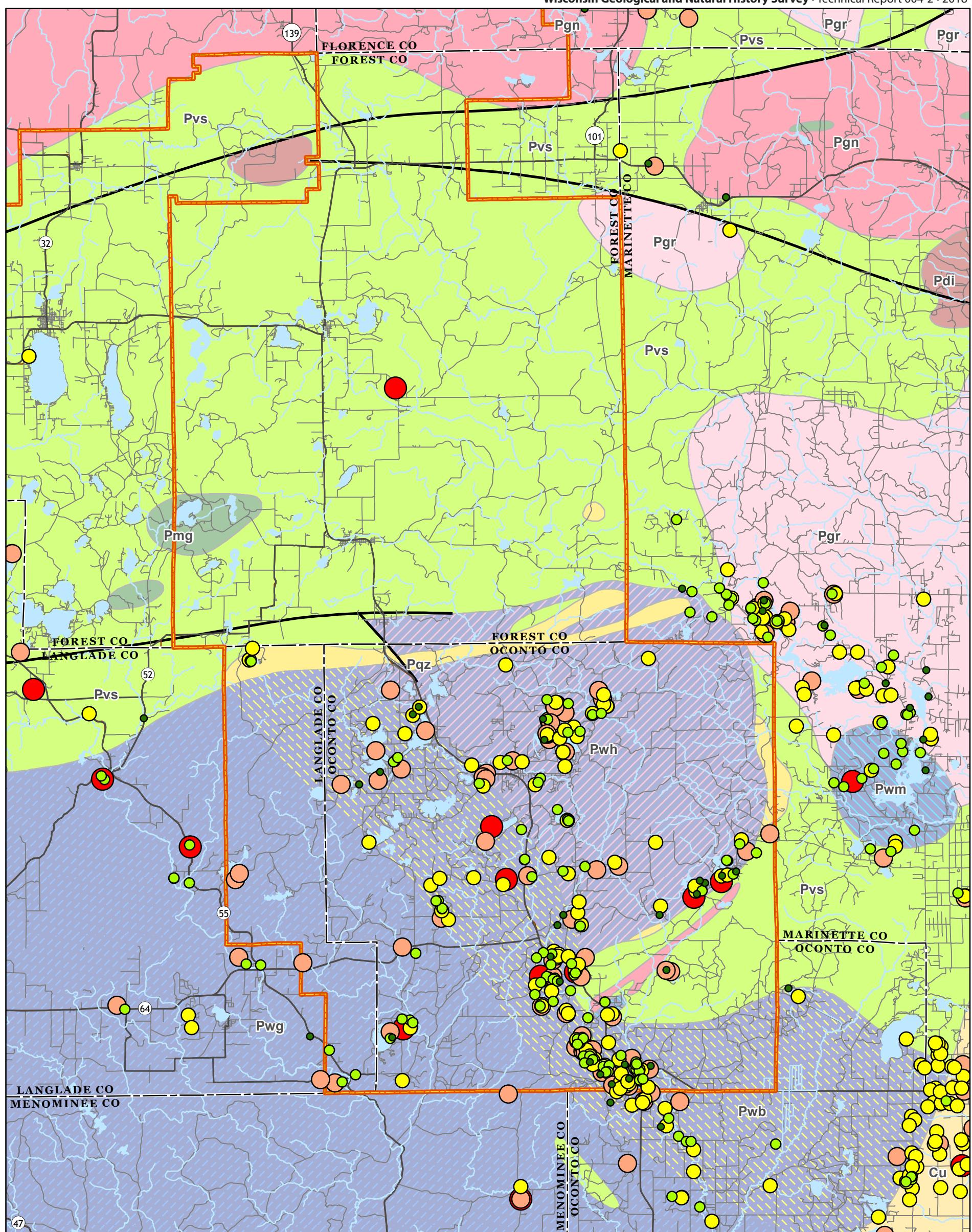


**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 3b

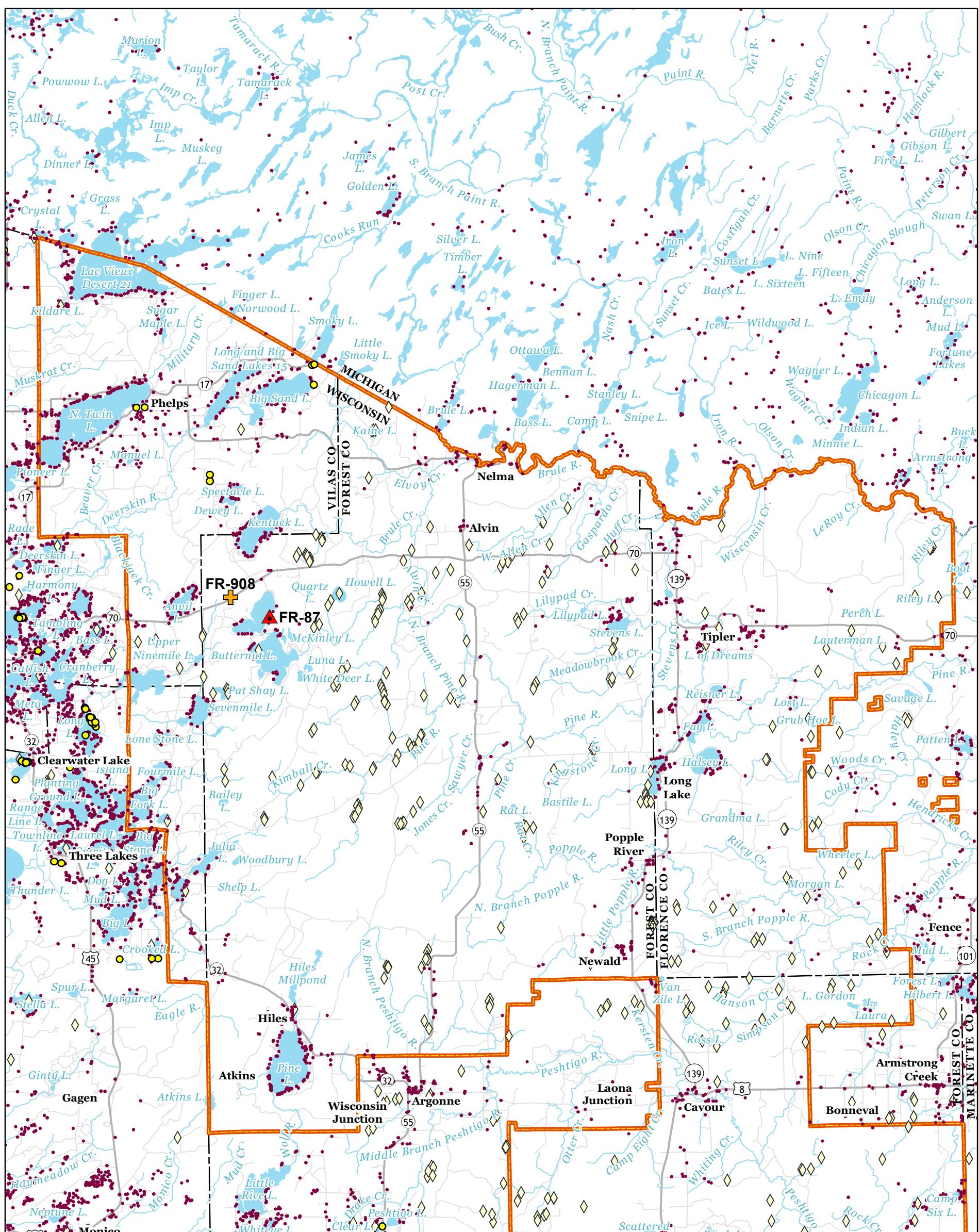
**Hydraulic Conductivity of Bedrock
Southern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 4a
Data points and springs
Northern Nicolet Unit



- Located wells
- High-capacity wells
- ▲ FR-87 monitoring well
- + FR-908 monitoring well
- Nicolet Unit

Mapped springs and spring ponds (no discharge measurement)

0 4 Miles

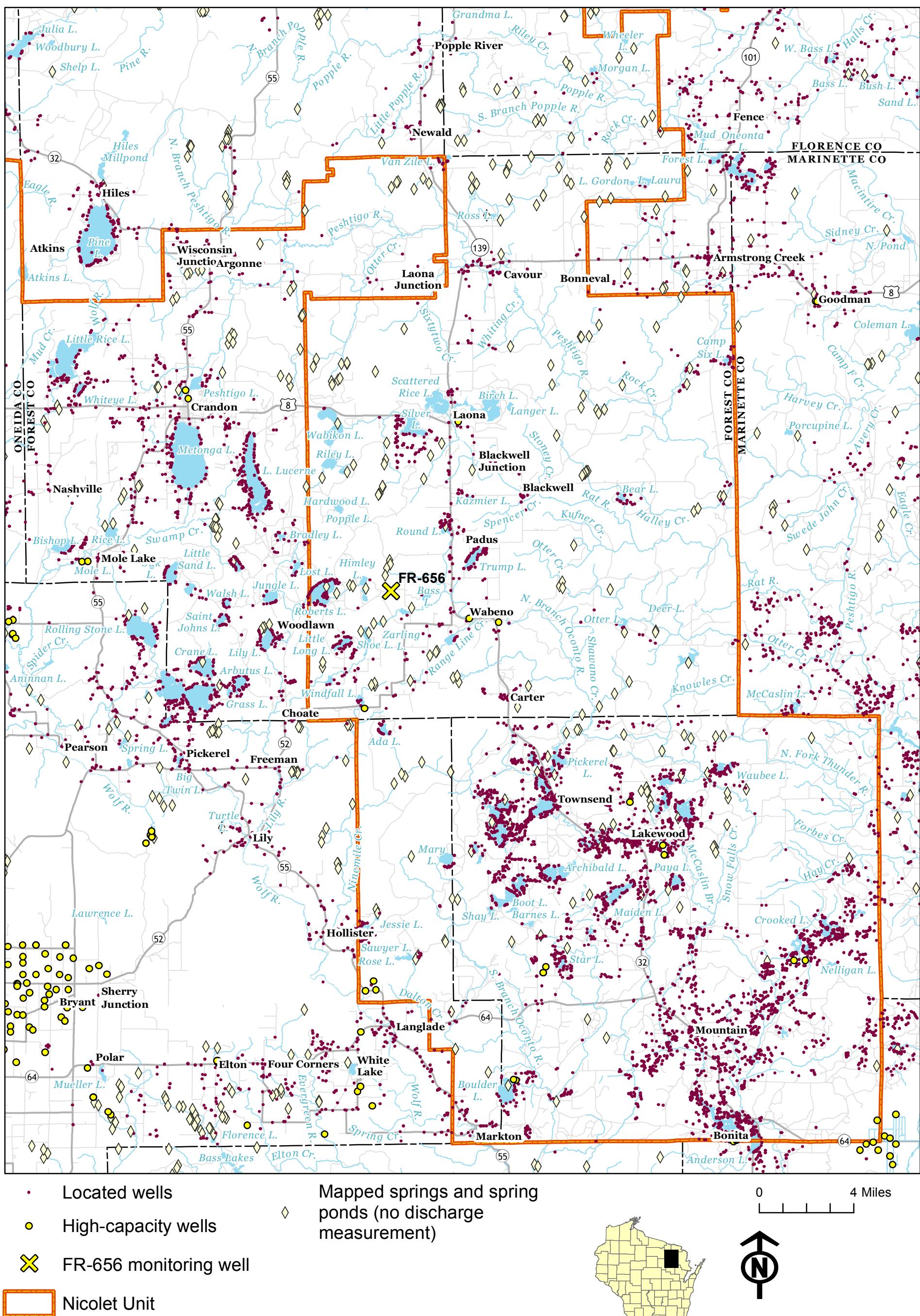


National Forest boundaries from the USDA Forest Service. Roads from CENSUS, 2015.
Hydrography from National Hydrography Dataset, 2012. Boundaries from multiple sources, 2015.
Terrain data from Wisconsin Department of Natural Resources and US Geological Survey.
Springs and spring ponds from Macholl (2007).

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 4b

**Data points and springs
Southern Nicolet Unit**



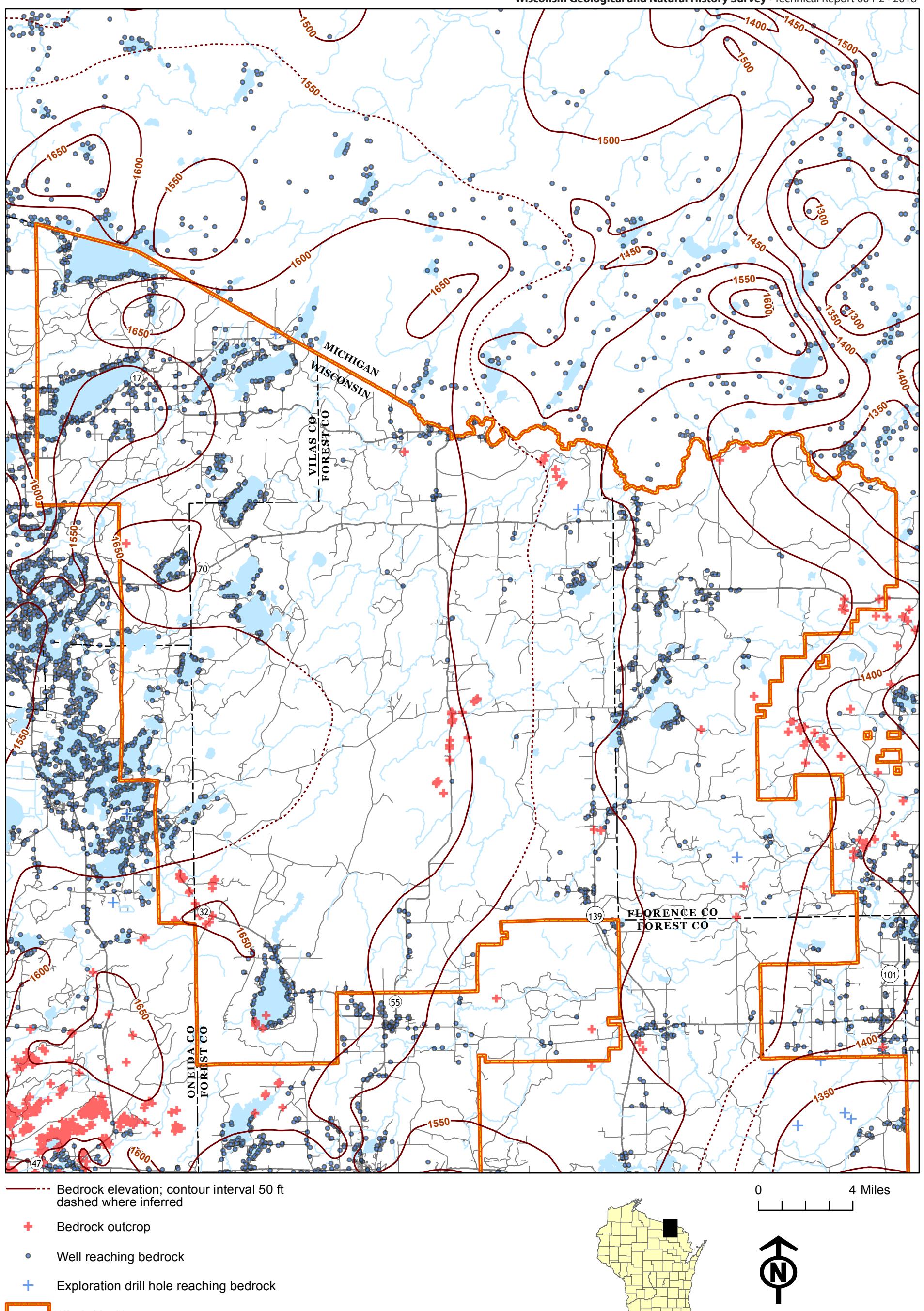
National Forest boundaries from the USDA Forest Service. Roads from CENSUS, 2015.
Hydrography from National Hydrography Dataset, 2012. Boundaries from multiple sources, 2015.
Terrain data from Wisconsin Department of Natural Resources and US Geological Survey.
Springs and spring ponds from Macholl (2007).

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 5a

**Elevation of bedrock surface
Northern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



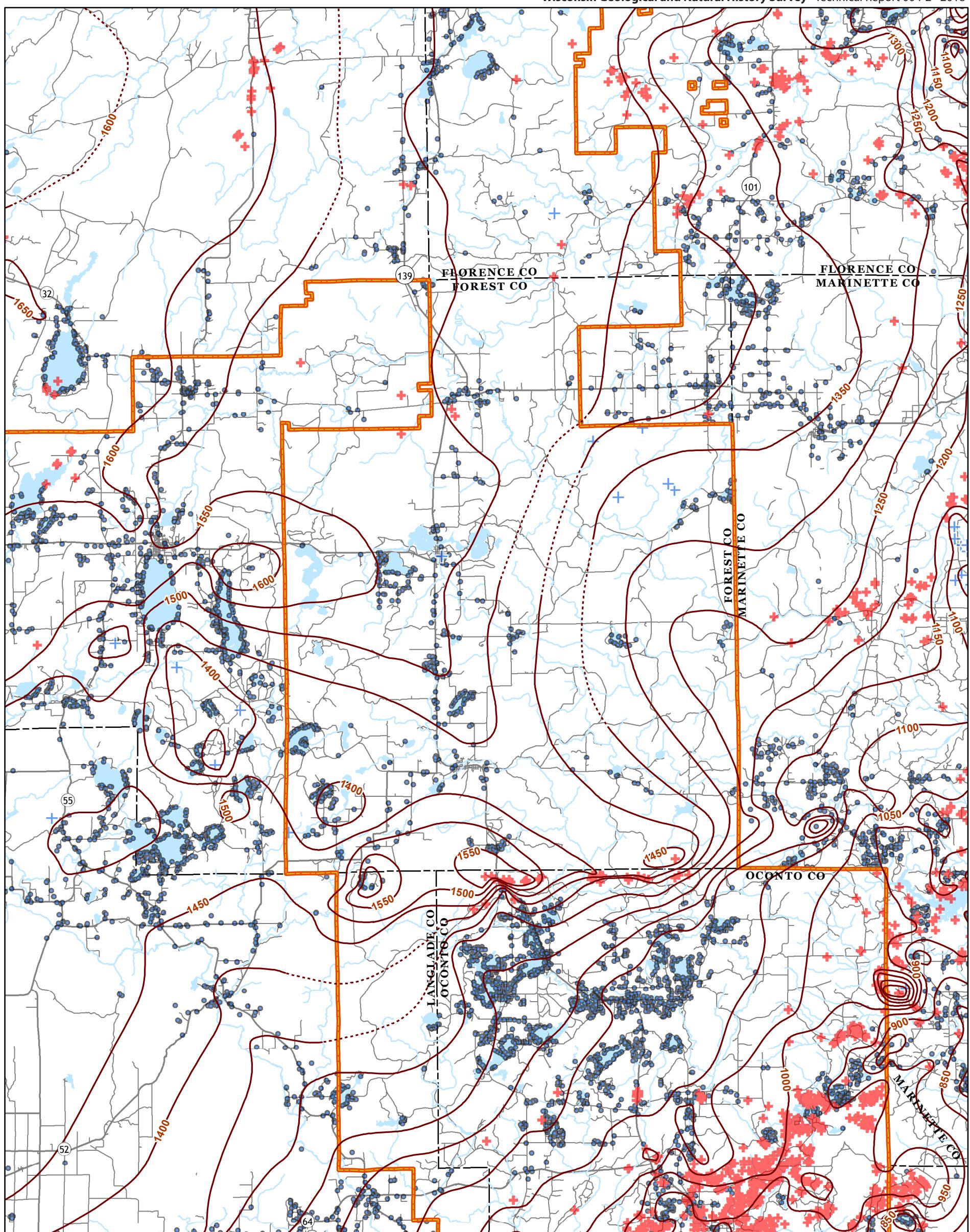
Bedrock outcrops from Attig and Ham, 1999, and Natural Resources Conservation Service, 2014b. Bedrock lithographic records from wisCLITH (WGNHS, 2012). Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Hydrography from National Hydrography Dataset, 2012.

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 5b

**Elevation of bedrock surface
Southern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



— Dashed line: Bedrock elevation; contour interval 50 ft

dashed where inferred

+

Bedrock outcrop

•

Well reaching bedrock

+

Exploration drill hole reaching bedrock

Box: Nicolet Unit

0 4 Miles



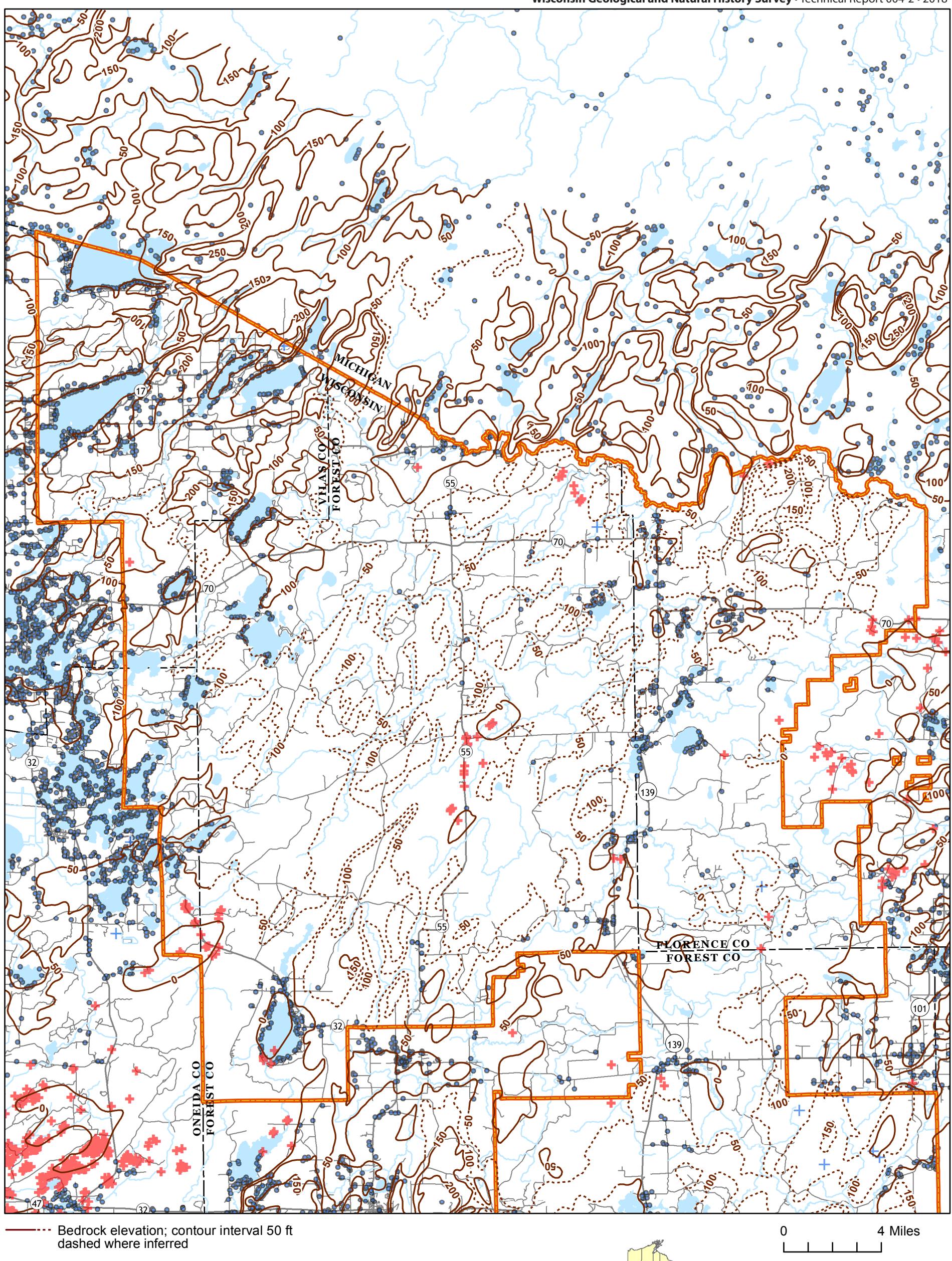
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**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 6a

Depth to bedrock
Northern Nicolet Unit

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



— Dashed line: Bedrock elevation; contour interval 50 ft
dashed where inferred

• Bedrock outcrop

• Well reaching bedrock

+ Exploration drill hole reaching bedrock

Nicolet Unit

0 4 Miles



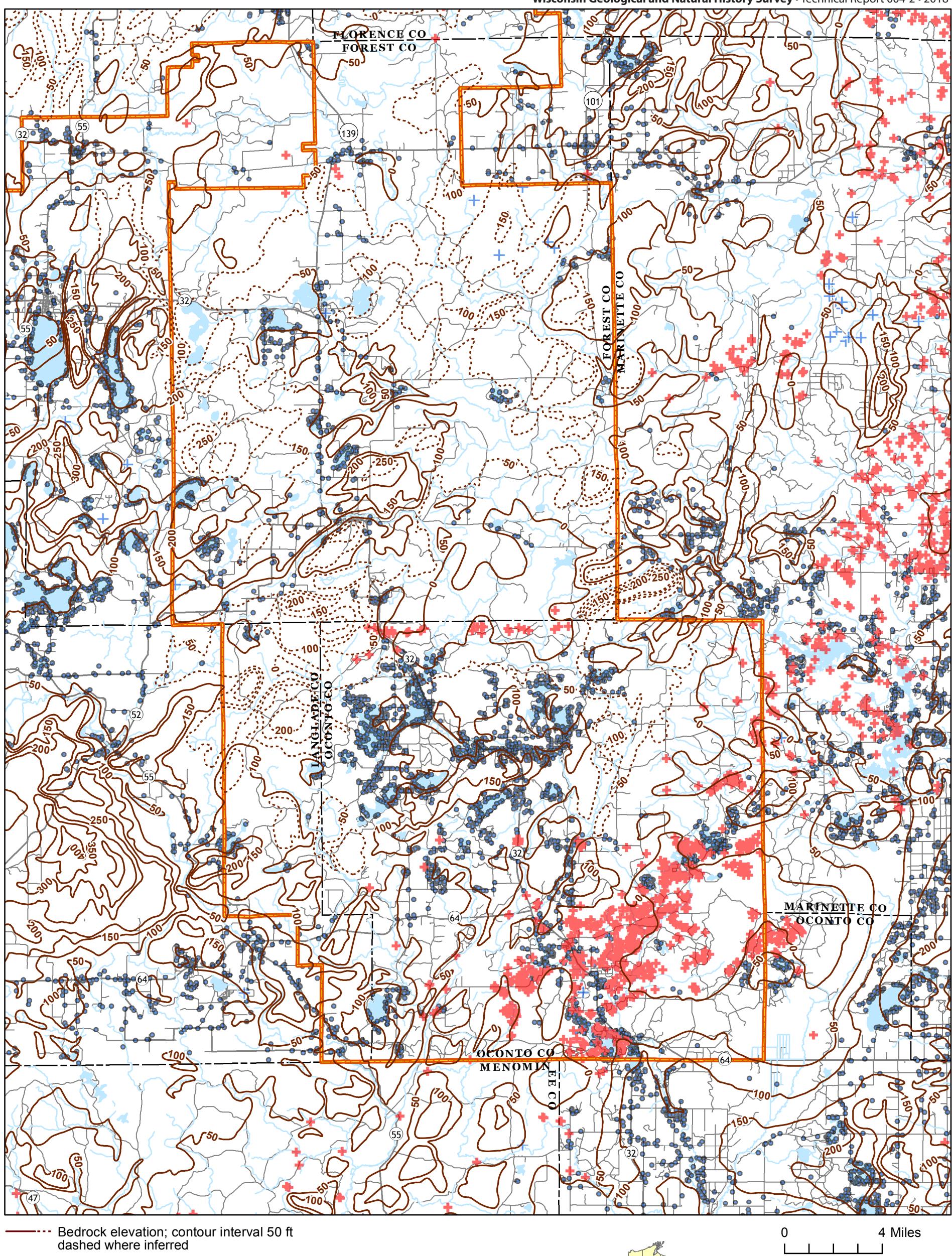
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**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 6b

**Depth to bedrock
Southern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



— Dashed line: Bedrock elevation; contour interval 50 ft

dashed where inferred

+ Bedrock outcrop

• Well reaching bedrock

+ Exploration drill hole reaching bedrock

Nicolet Unit

0 4 Miles

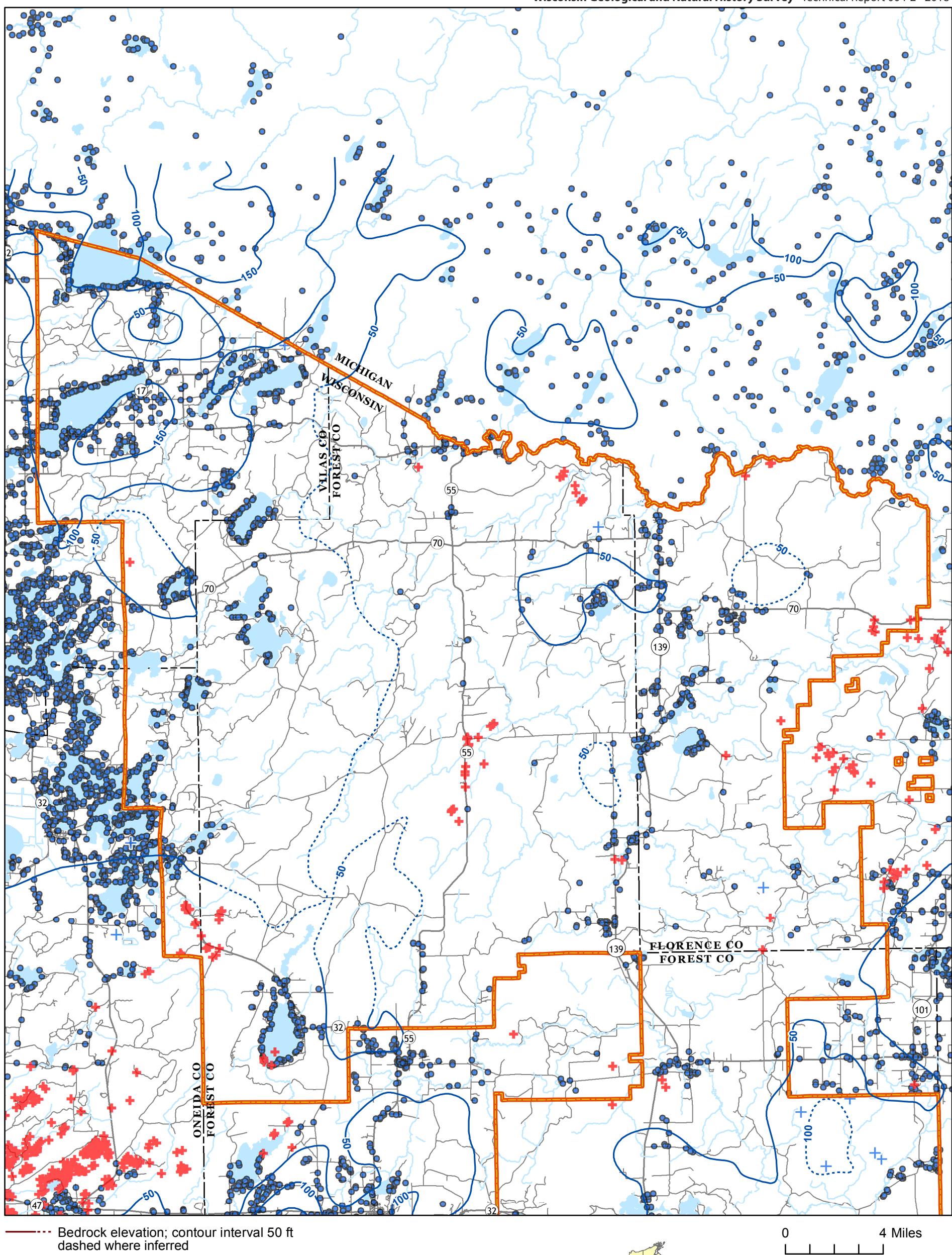


Bedrock outcrops from Attig and Ham, 1999, and Natural Resources Conservation Service, 2014b. Bedrock lithographic records from wisCLITH (WGNHS, 2012). Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Hydrography from National Hydrography Dataset, 2012.

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 7a
**Saturated thickness
of unlithified materials
Northern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



— ··· Bedrock elevation; contour interval 50 ft
dashed where inferred

• + Bedrock outcrop

• Well reaching bedrock

• + Exploration drill hole reaching bedrock

■ Nicolet Unit

0 4 Miles

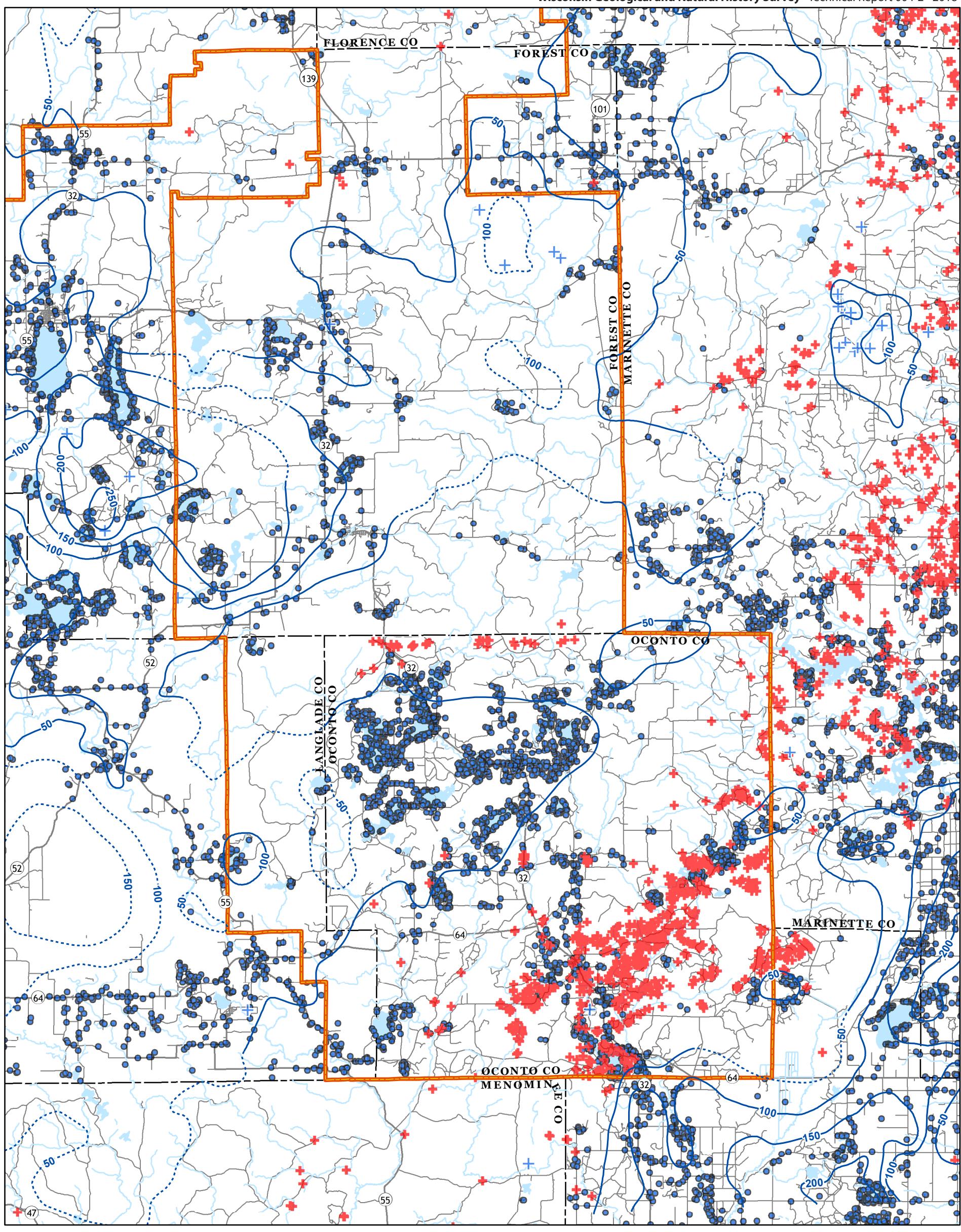


Bedrock outcrops from Attig and Ham, 1999, and Natural Resources Conservation Service, 2014b. Bedrock lithographic records from wisCLITH (WGNHS, 2012). Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Hydrography from National Hydrography Dataset, 2012.

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 7b
**Saturated thickness
of unlithified materials
Southern Nicolet Unit**

Wisconsin Geological and Natural History Survey • Technical Report 004-2 • 2018



— Dashed line = Bedrock elevation; contour interval 50 ft
dashed where inferred

• Bedrock outcrop

• Well reaching bedrock

+ Exploration drill hole reaching bedrock

Nicolet Unit

0 4 Miles



Bedrock outcrops from Attig and Ham, 1999, and Natural Resources Conservation Service, 2014b. Bedrock lithographic records from wisCLITH (WGNHS, 2012). Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Hydrography from National Hydrography Dataset, 2012.

Plate 8a
**Average annual groundwater recharge
(2000–2010)**

Northern Watersheds of the Nicolet Unit of the
Chequamegon-Nicolet National Forest
Wisconsin



1:250,000

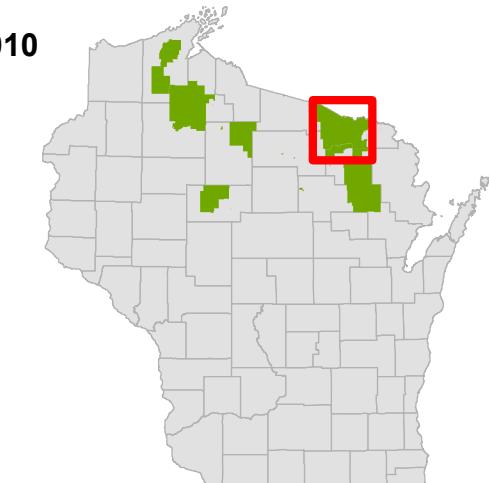
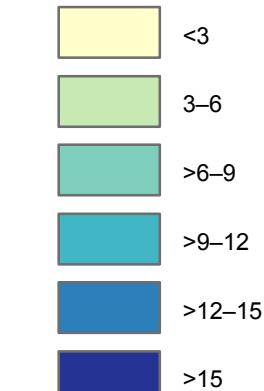
Miles

0 5 10

Nicolet Unit

Nicolet Unit watersheds

Mean annual recharge, 2000–2010



Groundwater recharge was estimated through application of a soil-water balance (SWB) model and calibrated in a separate groundwater flow model. A brief description is provided here; see accompanying report for model setup, results, and data availability.

The SWB model estimates the distribution of deep drainage, approximately equal to groundwater recharge, through time using a modified Thornthwaite-Mather method to track soil moisture storage and flux on a spatially referenced grid at daily time increments. Inputs to the SWB model include map data layers for land surface topography and soil and land cover characteristics, as well as daily climate records. Model outputs included datasets of annual recharge from 2000 to 2010 and tabular summaries of daily and annual water balance calculations.

The 2000–2010 SWB annual recharge output was then used as initial input for a groundwater flow model. During flow model calibration, recharge was adjusted by using a multiplier to calibrate to groundwater conditions by adjusting the magnitude of recharge while maintaining the spatial distribution of SWB results. The SWB results were also downsampled for use in the flow model, resulting in a grid that is more generalized than the original SWB output. The results of this recharge calibration are shown here.

Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Watershed boundaries and hydrography from National Hydrography Dataset, 2011–12.

Plate 8b

Average annual groundwater recharge (2000–2010)

Southern Watersheds of the Nicolet Unit of the
Chequamegon-Nicolet National Forest
Wisconsin



1:250,000

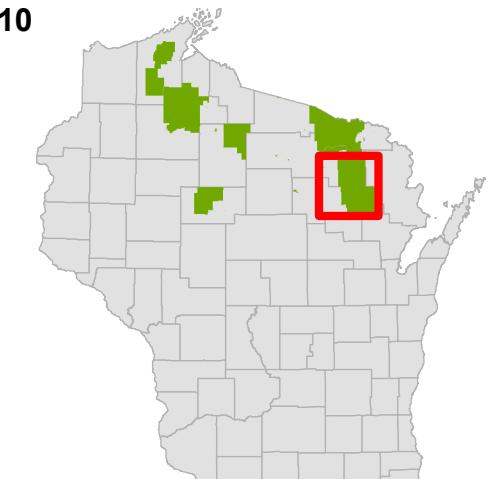
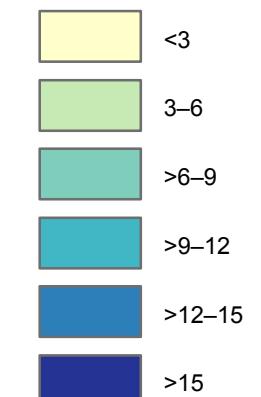
Miles

0 5 10

Nicolet Unit

Nicolet Unit watersheds

Mean annual recharge, 2000–2010



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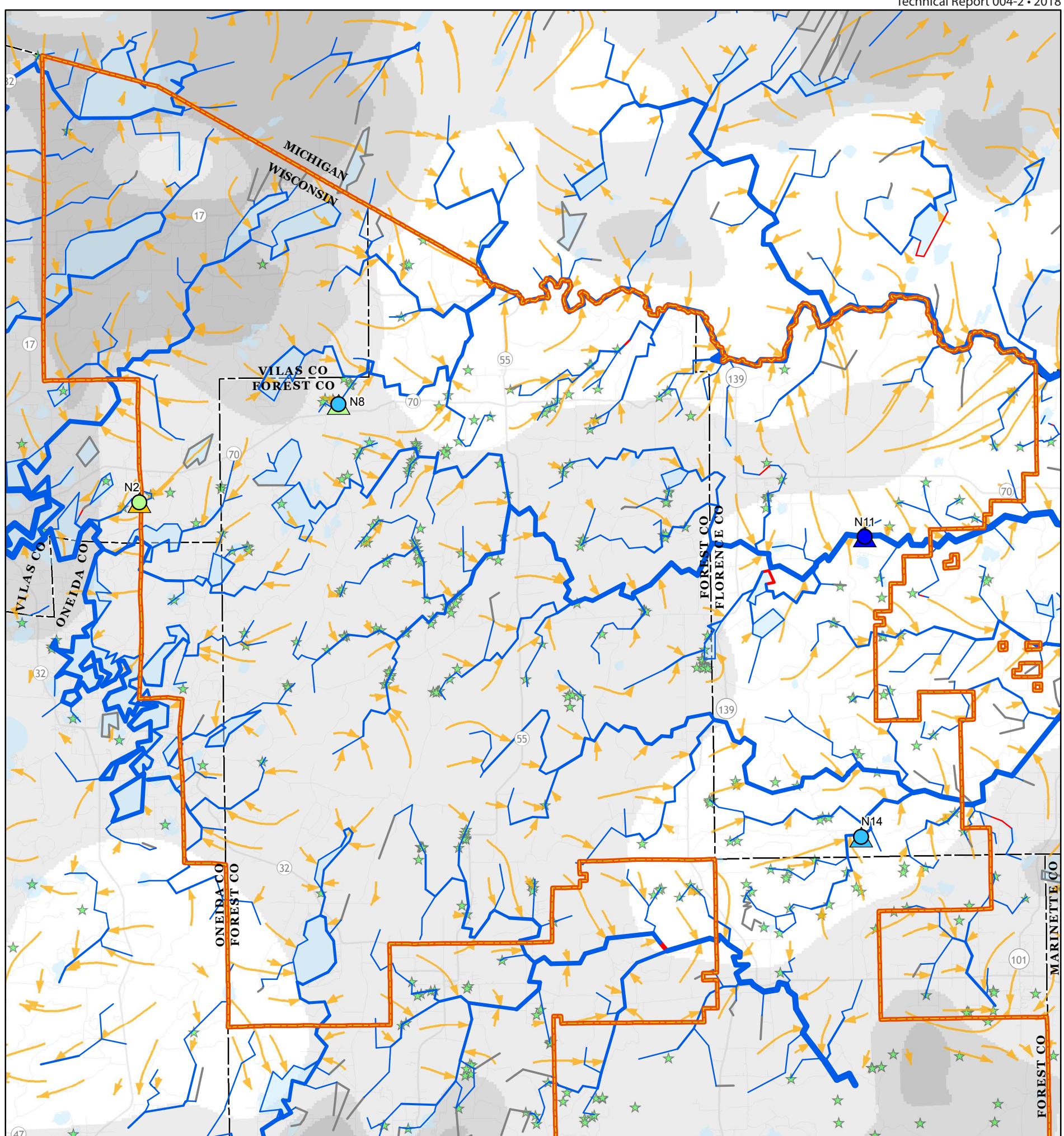
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Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Watershed boundaries and hydrography from National Hydrography Dataset, 2011–12.

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 9a
Surface water chemistry and simulated baseflow
Northern Nicolet Unit
Wisconsin Geological and Natural History Survey
Technical Report 004-2 • 2018



Stream, spring, and lake samples¹

Conductivity, $\mu\text{s}/\text{cm}$	Alkalinity, mg/L
● >100–200	▲ >20–50
● >200–300	▲ >50–100
● >300	▲ >100–150
	▲ >150

¹Label indicates site number. See report for further explanation.

Simulated stream baseflow, by color and line weight²

Dry	Baseflow, cfs
— Gaining from groundwater	— ≤2
— Losing to groundwater	— >2–7
	— >7–14
	— >14–20
	— >20–35
	— >35–55
	— >55–80
	— >80–100
	— >100–150
	— >150

²Color indicates interaction with aquifer; linewidth proportional to baseflow volume. Gray lines indicate streams that are represented in the flow model but have zero simulated baseflow. Far-field streams not shown.

Nicolet Unit
★ Springs and spring ponds
→ Simulated groundwater flow path
Saturated glacial aquifer thickness, ft
≤30
>30–60
>60–100
>100–200
>200

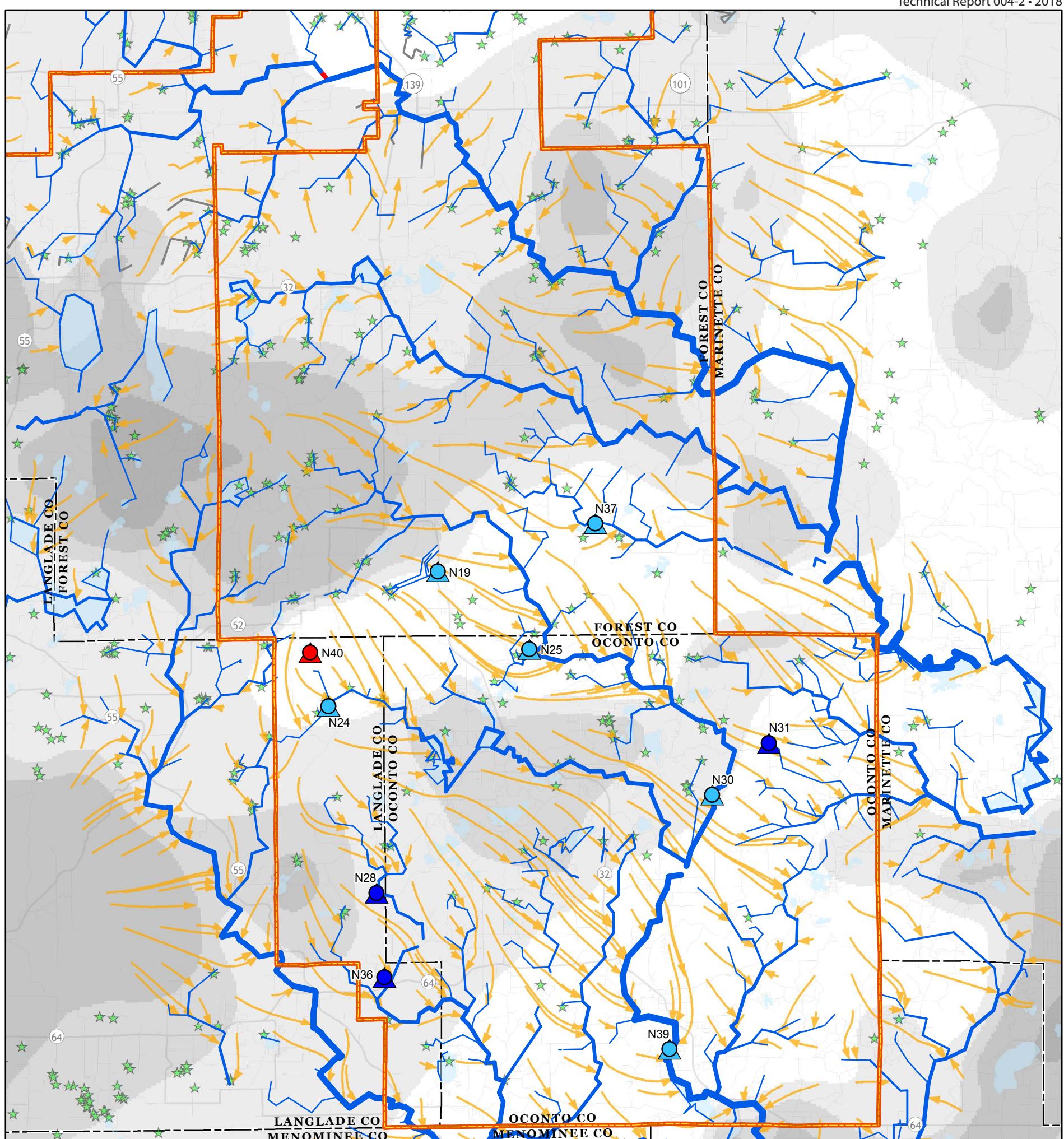


0 4 Miles

Springs and spring ponds from Macholl, 2007. Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Hydrography from National Hydrography Dataset, 2012.

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 9b
Surface water chemistry and simulated baseflow
Southern Nicolet Unit
Wisconsin Geological and Natural History Survey
Technical Report 004-2 • 2018



Stream, spring, and lake samples¹

Conductivity, $\mu\text{s}/\text{cm}$

● <40

○ >200–300

● >300

Alkalinity, mg/L

▲ <20

△ >100–150

▲ >150

Simulated stream baseflow, by color and line weight²

Dry

Gaining from groundwater

Losing to groundwater

Baseflow, cfs

≤2

>2–7

>7–14

>14–20

>20–35

>35–55

>55–80

>80–100

>100–150

>150

Nicolet Unit

Springs and spring ponds

Simulated groundwater flow path

Saturated glacial aquifer thickness, ft

≤30

>30–60

>60–100

>100–200

>200

¹Label indicates site number. See report for further explanation.

²Color indicates interaction with aquifer; linewidth proportional to baseflow volume. Gray lines indicate streams that are represented in the flow model but have zero simulated baseflow. Far-field streams not shown.



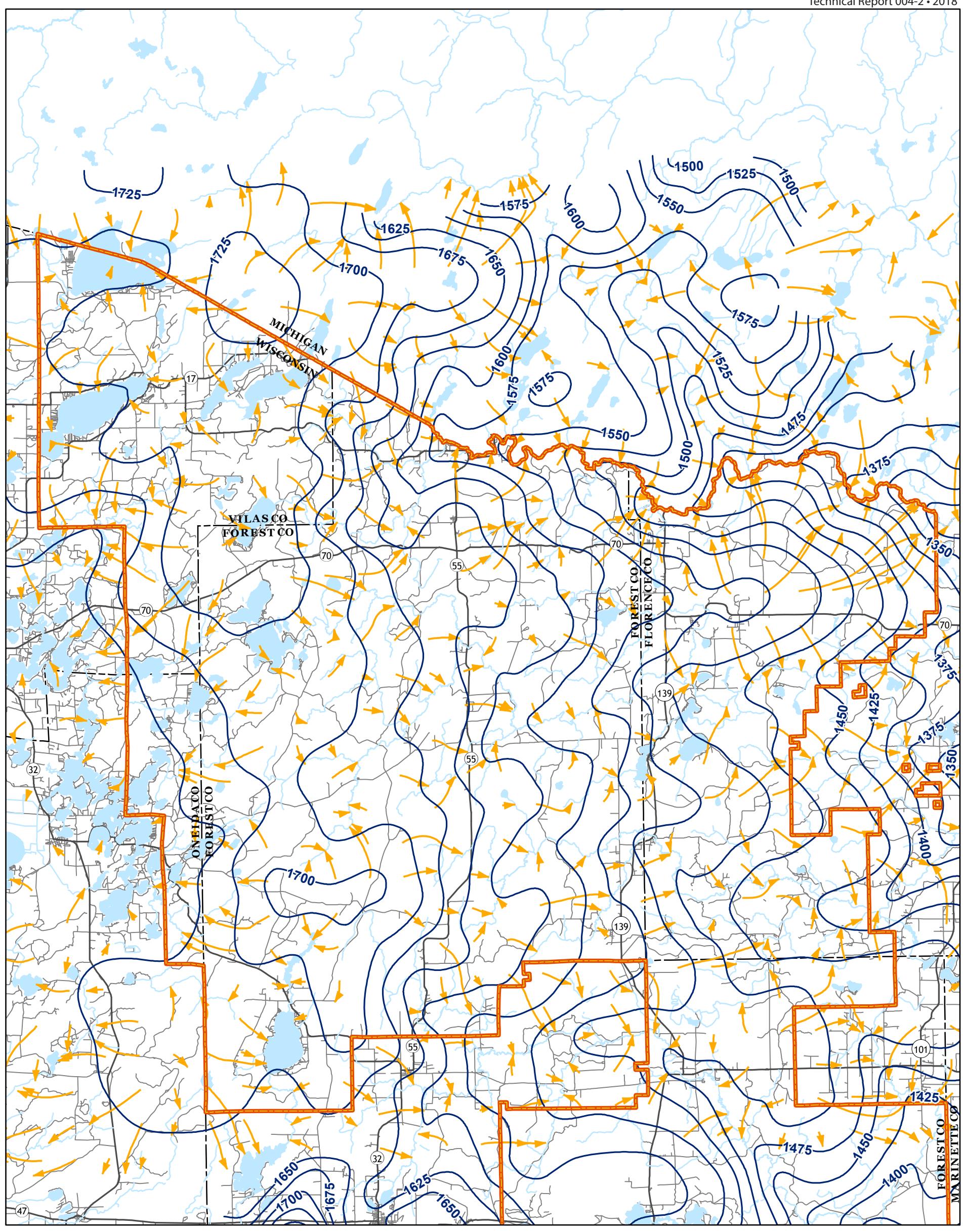
0

4 Miles

Springs and spring ponds from Macholl, 2007. Political boundaries from Wisconsin DNR, 2011. National Forest boundaries from the USDA Forest Service, 2011. Roads from U.S. Census Bureau, 2015. Hydrography from National Hydrography Dataset, 2012.

**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 10a
Model-simulated water table
Northern Nicolet Unit
Wisconsin Geological and Natural History Survey
Technical Report 004-2 • 2018



Nicolet Unit

— Simulated water table; contour interval 25 ft

→ Simulated flow paths

0 4 Miles



**Groundwater Data Summary for the
Nicolet Unit, Chequamegon-Nicolet National Forest**
Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties, Wisconsin

Plate 10b
Model-simulated water table
Southern Nicolet Unit
Wisconsin Geological and Natural History Survey
Technical Report 004-2 • 2018

