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science for a changing world

Ground-Water Monitoring in the Lake Michigan Basin

Lake Michigan Pilot – National Monitoring Conference

May 21, 2008

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

Reasons for GW Monitoring

- Water Availability/Water Supply
- Conflict Resolution
- Drought Warning
- Diversion of Great Lakes Water by GW Pumping
- Water Quality in the Nearshore Zone

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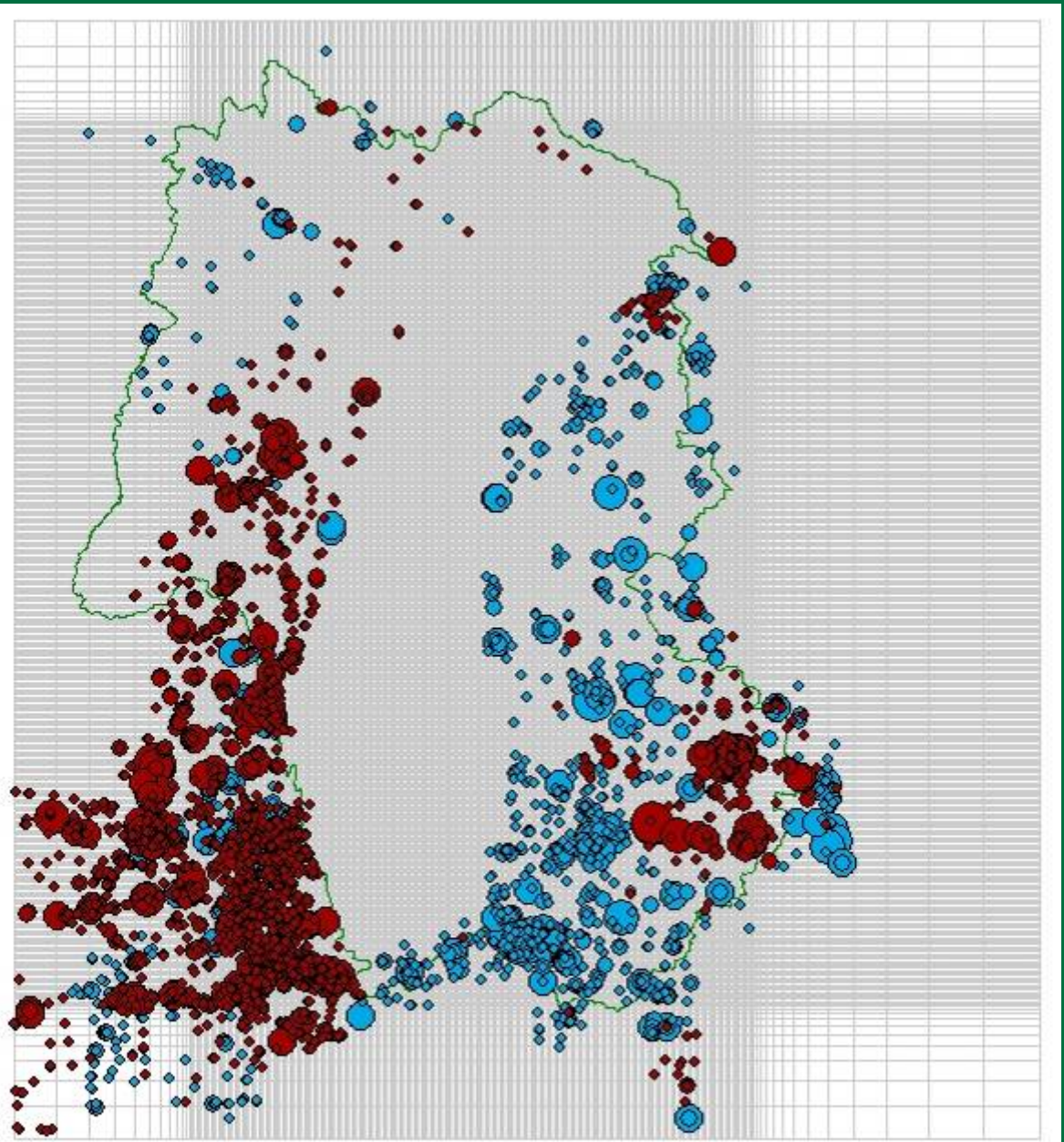
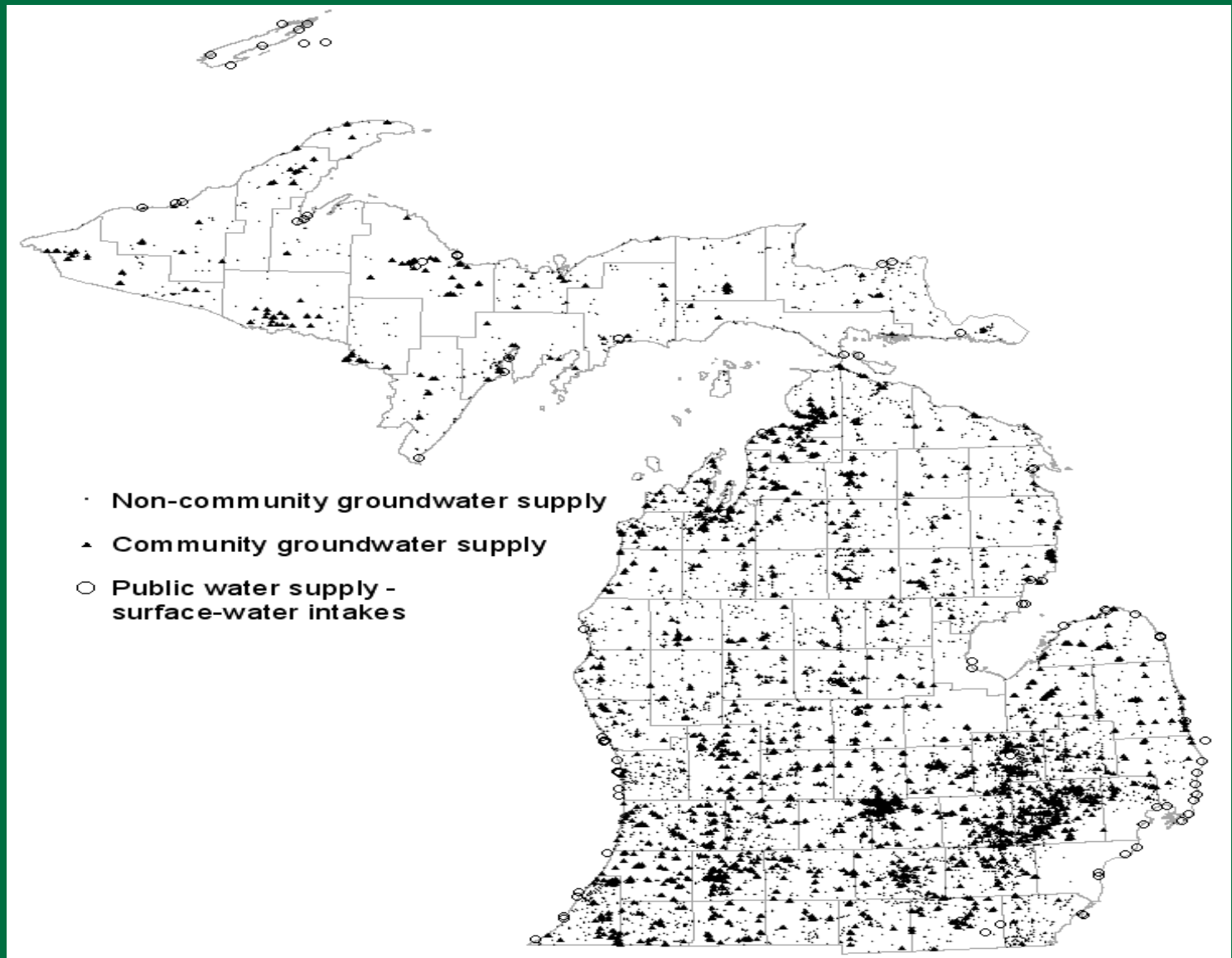
CANADA
U.S.A.
Lake Superior
Thunder Bay
Marathon
Duluth
Marquette
Sault Ste. Marie
Sault Ste. Marie
Sudbury
Trois Rivires
Montral
Cornwall
Massena
Parry Sound
Georgian Bay
Lake Huron
Petoskey
Traverse City
Owen Sound
Kingston
Trenton
Lake Ontario
Oswego
Toronto
Rochester
Syracuse
Hamilton
Niagara Falls
Buffalo
Lake Michigan
Green Bay
Bay City
Saginaw
Flint
Sarnia
London
Grand Rapids
Lansing
Milwaukee
Kalamazoo
Battle Creek/ Jackson
Detroit
Windsor
Lake Erie
Erie
Chicago
Portage/Michigan City
Elkhart/Goshen
Toledo
Cleveland/Akron
Fort Wayne
South Bend/Mishawaka
EXPLANATION
Great Lakes Drainage Basin
U.S.A./Canada border
Cities/towns
Ground-water withdrawal rate, in millions of gallons per day
0 50 100 MILES
0 50 100 KILOMETERS
Source map: Environment Canada



Public Supply, 2001 - 2004 Stress Period,
Blue -glacial wells, Brown - bedrock wells, 7600 total

Water Supplies in Michigan



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GW Monitoring for Lake Michigan Basin
Aspects of the GW Flow System

- Understand monitoring data with respect to the gw flow system
- Most areas will need to have deep and shallow monitoring wells – bedrock and glacial deposits
- Karst and fractured-rock aquifers are a special case

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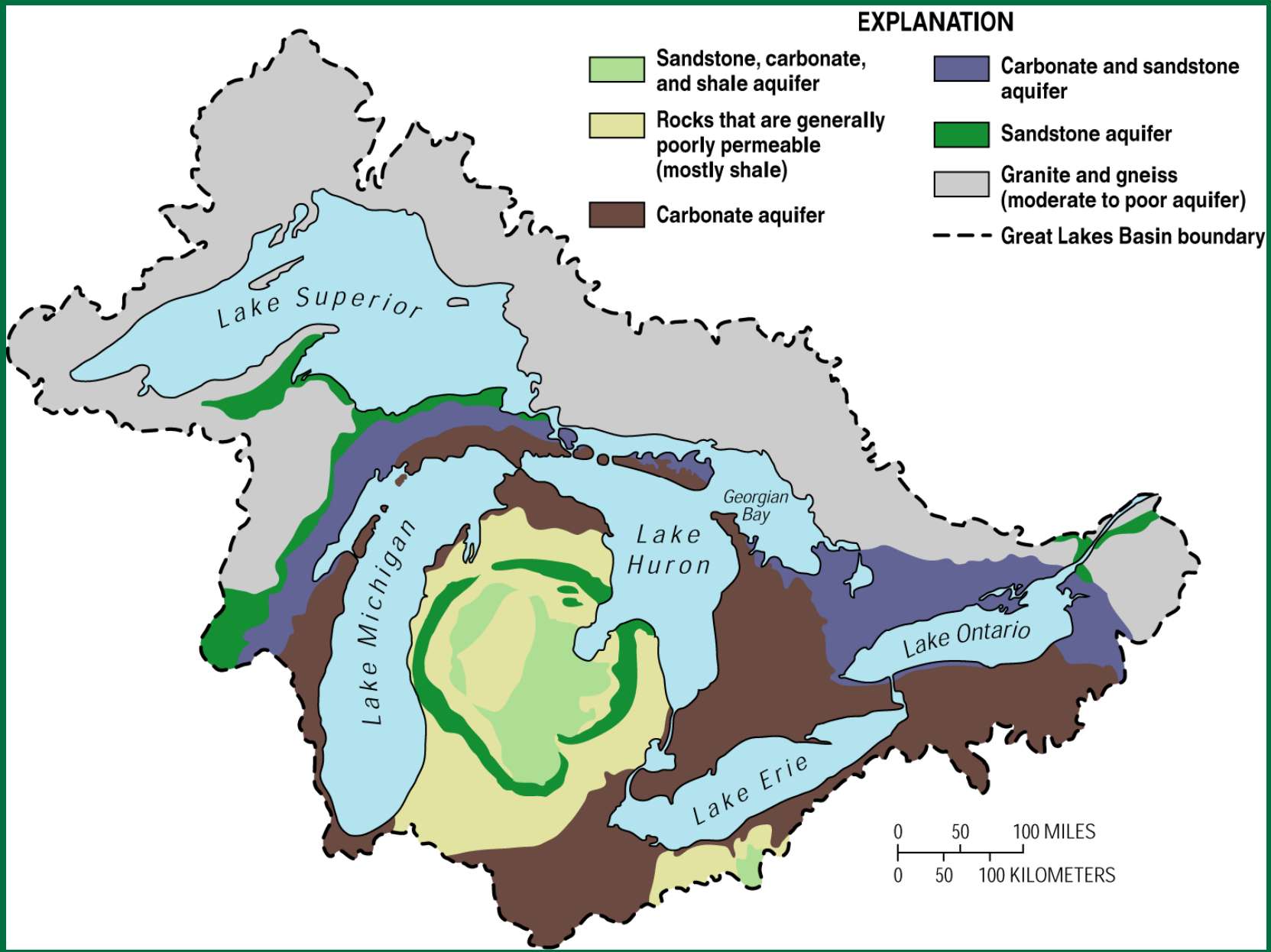
EXPLANATION
Sandstone, carbonate, and shale aquifer
Rocks that are generally poorly permeable (mostly shale)
Carbonate aquifer
Carbonate and sandstone aquifer
Sandstone aquifer
Granite and gneiss (moderate to poor aquifer)
Great Lakes Basin boundary
Lake Superior
Lake Michigan
Georgian Bay
Lake Huron
Lake Ontario
Lake Erie
0 50 100 MILES
0 50 100 KILOMETERS

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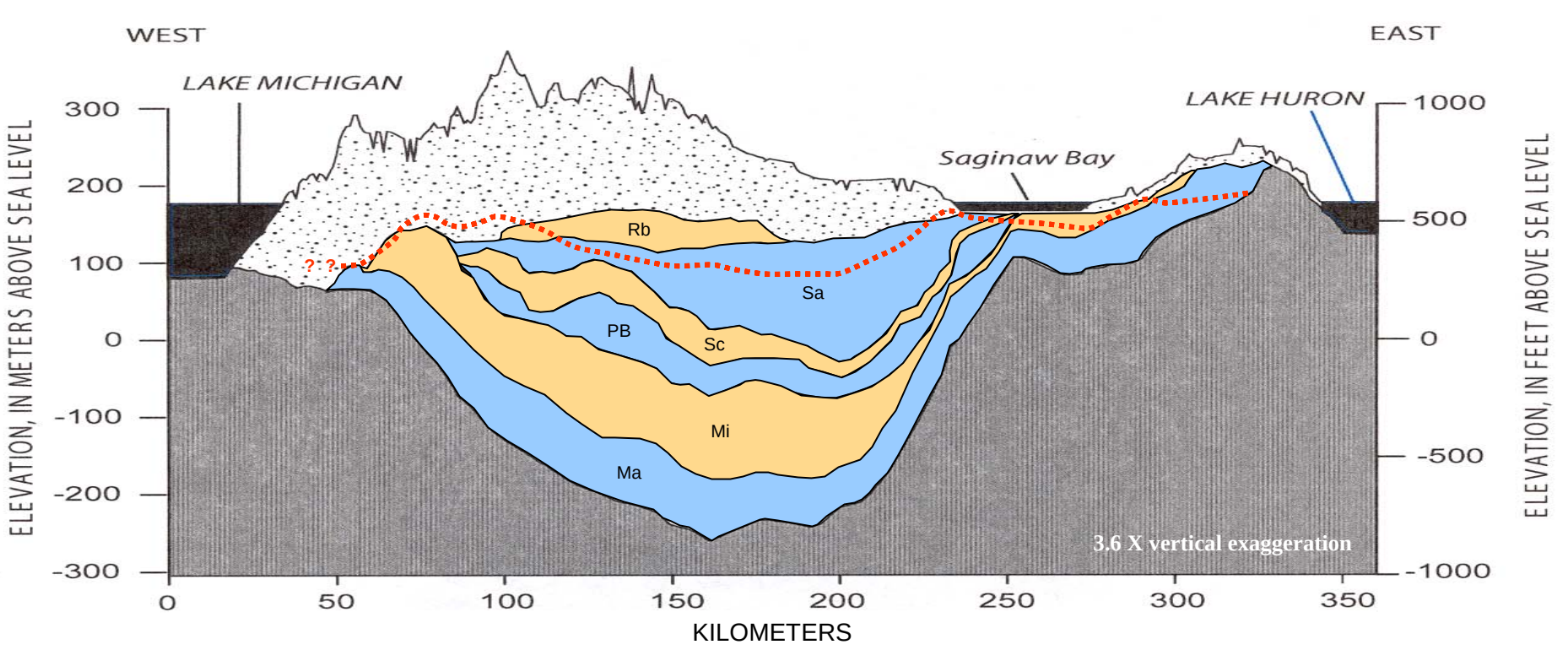
Bedrock Aquifers



	GLACIAL DEPOSITS
Rb	RED BEDS CONFINING UNIT
Sa	SAGINAW AQUIFER
Sc	SAGINAW CONFINING UNIT
PB	PARMA-BAYPORT AQUIFER
Mi	MICHIGAN CONFINING UNIT
Ma	MARSHALL AQUIFER
	COLDWATER CONFINING UNIT

Freshwater / Saline-water interface

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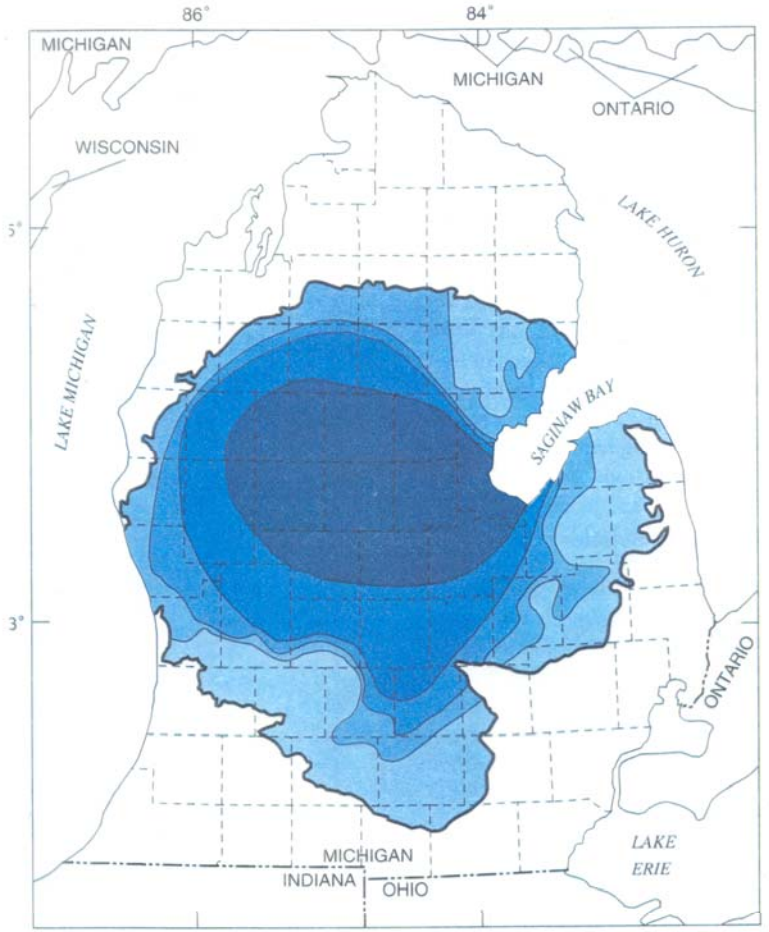

gure 7. Distribution of dissolved chloride in ground water from the Marshall aquifer, ›wer Peninsula of Michigan.

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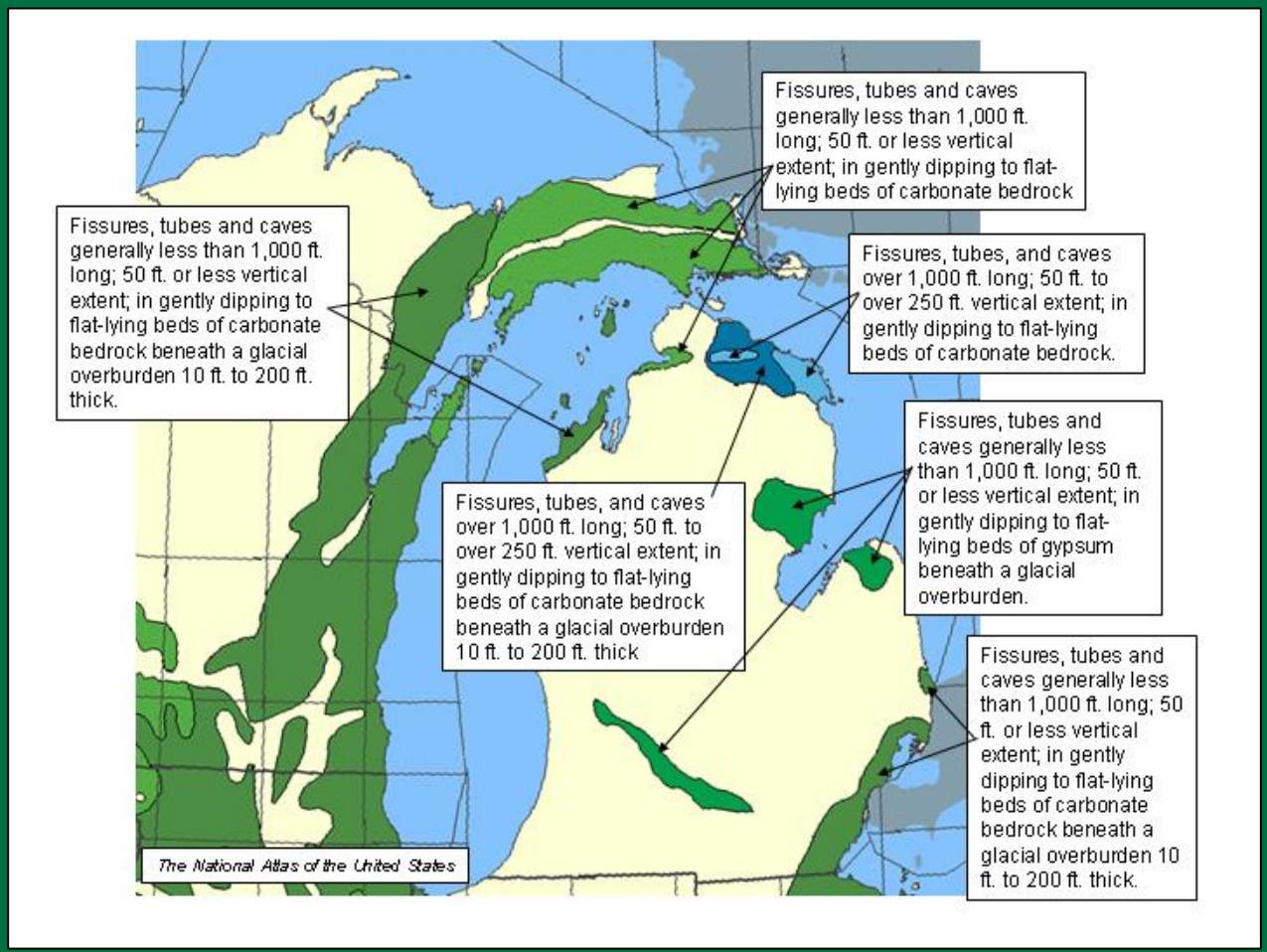
Karst Features



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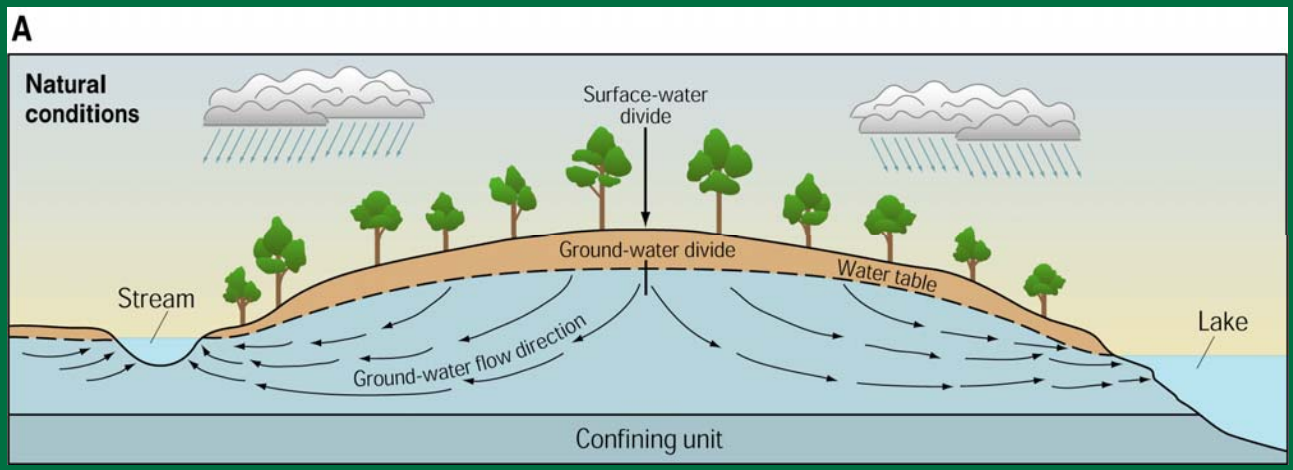
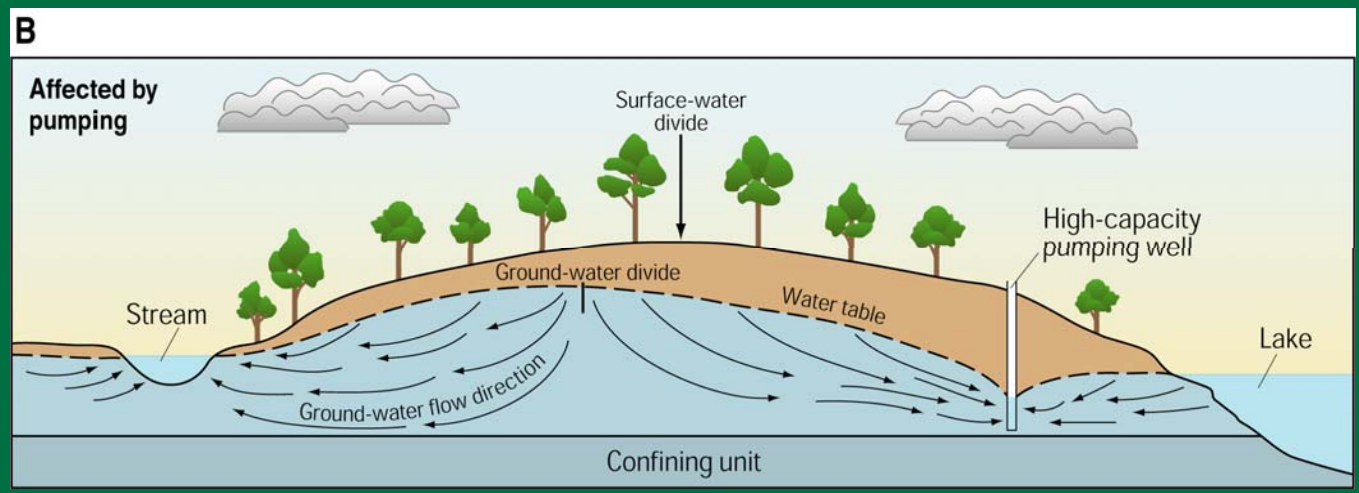
Ground-Water Divides





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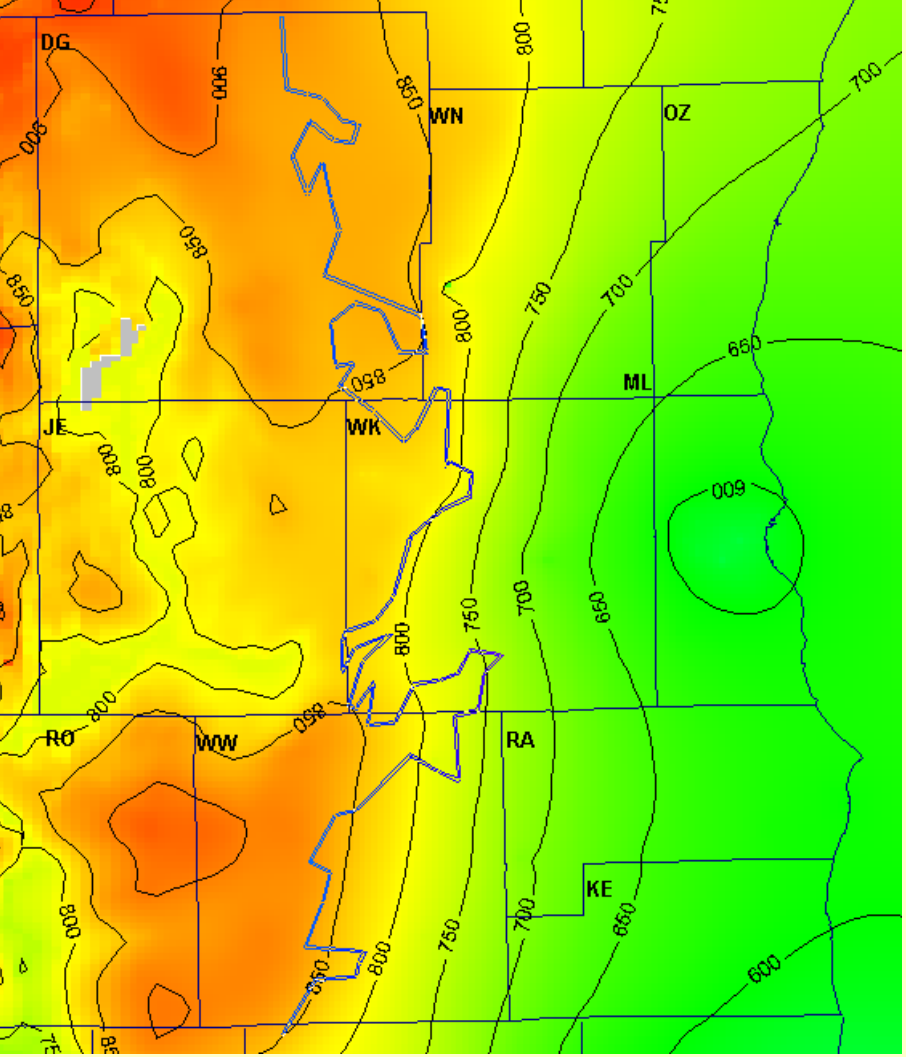

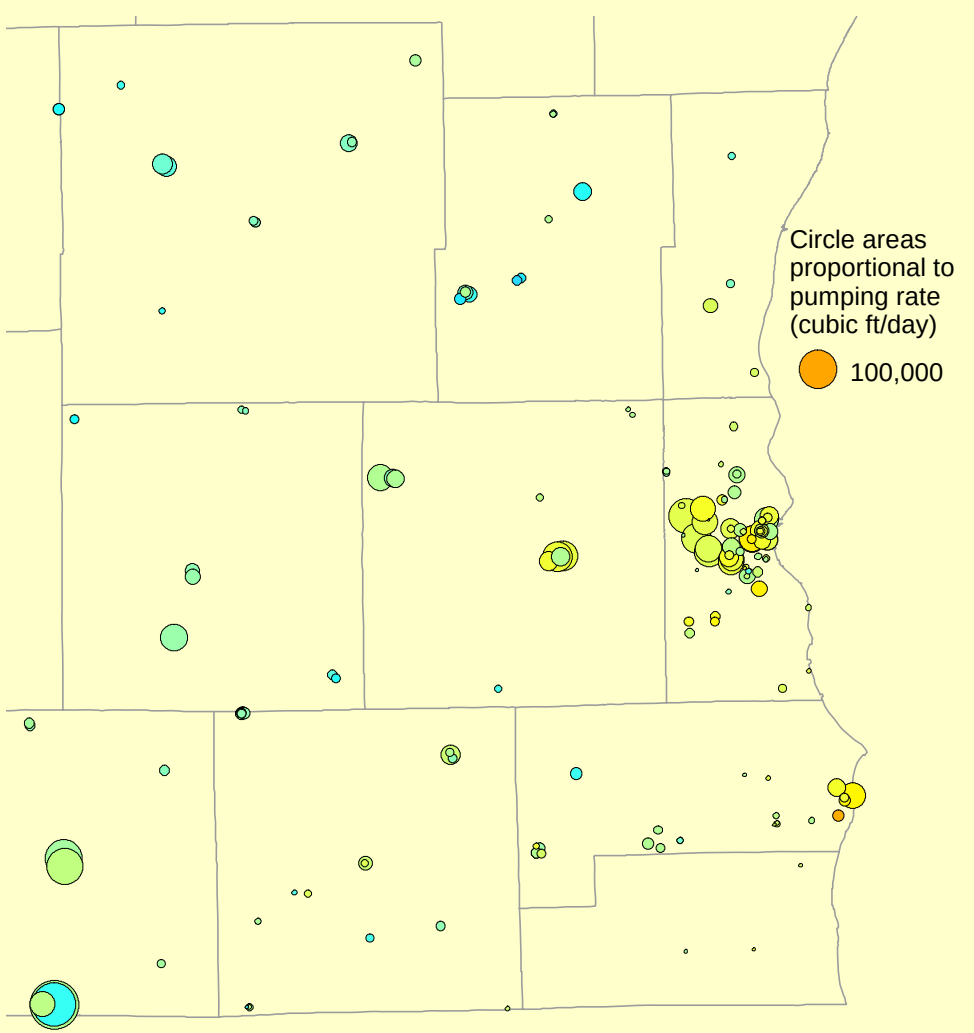

1930 -1940

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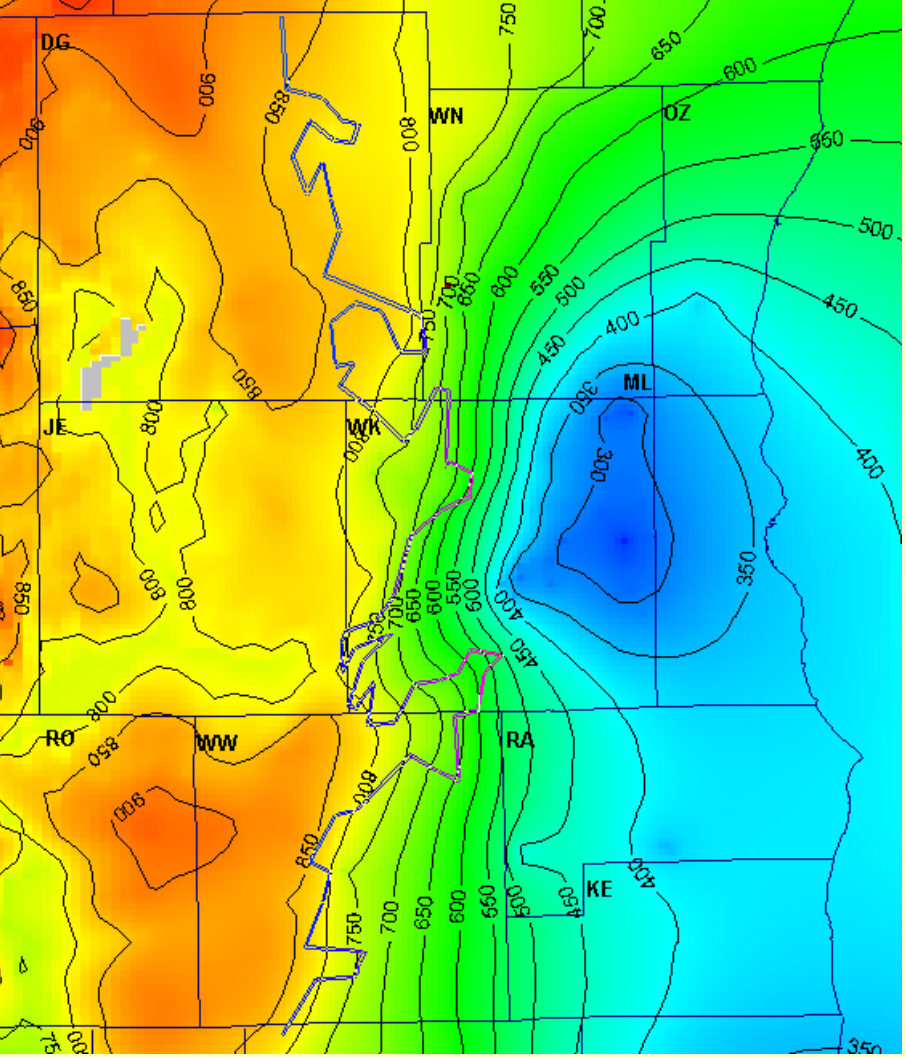

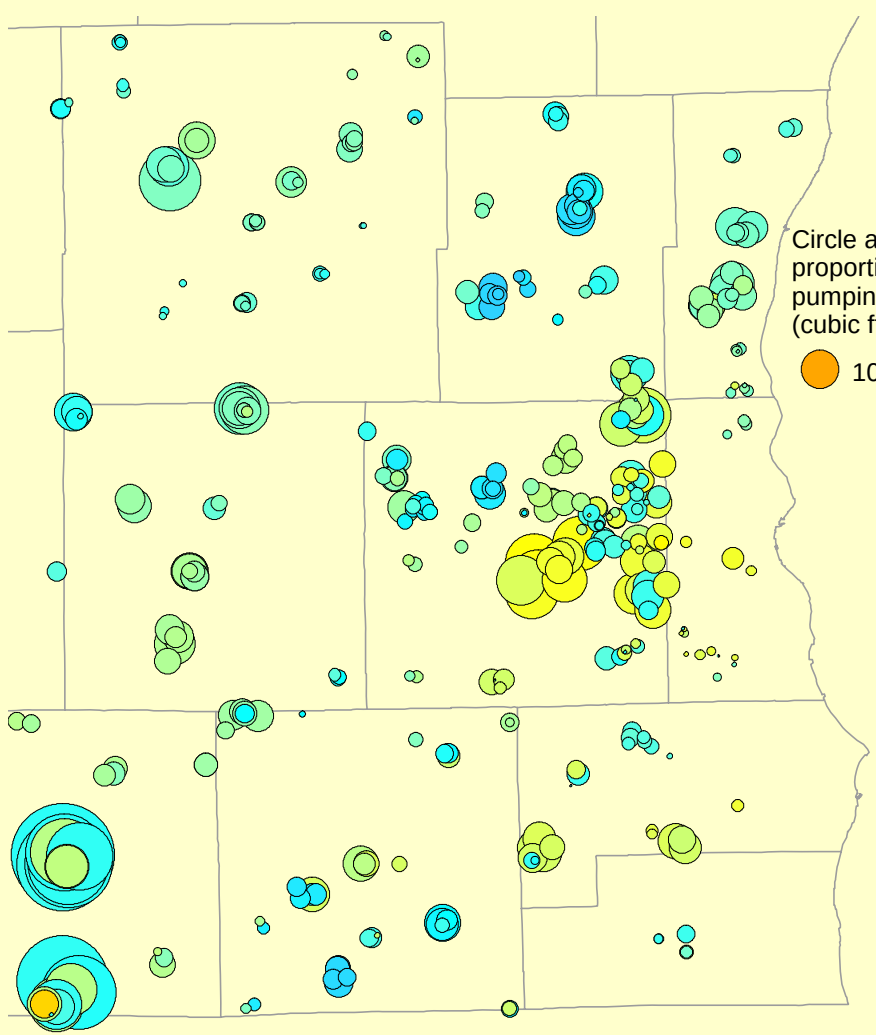

2000 - 2010

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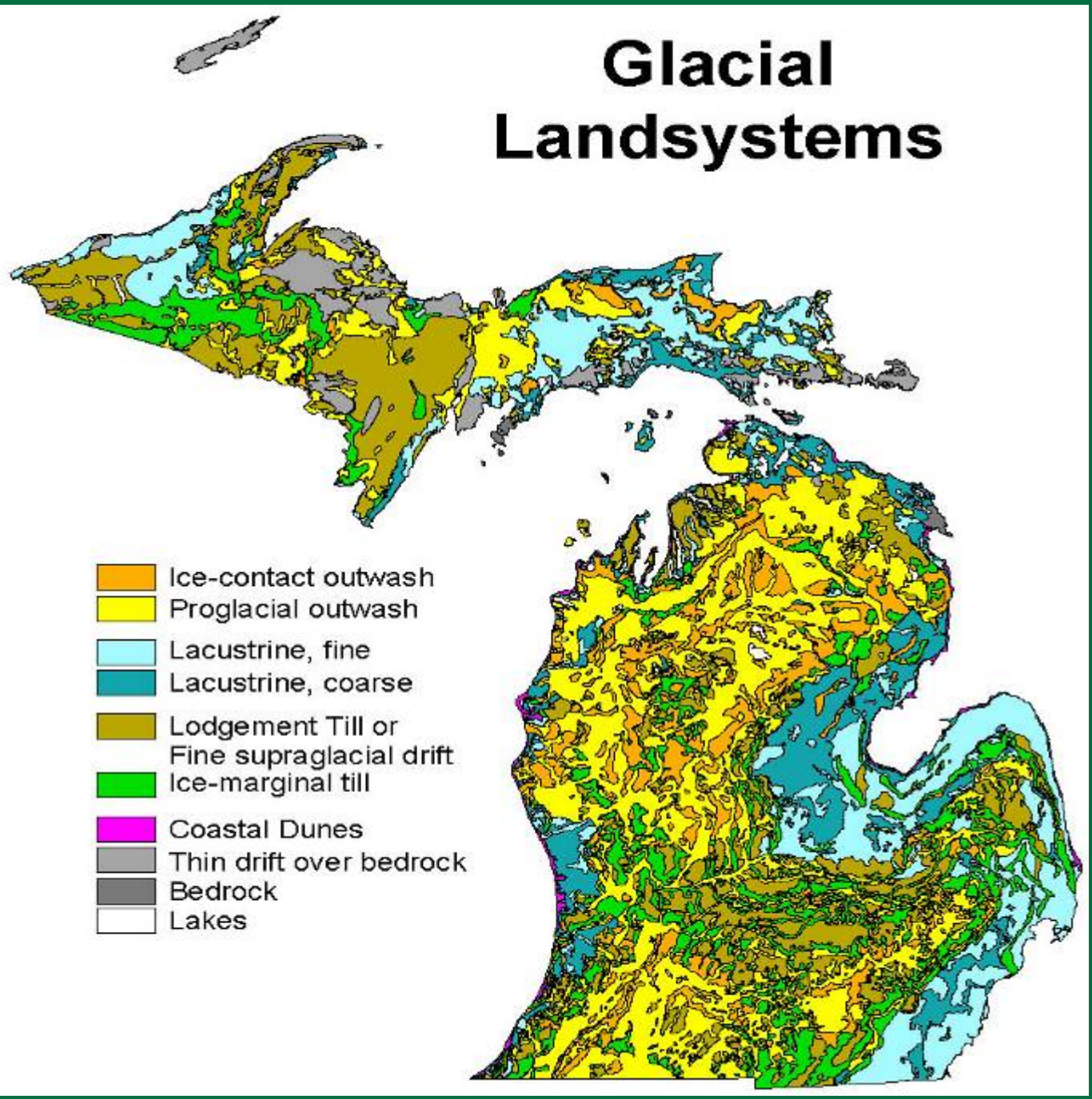
Glacial Landsystems



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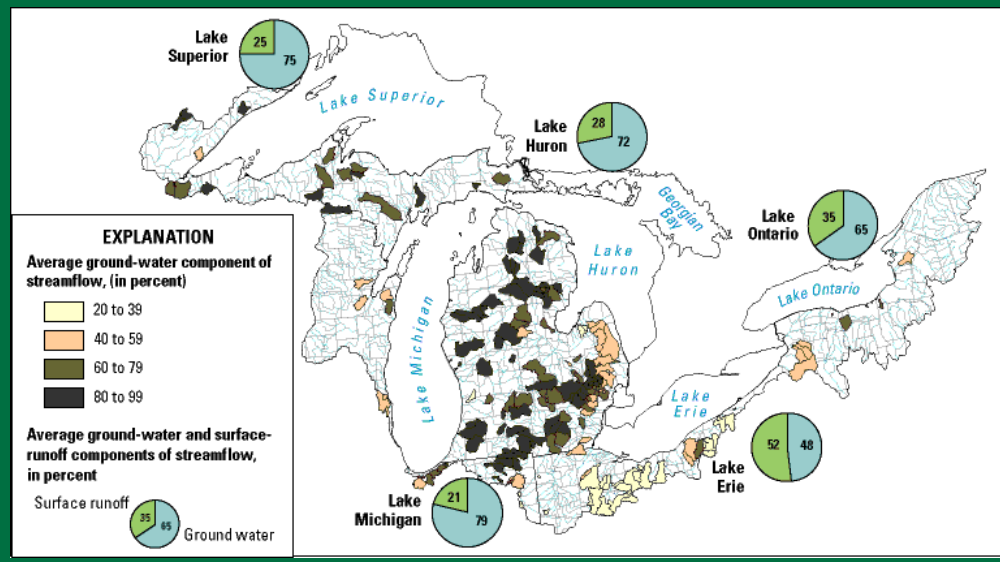
Ground-Water/Surface-Water Interaction

- Nearly 80 percent of discharge to Lake Michigan originates as ground water
- How does gw pumping affect ecosystems dependent on gw discharge to streams?
- Important for water-quality issues such as non-point source



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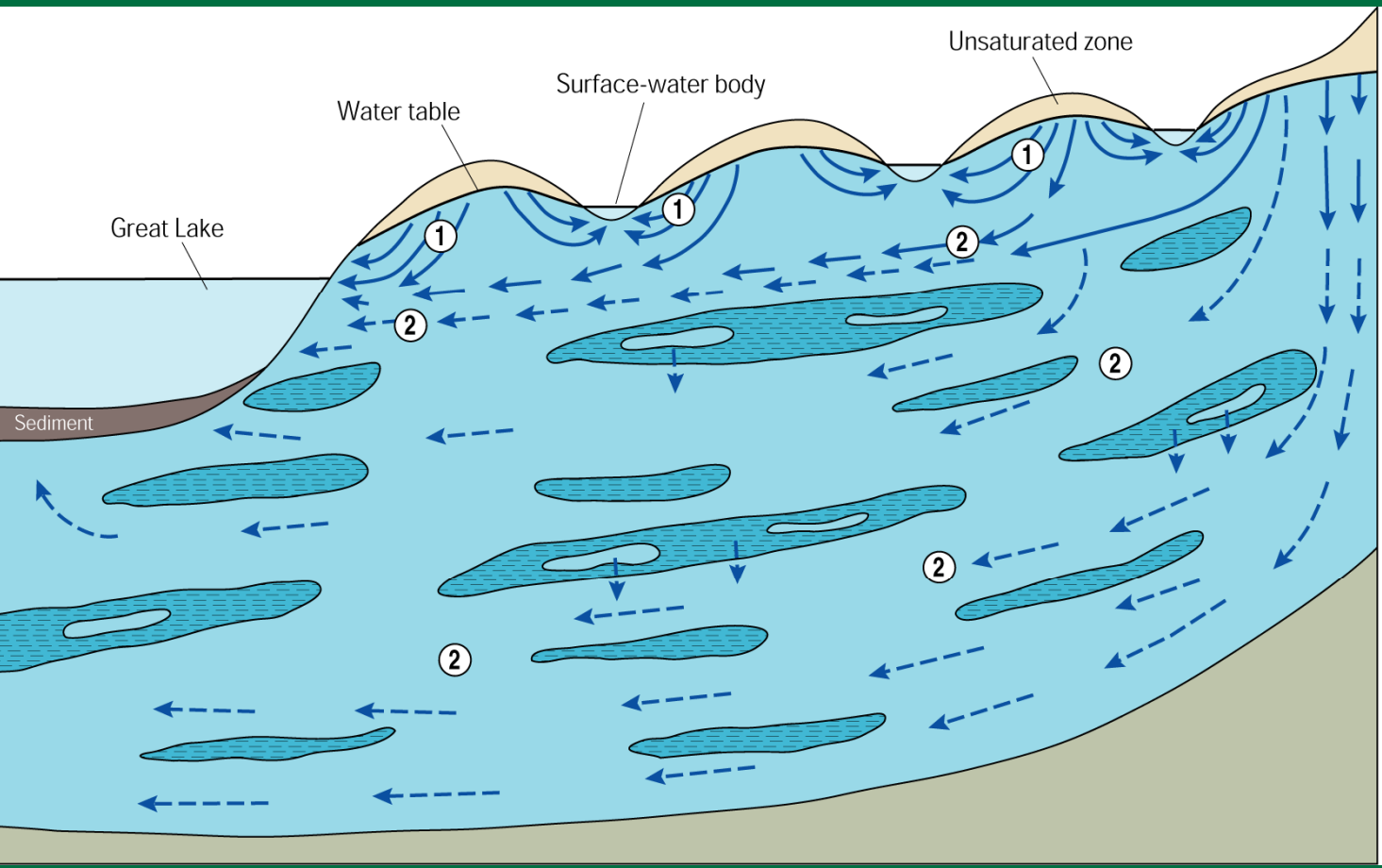
Unsaturated zone
Surface-water body
Water table
Great Lake
Sediment
1
2
EXPLANATION
Highly permeable aquifer
Poorly permeable confining unit
Very poorly permeable bedrock
Direction of ground-water flow, local ground-water system
Direction of ground-water flow, regional ground-water system
1 Local ground-water system
2 Regional ground-water system

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Importance of Old GW Level Data

- Lots of GW level data starting in the 1930's
- Many sites discontinued in the 1970's and 1980's
- Water-level data to identify hydraulic properties – days to months
- Water-level data to address long-term gw development – years to decades

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6-27-91 @1400
PJK
19.04
Kalamazoo Co.
Prairie View Park
8-9-91
@1100 PJK
19.00
18.8
18.9
Start
Printed in U.S.A.
Leupold & Stevens, Inc., Beaverton, Ore.
Chart
Water Level Recorder — Type F

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9-195
(July 1949)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION 4N 1W 18-1

WATER LEVEL MEASUREMENTS (Office) FIELD NO.

OWNER Marble School OFFICE NO.

LOCATION Haydon Road PROJECT

MEASURING POINT top of 3" casing

ELEVATION OF MEASURING POINT 2.50 ft below L.S.D.

DATE 1961	HOUR	DEPTH TO WATER	ELEV. OF WATER SURFACE	MEAS. BY	REMARKS (Nearby wells pumping, etc.)
Jan. 31	10:55 A.M.	30.62	33.12	PRG	32.00 - 1.38
Feb. 27	11:39	31.36	33.86	PRG	33.00 - 1.64
Mar. 29	3:40 P	30.46	32.96	"	32.00 - 1.54
Apr. 27	11:45 A	30.55	33.05	✓	33.00 - 2.45
May 29	3:15 P	32.49	34.99	✓	33.00 - 0.51
June 27	3:15 P	32.60	35.10	✓	3800 - 5.40
July 27	4:30 P	34.13	36.63	✓	3700 - 2.87
Aug. 31	10:45 P	33.18	35.68	"	3500 - 1.82
Sept. 26	12:40 pm	33.82	36.32	✓	3600 - 2.18
Oct. 30	12:20 pm	32.70	35.20	PRG GCH	3500 - 2.80
Nov. 27	10:55 am	32.35	34.85	GCH	3400 - 1.65
Dec. 28	1:55	32.36	34.86	GCH	3400 - 1.64

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GW Monitoring for Lake Michigan Basin Monitoring Principles

- First and foremost, a collaborative process is required
- Organize so that the same data can be analyzed for both local and regional purposes

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GW Monitoring for Lake Michigan Basin Monitoring Areas

- Areas with large withdrawals
- Areas not effected by withdrawals (for drought and climate studies)
- Areas to be developed
- Areas with important amounts of recharge

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GW Management Decisions

- Most are made at the State or local level
- Effective monitoring must involve these units of government
- However, gw issues are becoming more regional

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USGS Monitoring

RASA Studies

Ground-Water Inventory and Map

WelLogic Lithology

Local Studies

Hydrogeology
Mapping
Geostatistics
Geographic Database

Aquifer Tests

Geologic Maps

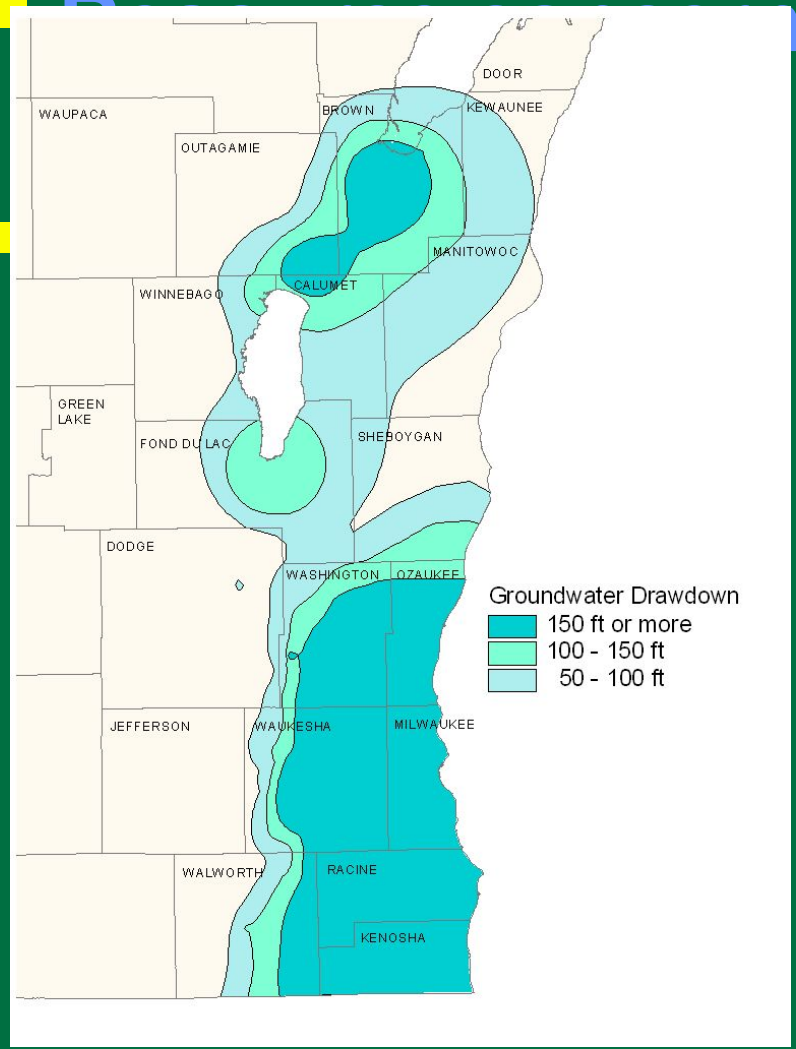
State of Michigan
DEQ
Department of Environmental Quality

USGS
science for a changing world
125 years of science for America

RS&GIS
Michigan State University

Ground-water Management Areas

- Centered on Waukesha and Brown County
- Areas of significant drawdowns and over-pumping
- Water quality problems (arsenic, radium, salinity)
- Need for a coordinated management strategy



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Monitoring Adapted to Degree of Confinement

- Unconfined
  - Gravity drainage
  - Less water-level change
  - Cannot effectively use entire saturated thickness
- Confined
  - Aquifer compression and water expansion
  - Hydraulic pressure reduced
  - Pumping same quantity of water produces larger water-level declines than unconfined aquifers

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Ground-Water Monitoring and Ground-Water-Flow Models

- Used to indicate the status and trends of ground-water availability
- Relate regional modeling simulations to sub-regional scale model simulations
- Climate variability and effects of climate change on recharge and shallow flow systems
- Iterative process – monitoring improves model and vice versa
- Model provides a logical way to evaluate the GW monitoring network

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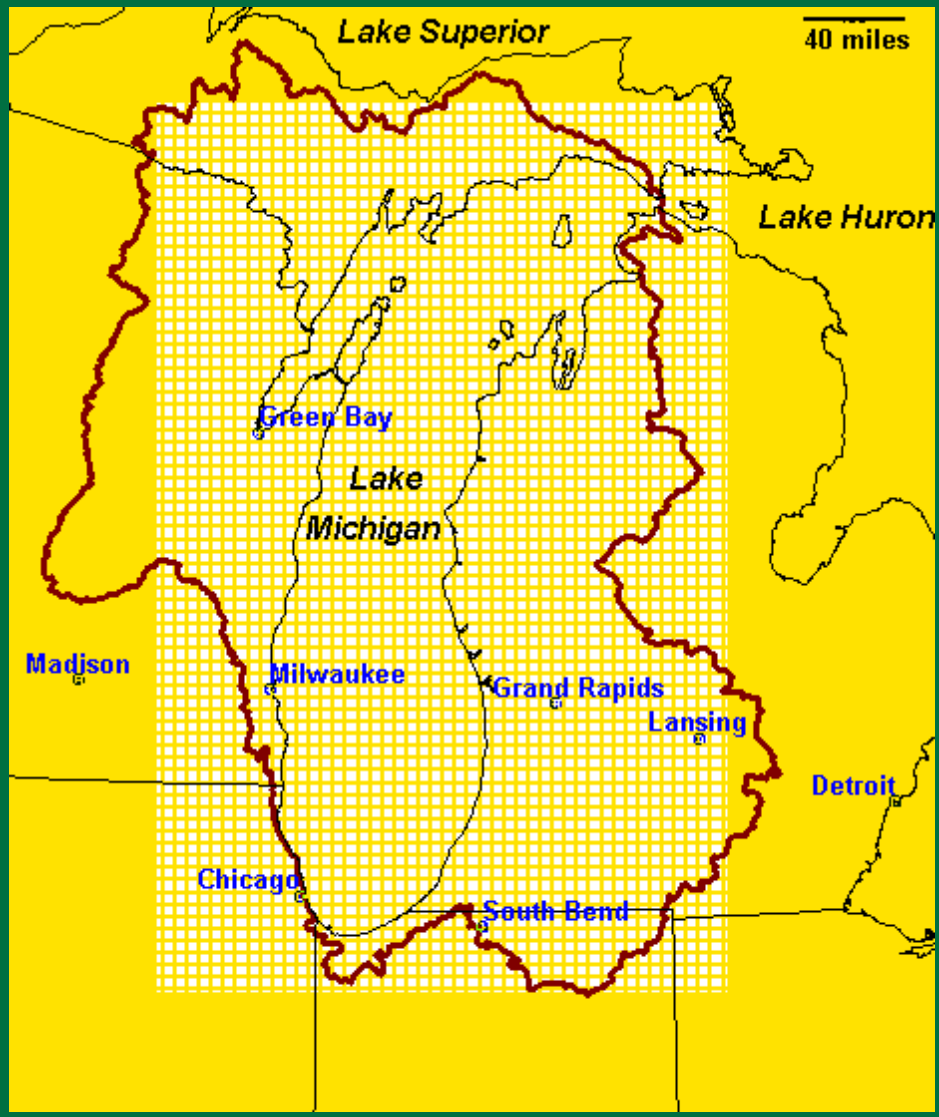

Lake Michigan Basin Model Domain

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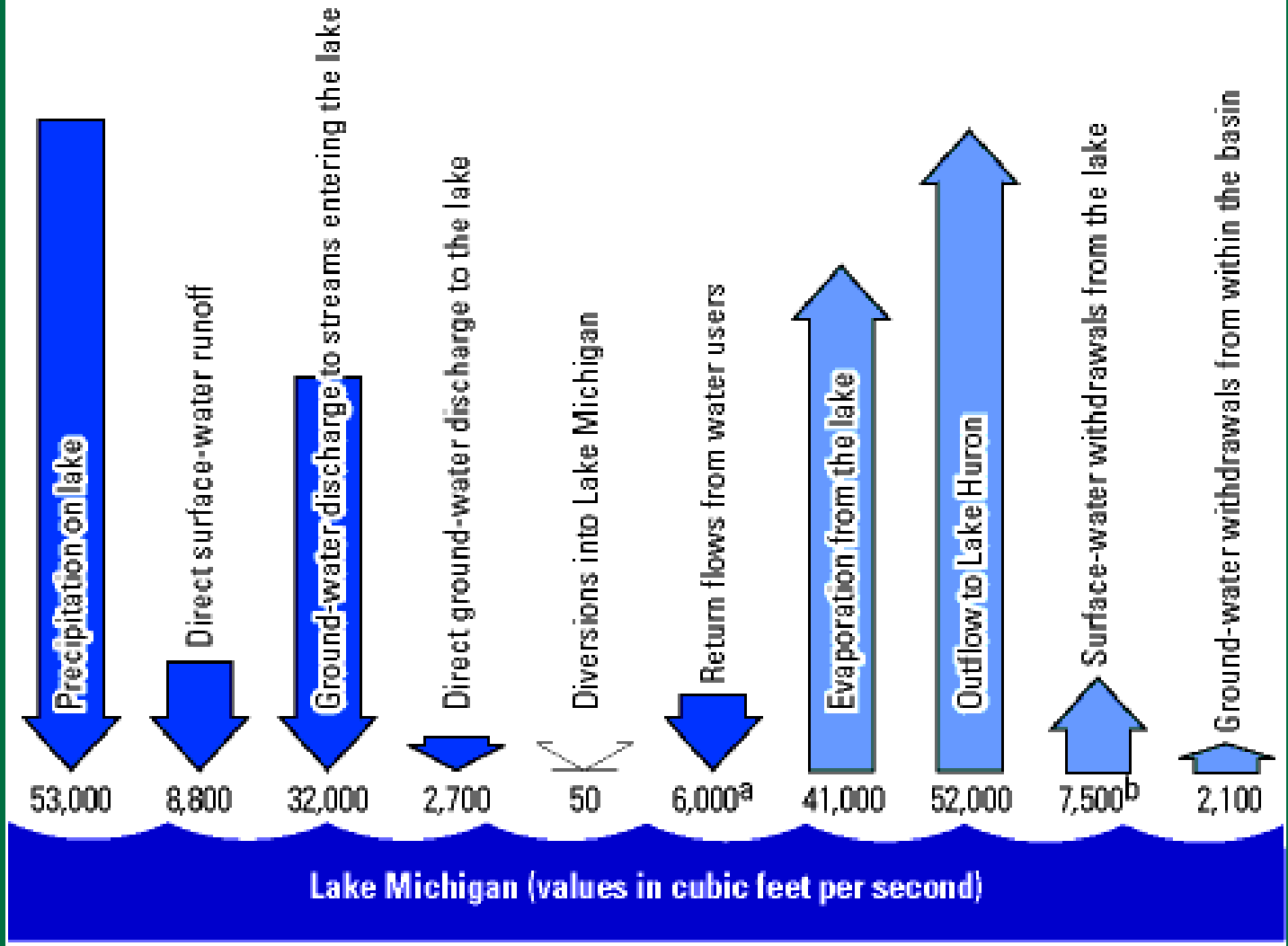

[a]Return flow is reduced by 3,200 ft^3/s that is diverted out of the basin at Chicago, Ill.

[b]Withdrawals for power plant cooling not included

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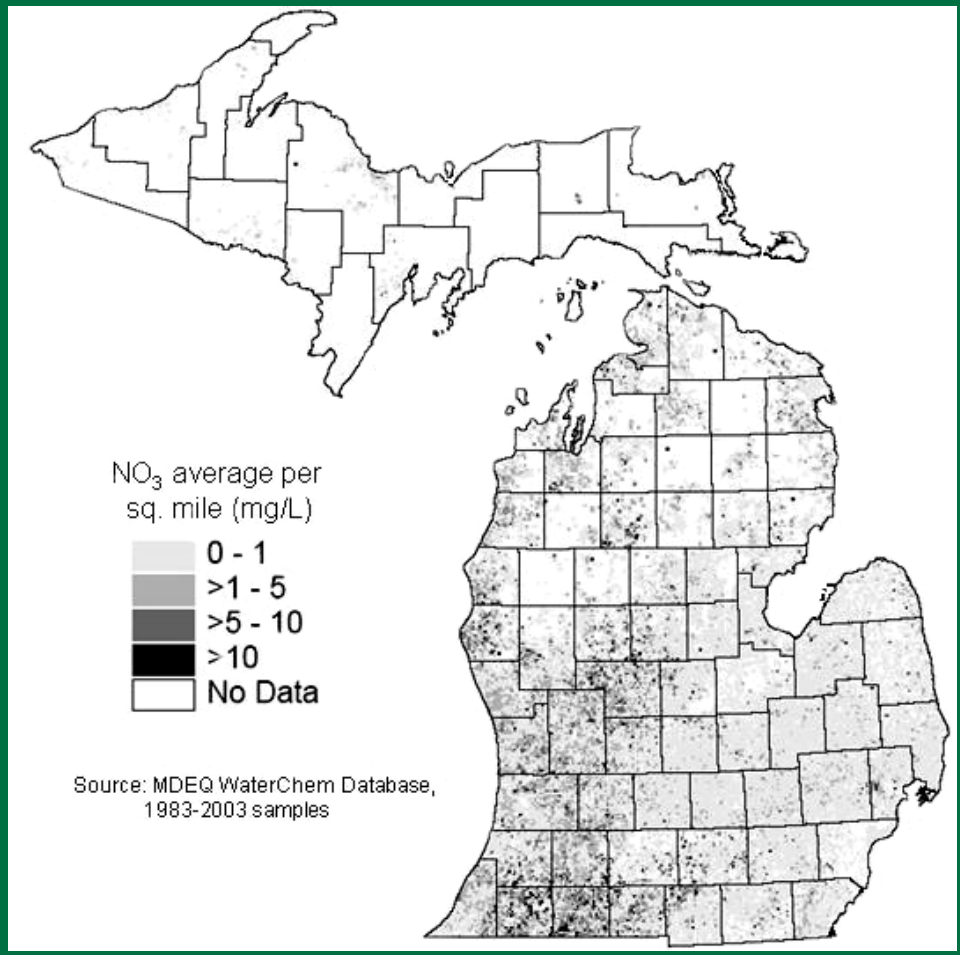
Nitrate Concentrations in Michigan



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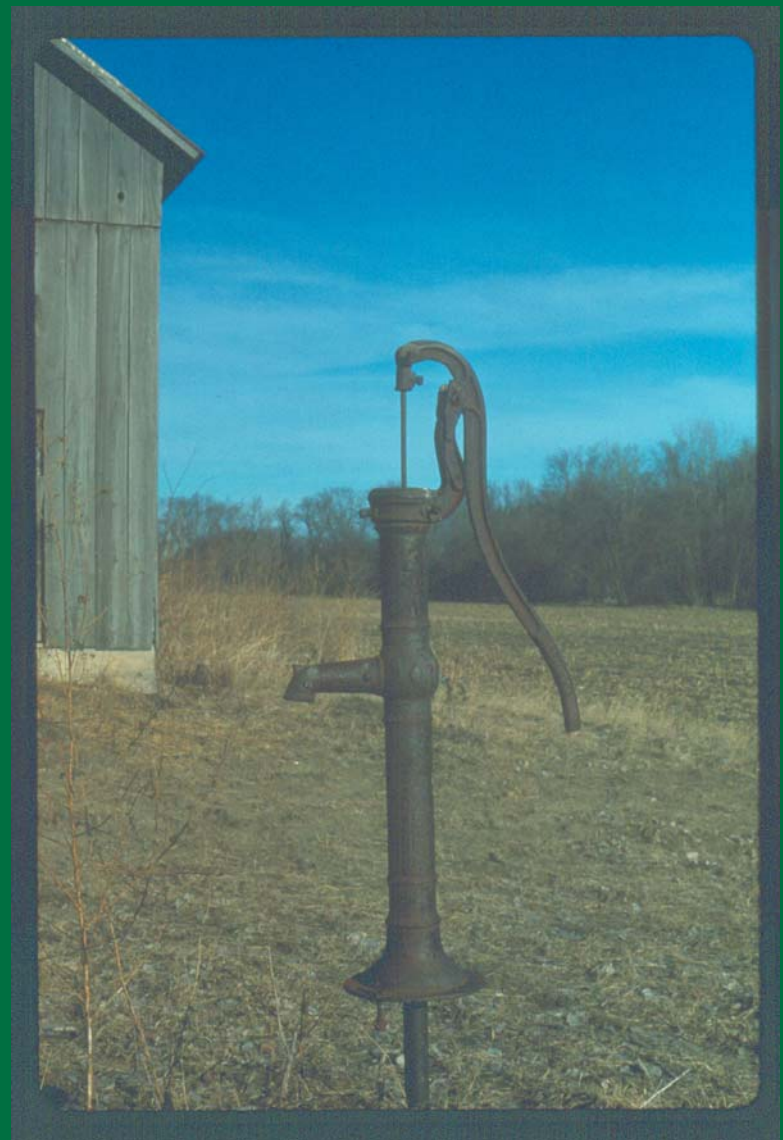
Opportunities to promote regional Ground-Water Monitoring in the Lake Michigan Basin

- Annex to the Great Lakes Charter
- Great Lakes Regional Collaboration
- LaMP Process
- SOLEC



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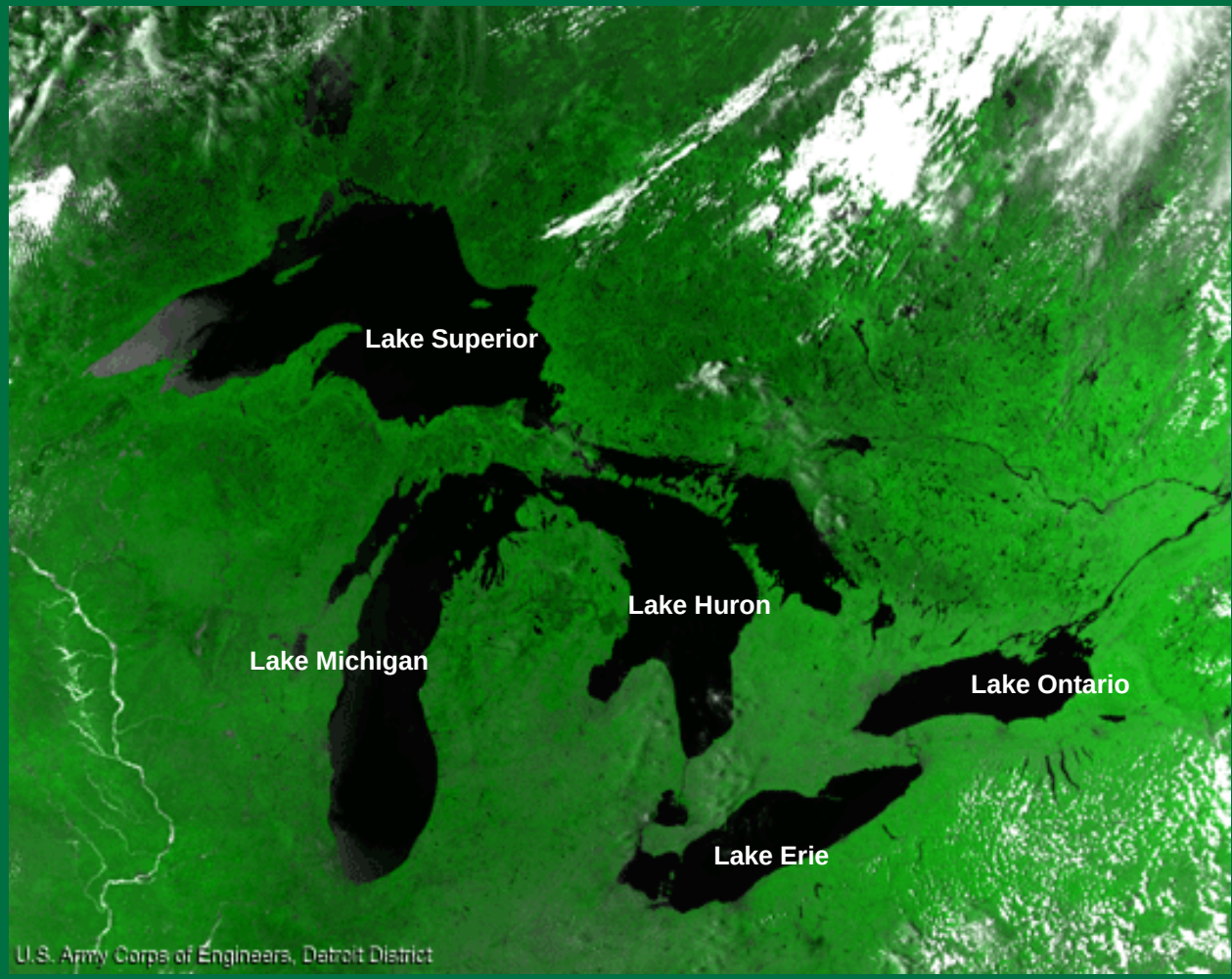
The Great Lakes
An International Treasure



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