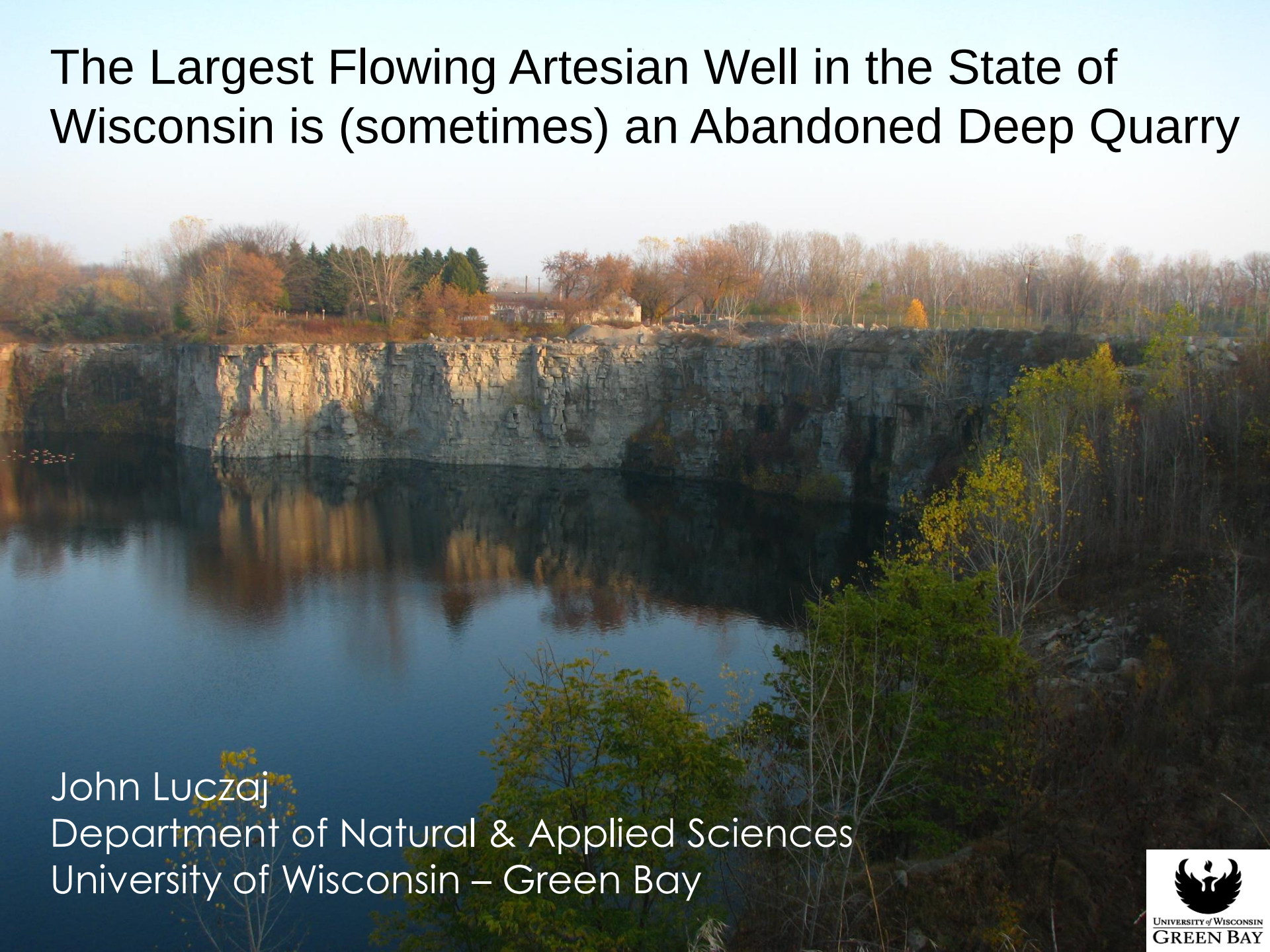
The Largest Flowing Artesian Well in the State of Wisconsin is (sometimes) an Abandoned Deep Quarry



John Luczaj
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University of Wisconsin – Green Bay

University of Wisconsin Green Bay

OBJECTIVES OF THE DUCK CREEK QUARRY STUDY:

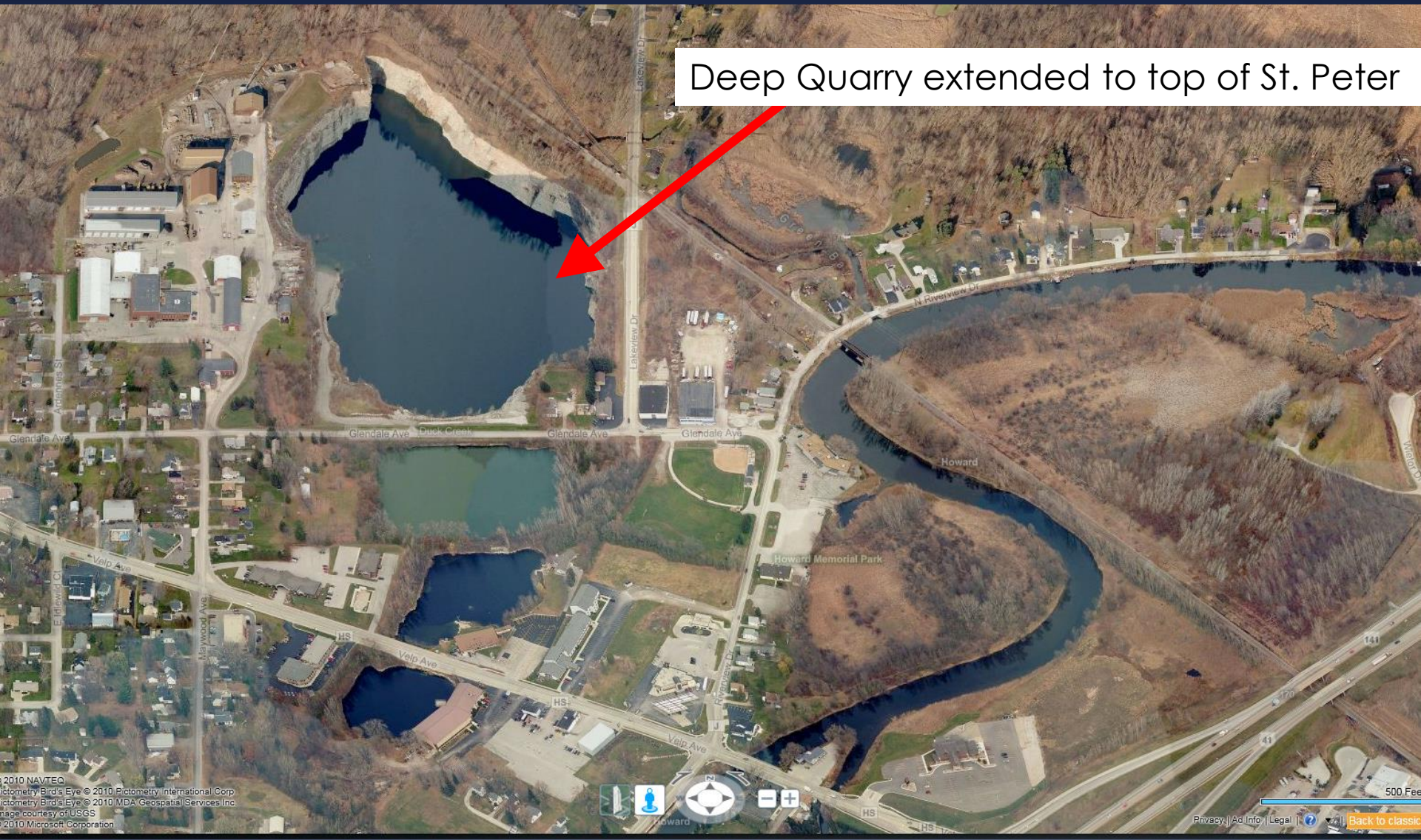
- Monitor water level changes in Duck Creek Quarry through direct measurements and historical reconstructions from photographs.

- Determine if the rate of filling of the quarry has accelerated in response to the switch from groundwater to surface water by municipalities in 2007.

- Determine the extent to which artesian conditions influence outflow.

Photo by John Luczaj – October 4, 2011

Duck Creek Quarries – Village of Howard (Brown County)



Quarries were active between 1827 and 2001.

Photo Courtesy of Pictometry International Corp.
November 18, 2006

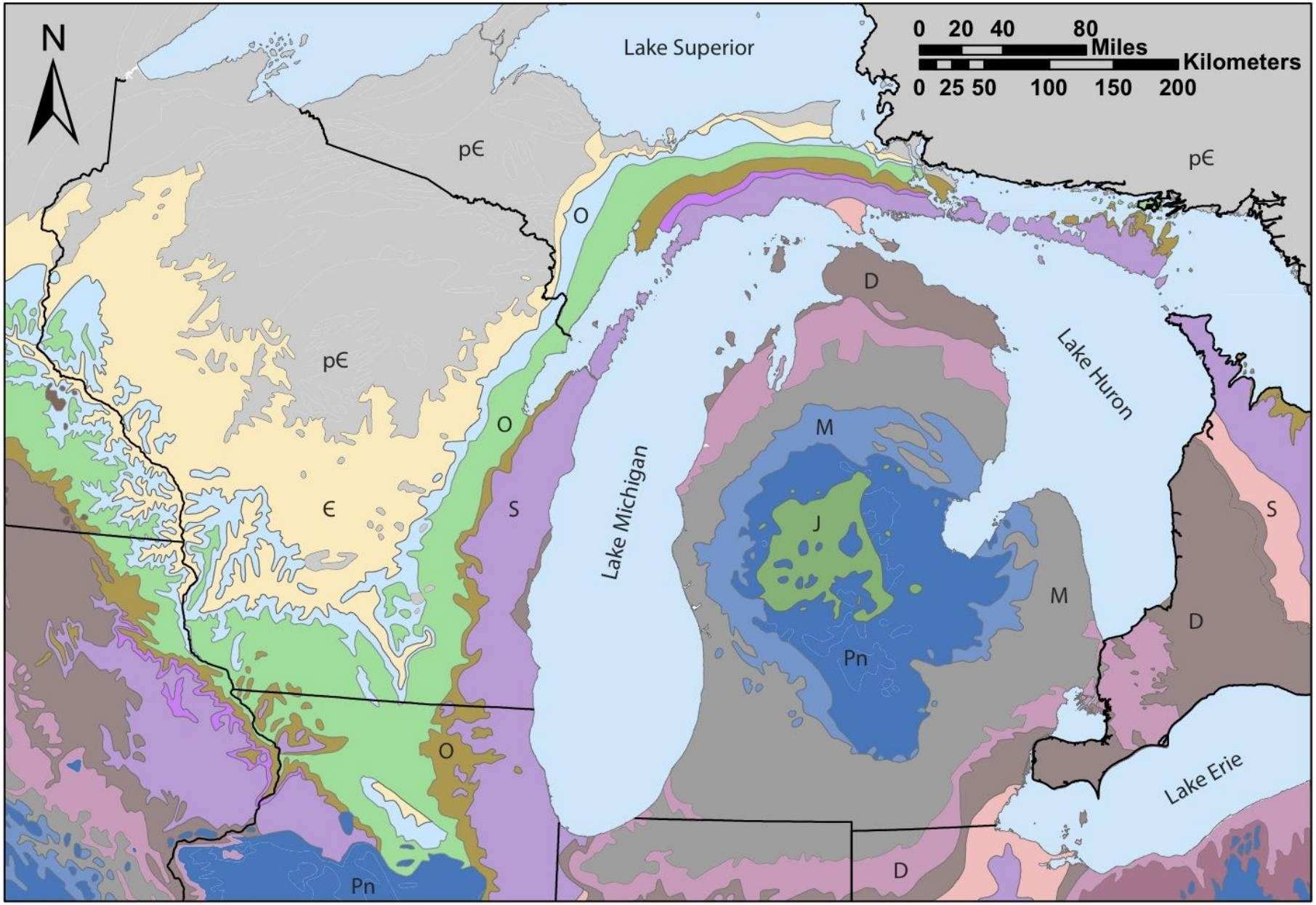
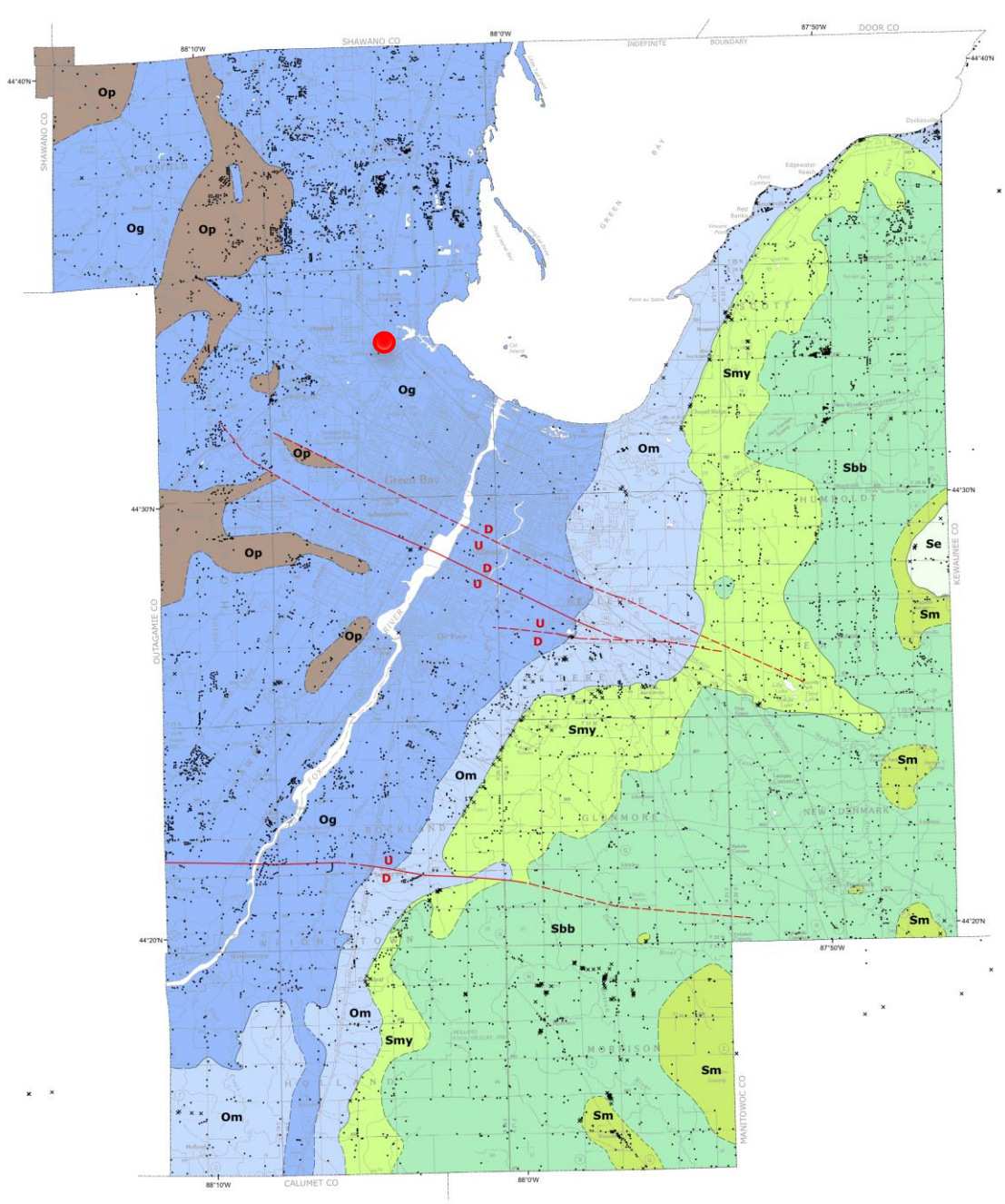
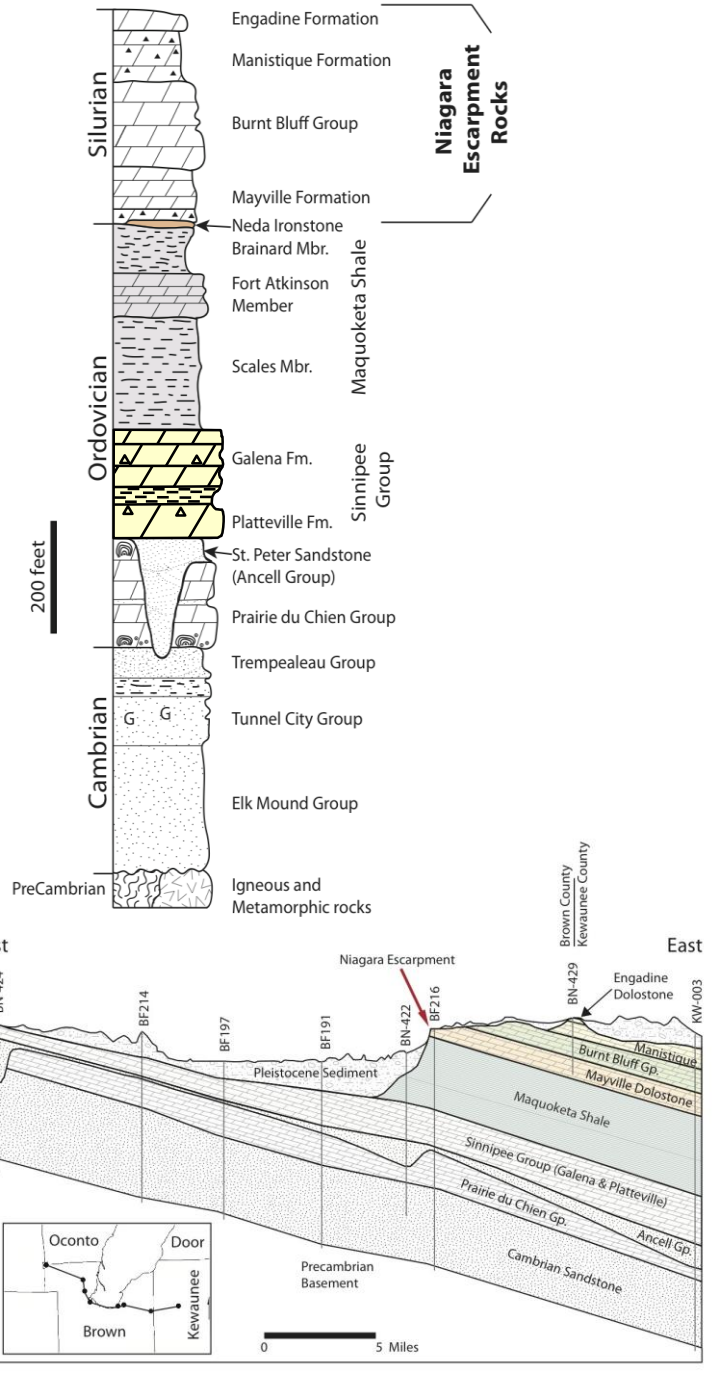


Figure 2a. Bedrock geologic map showing eastern Wisconsin and the ancestral Michigan basin (bullseye pattern). Geologic rock systems (periods) are as follows: pЄ = Precambrian, Є = Cambrian, O = Ordovician, S = Silurian, D = Devonian, M = Mississippian, Pn = Pennsylvanian, J = Jurassic. Base map data modified after Schruben and others (1994) and Ontario Geological Survey (1993).



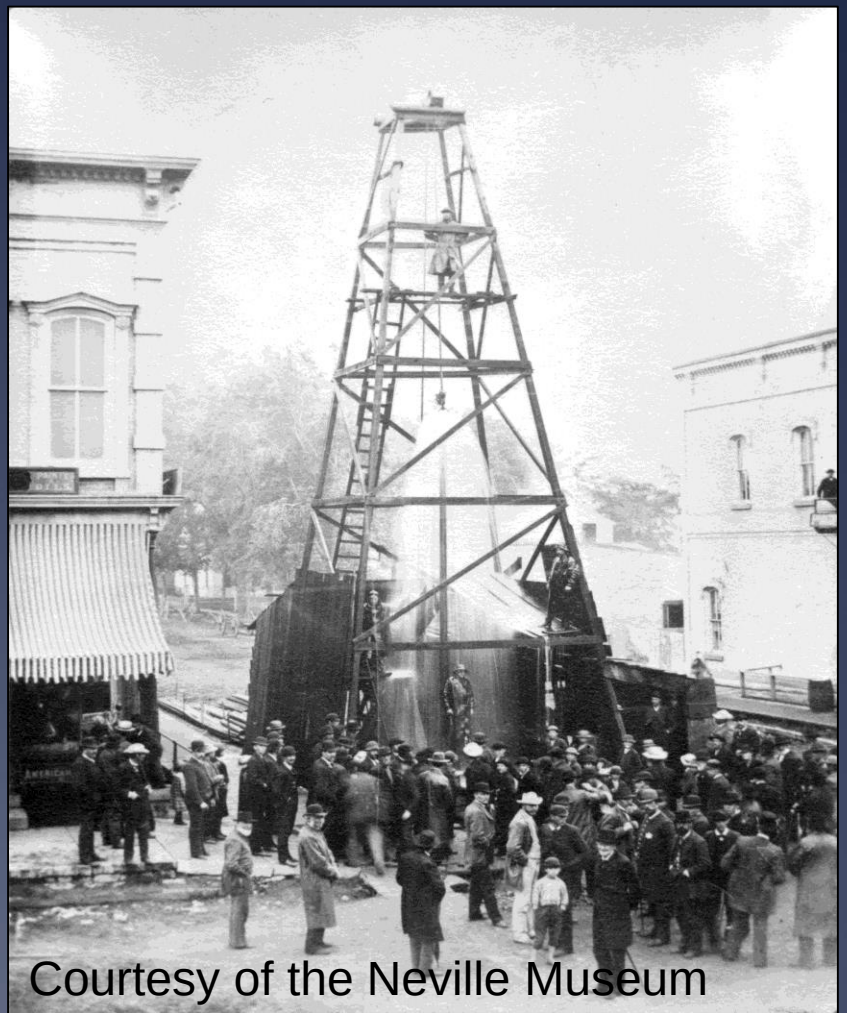
Luczaj (2011)



Luczaj (in press)

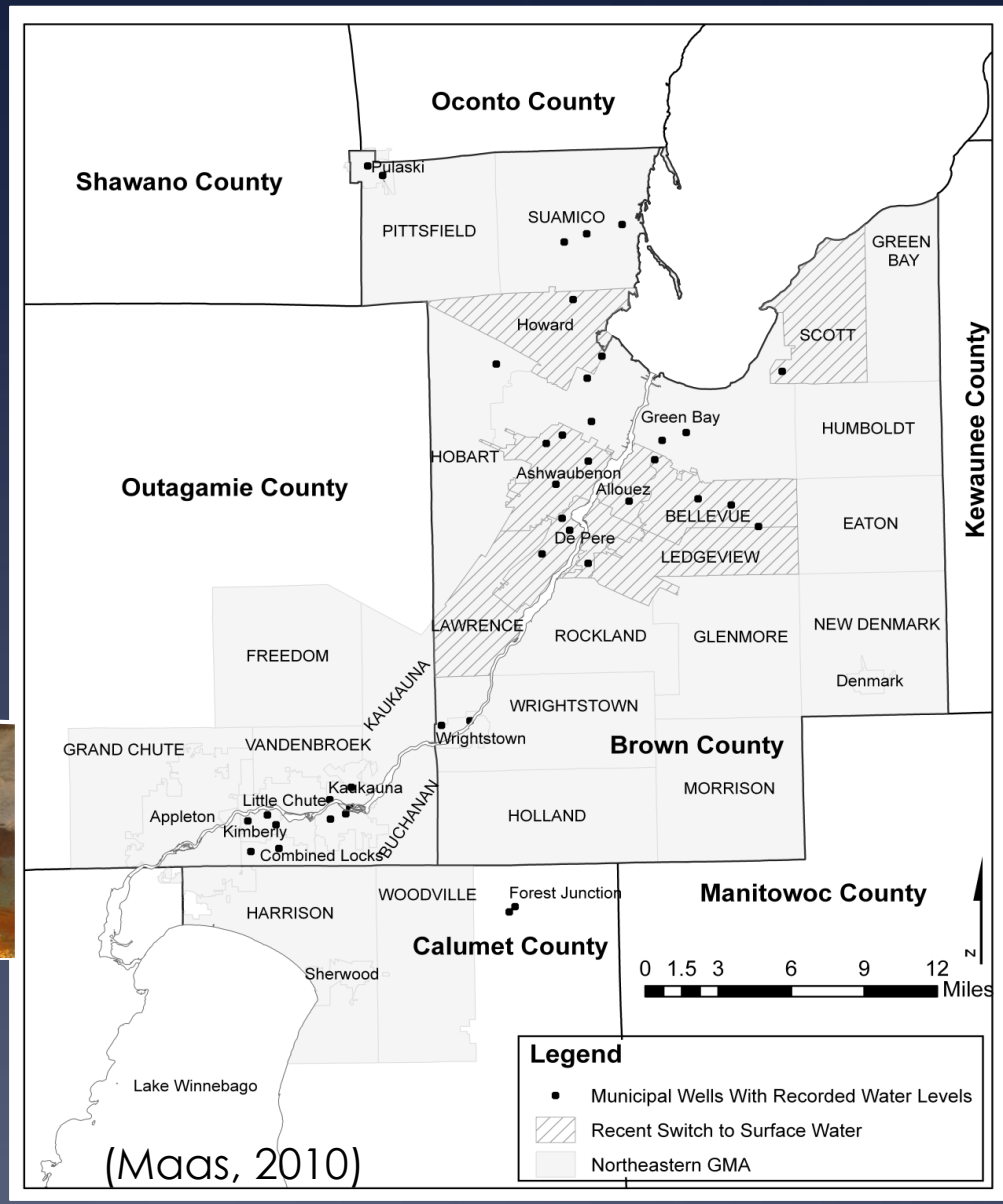
GENERAL WATER LEVEL HISTORY IN THE NORTHEAST GMA

- Predevelopment water levels exceeded ground surface by ~90-100 feet
- Water levels declined until 1957 when Green Bay switched to surface water
- Rapid recovery (up to 200 feet)
- Water levels slowly declined again until 2006-2007 when 8 communities surrounding Green Bay switched to surface water
- Rapid recovery (>150 feet)
  Recovery is ongoing!

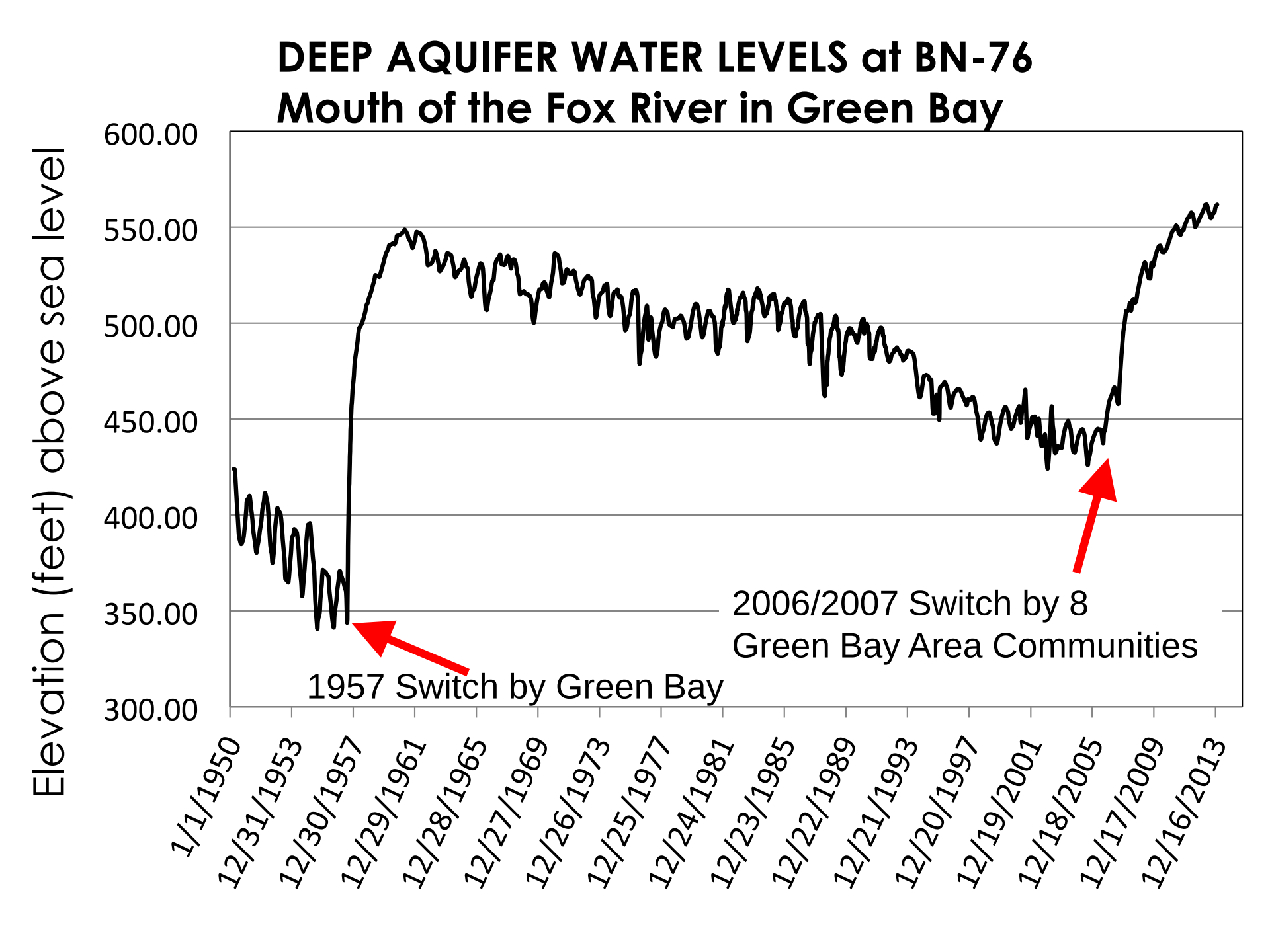


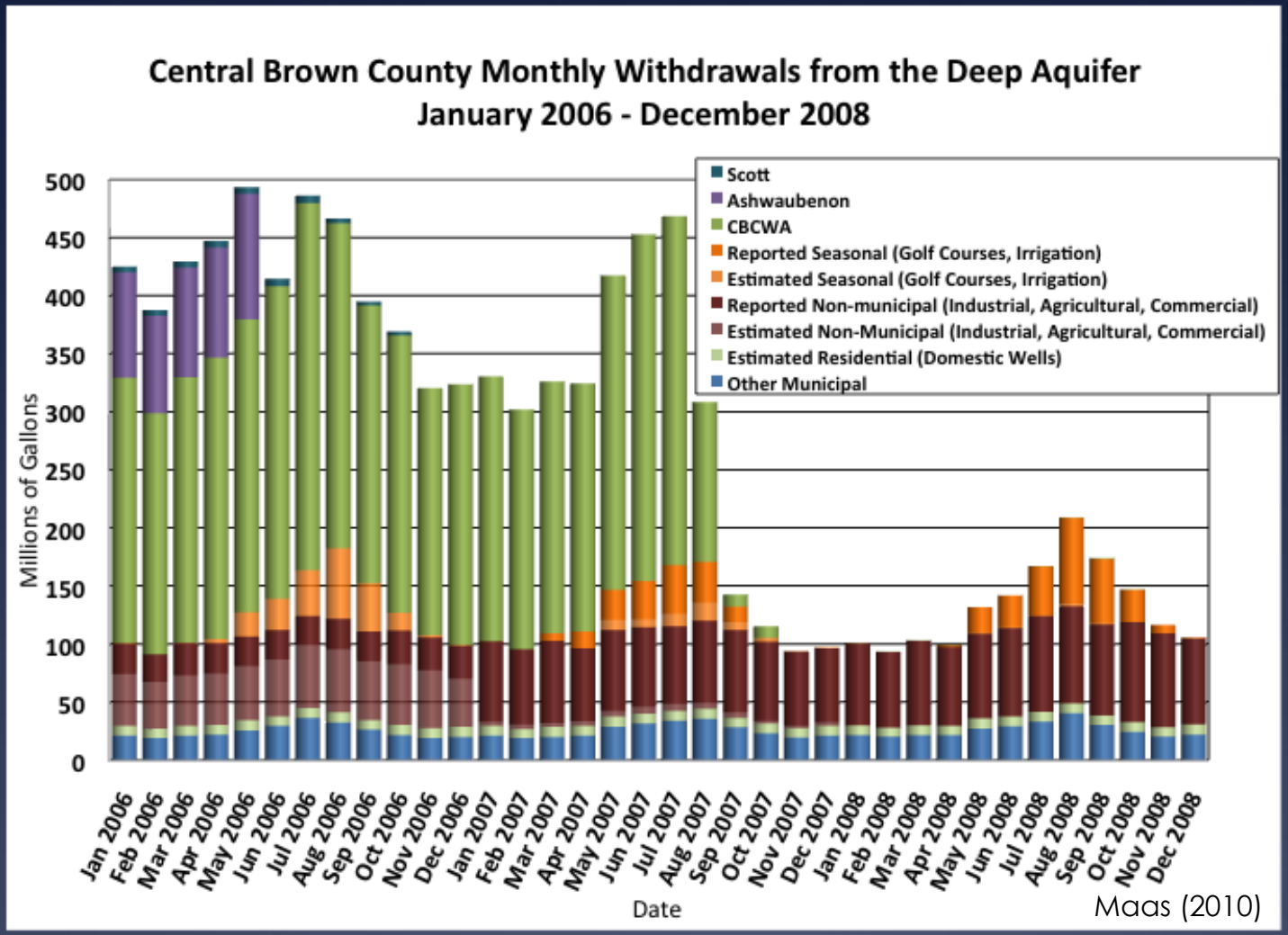
Courtesy of the Neville Museum

Flowing Artesian Well in De Pere (1890)



Left: Flowing artesian well in the Village of Howard
Right: Northeast GMA and municipalities that switched to surface water 2006 - 2007

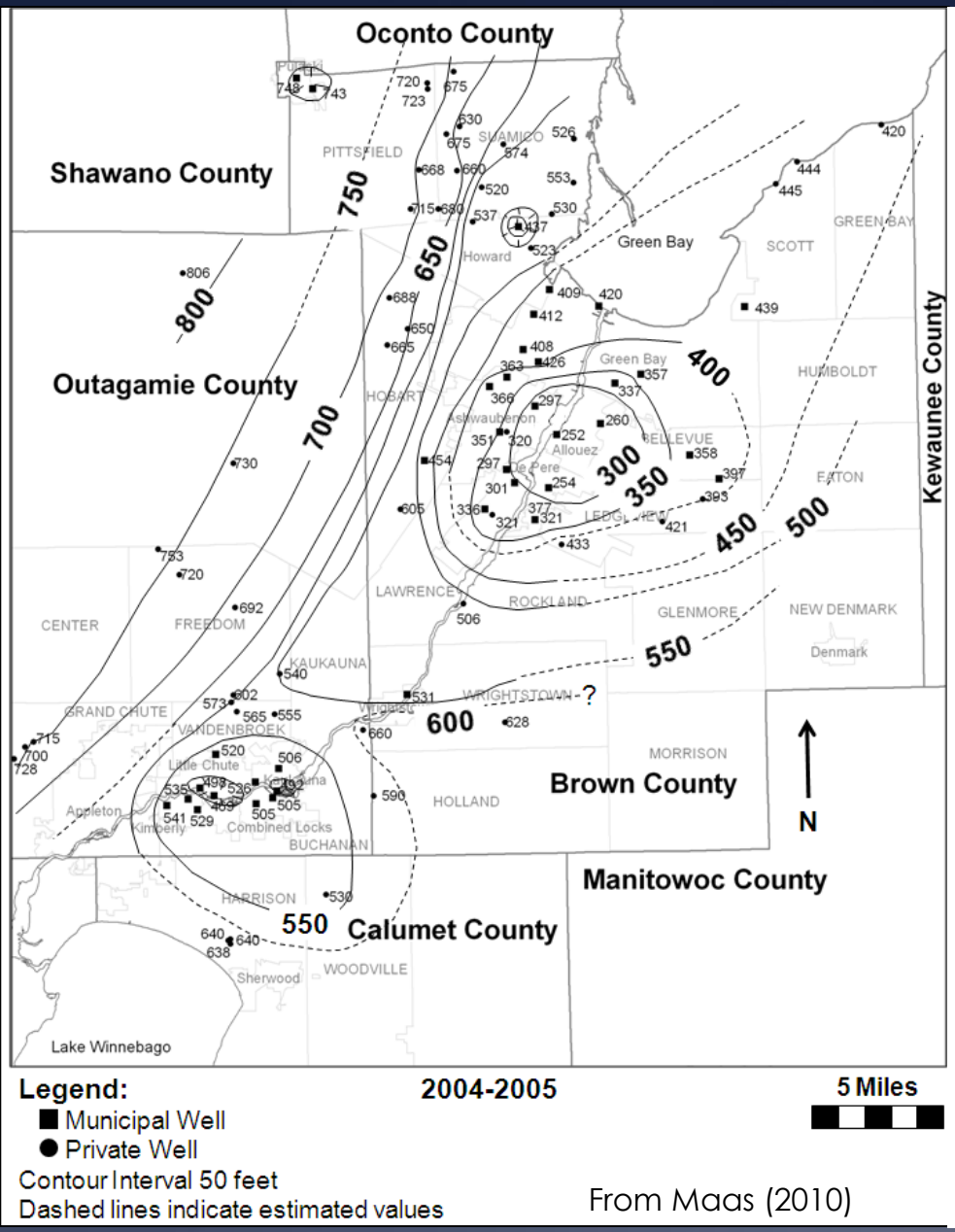

DEEP AQUIFER WATER LEVELS at BN-76
Mouth of the Fox River in Green Bay
Elevation (feet) above sea level
600.00
550.00
500.00
450.00
400.00
350.00
300.00
1/1/1950
12/31/1953
12/30/1957
12/29/1961
12/28/1965
12/27/1969
12/26/1973
12/25/1977
12/24/1981
12/23/1985
12/22/1989
12/21/1993
12/20/1997
12/19/2001
12/18/2005
12/17/2009
12/16/2013
1957 Switch by Green Bay
2006/2007 Switch by 8
Green Bay Area Communities



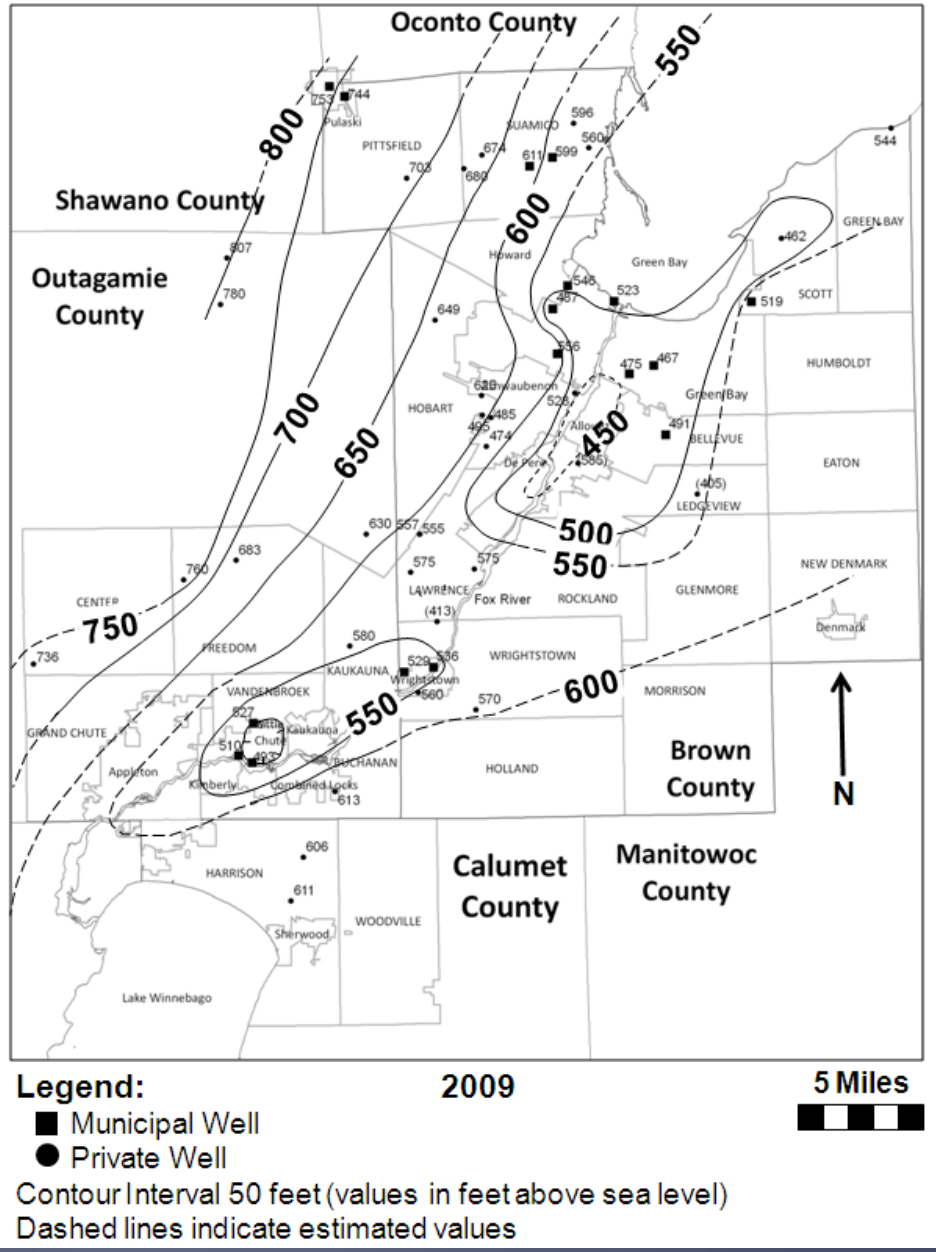
Maas (2010)

Groundwater withdrawals decreased from 16.4 Mgd to 4.2 Mgd when the Central Brown County Water Authority switched to Lake Michigan water via a 60 mile long pipeline in 2006-2007.

REGIONAL POTENTIOMETRIC SURFACE (DEEP AQUIFER)



From Maas (2010)

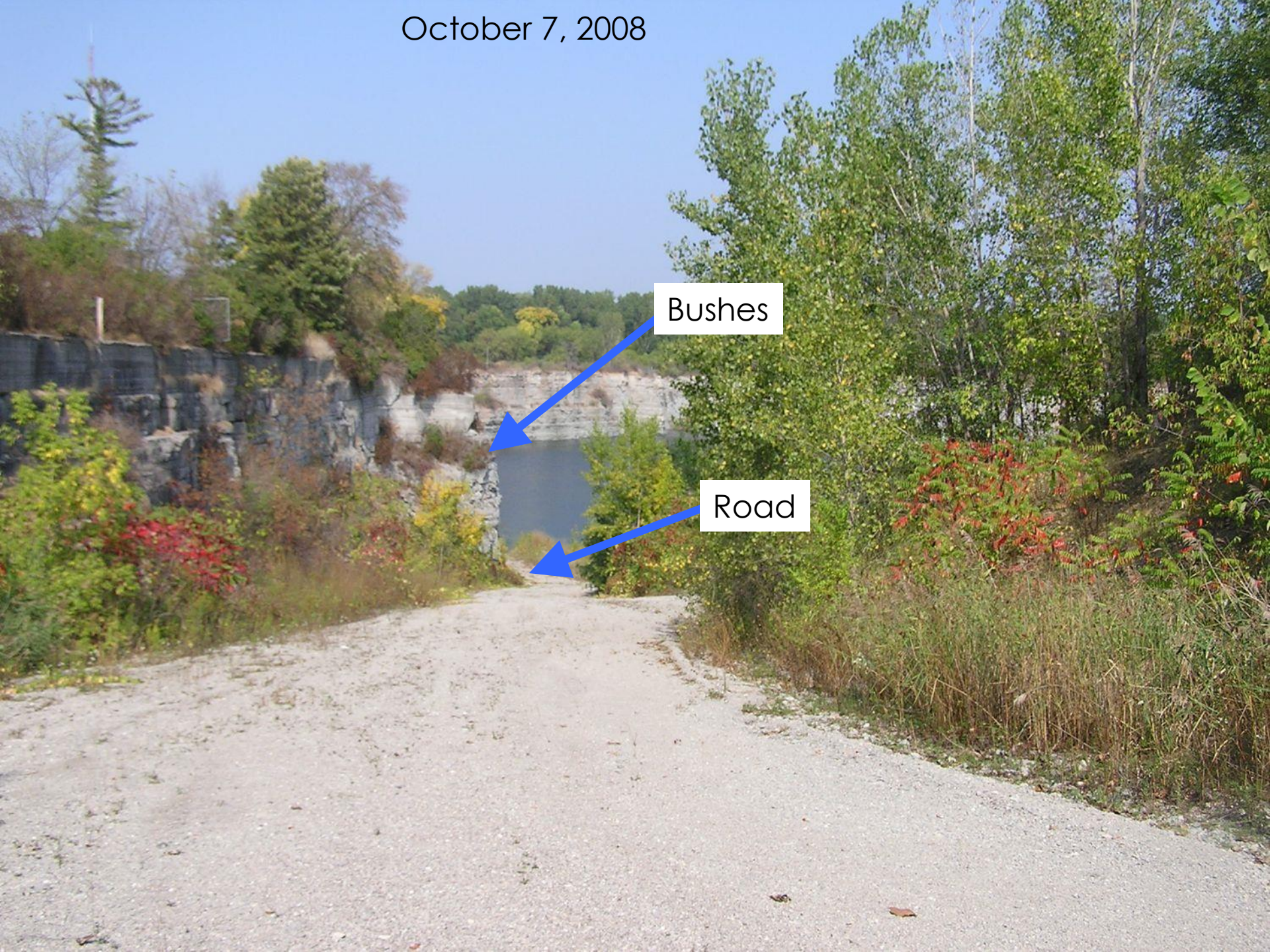


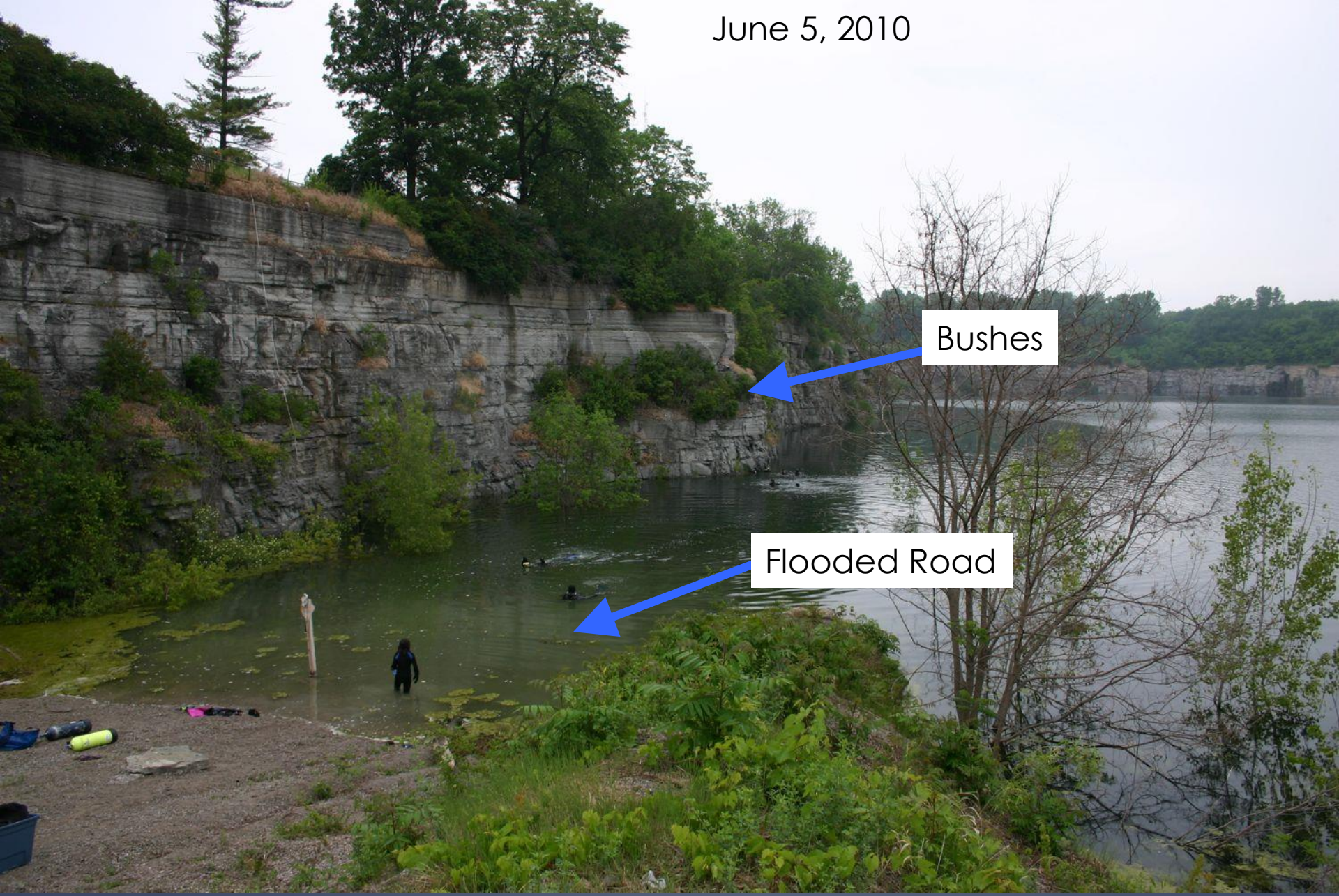
HISTORICAL PHOTOGRAPHS

October 26, 2003

Photo courtesy of Steve Dutch


July 2005
Photo courtesy of Marianne Pigeon


October 7, 2008
Bushes
Road



Note the SCUBA Divers!

June 25, 2011

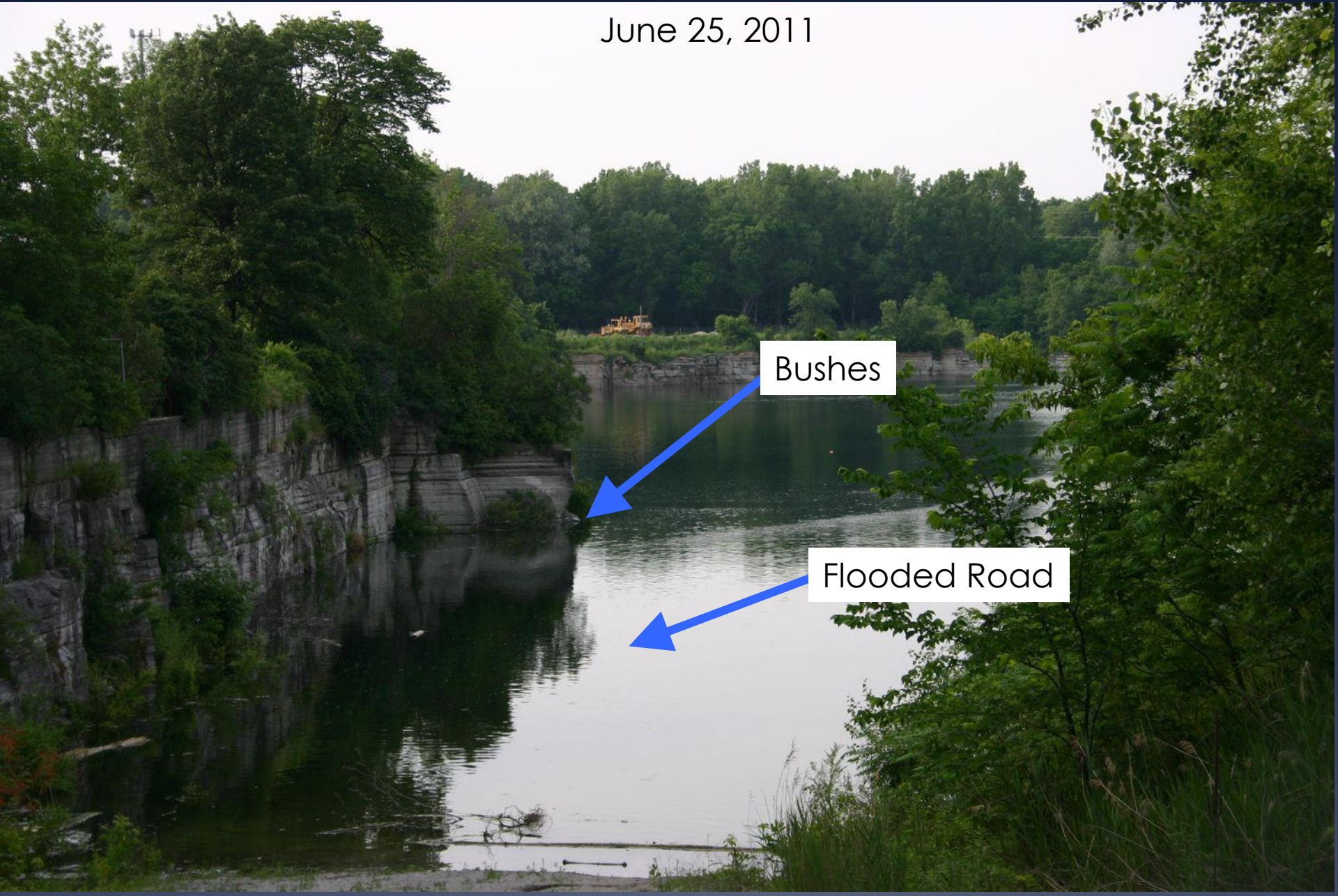


Photo by John Luczaj

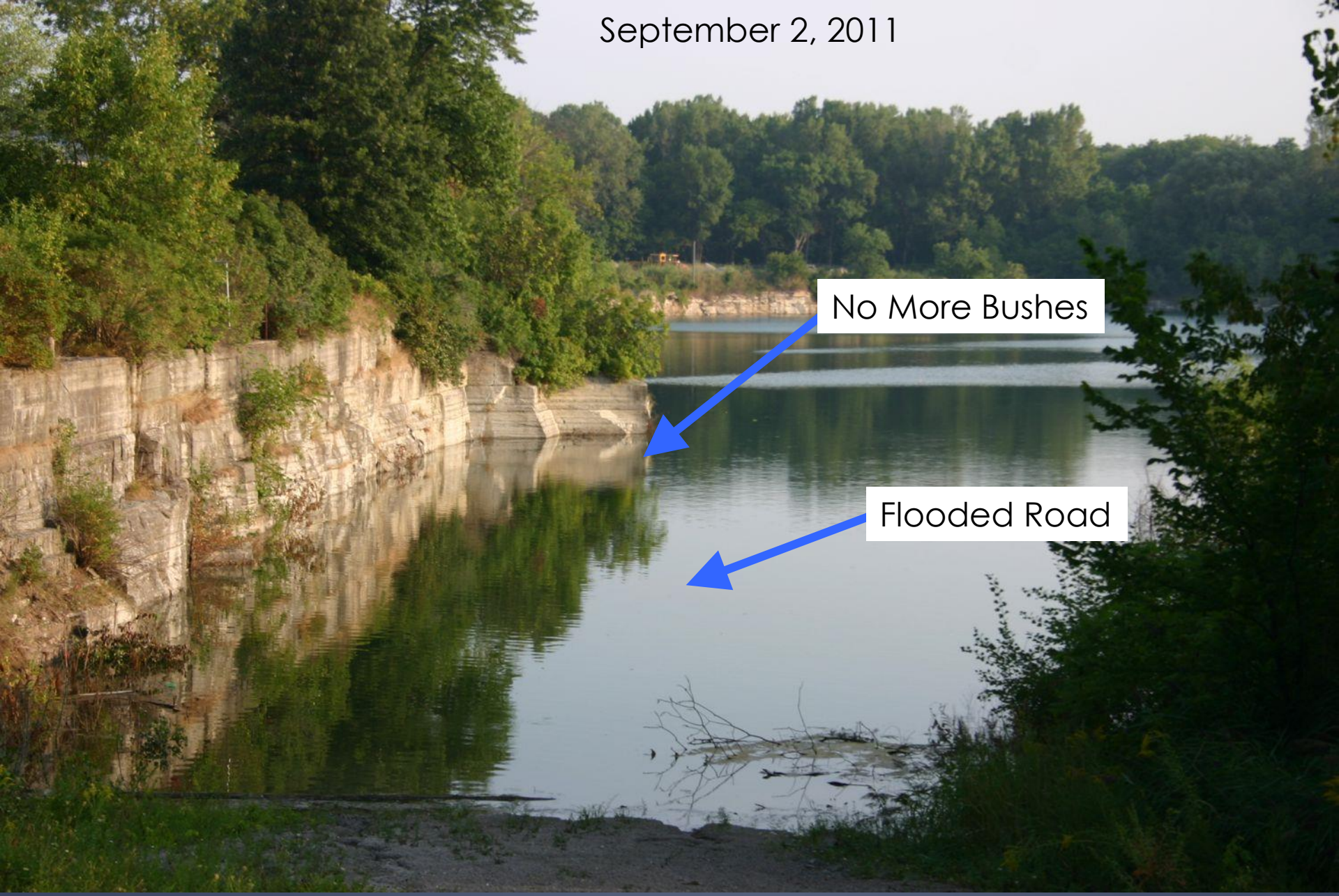


Photo by John Luczaj

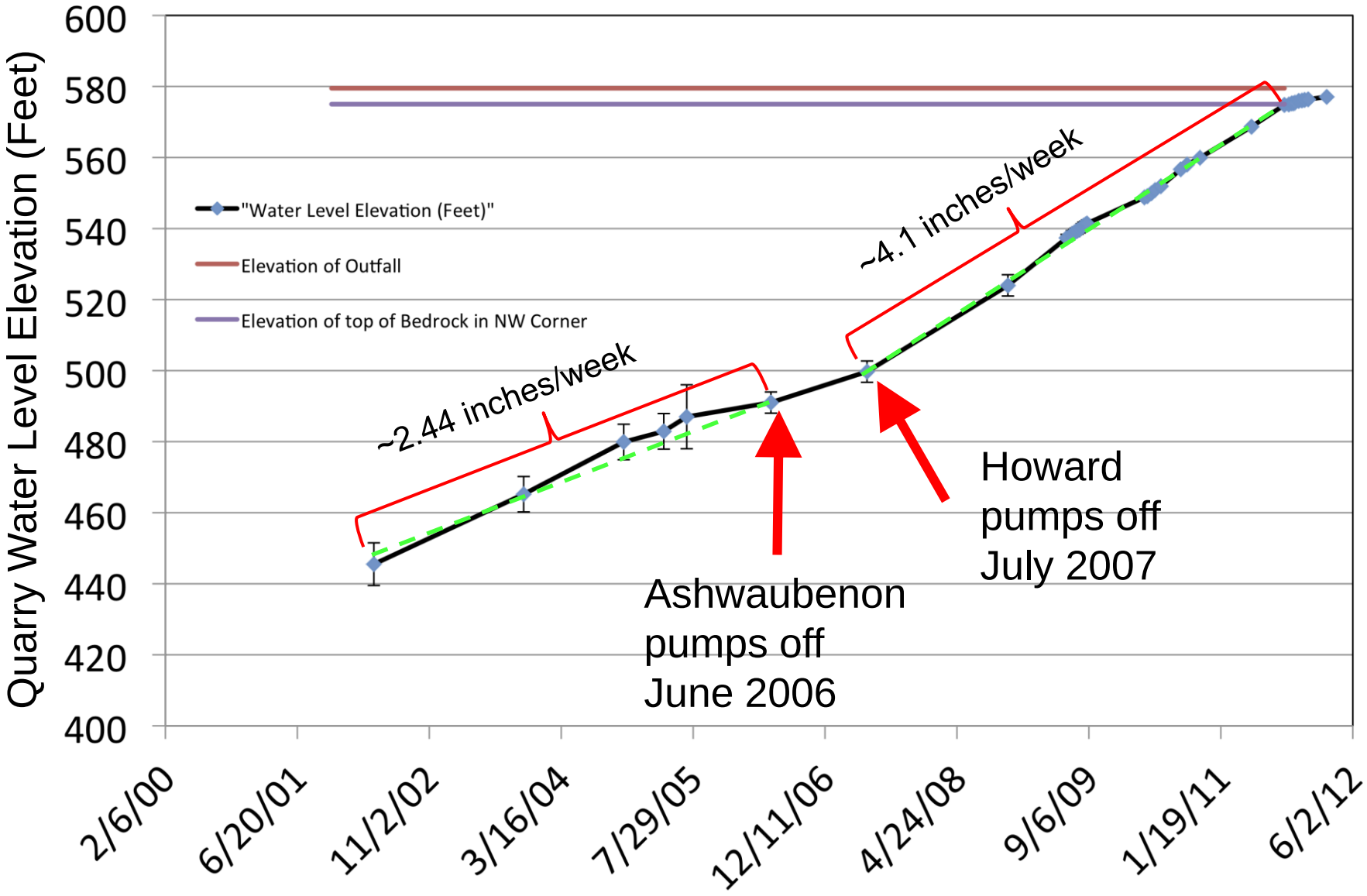

May 20, 2006 – View looking Northeast
Photo courtesy of Steve Dutch

September 2, 2011 – View looking Northeast

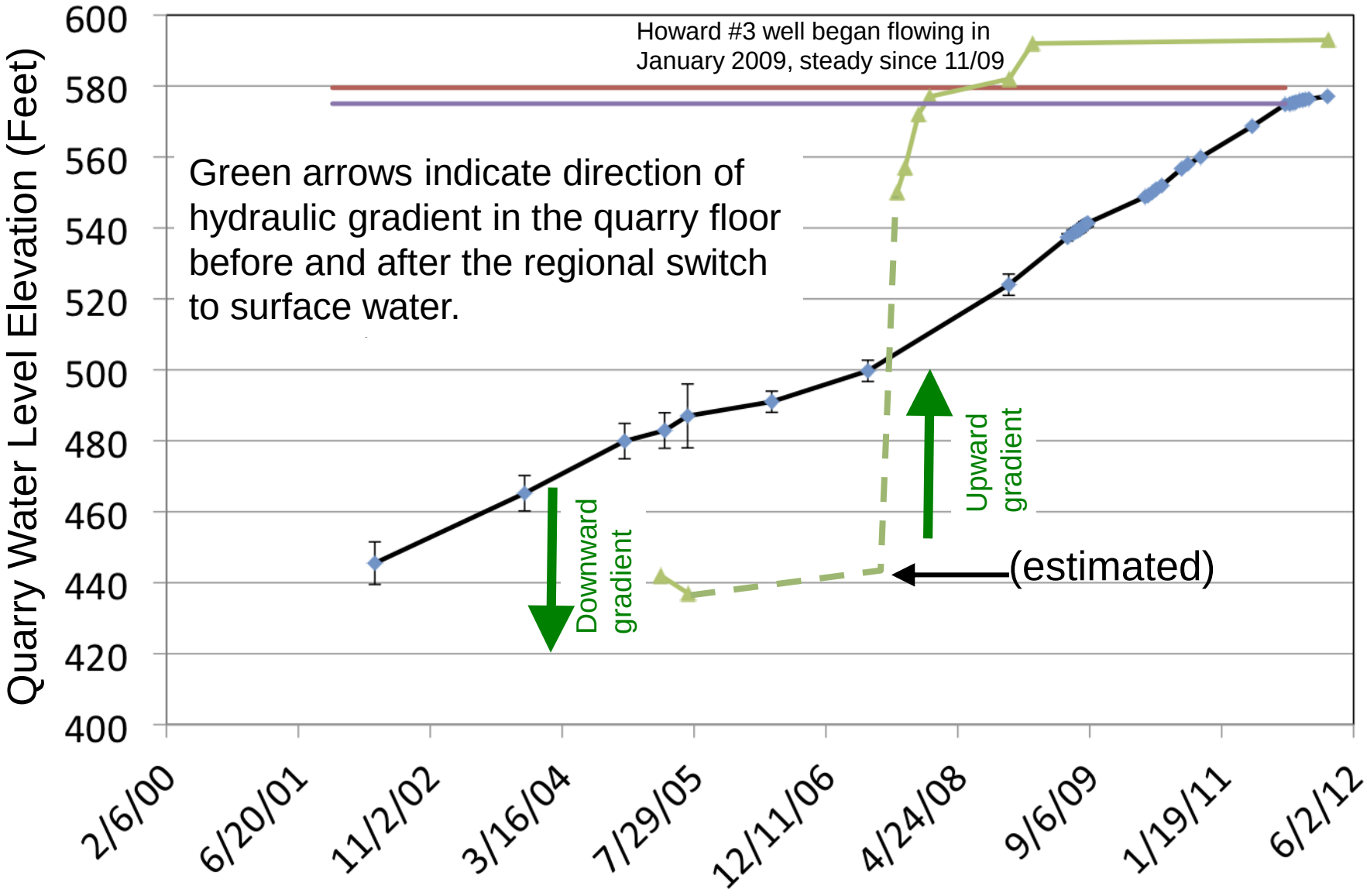
Photo by John Luczaj

Water Levels have been measured directly since June 2009 by various methods tied to elevation surveys.

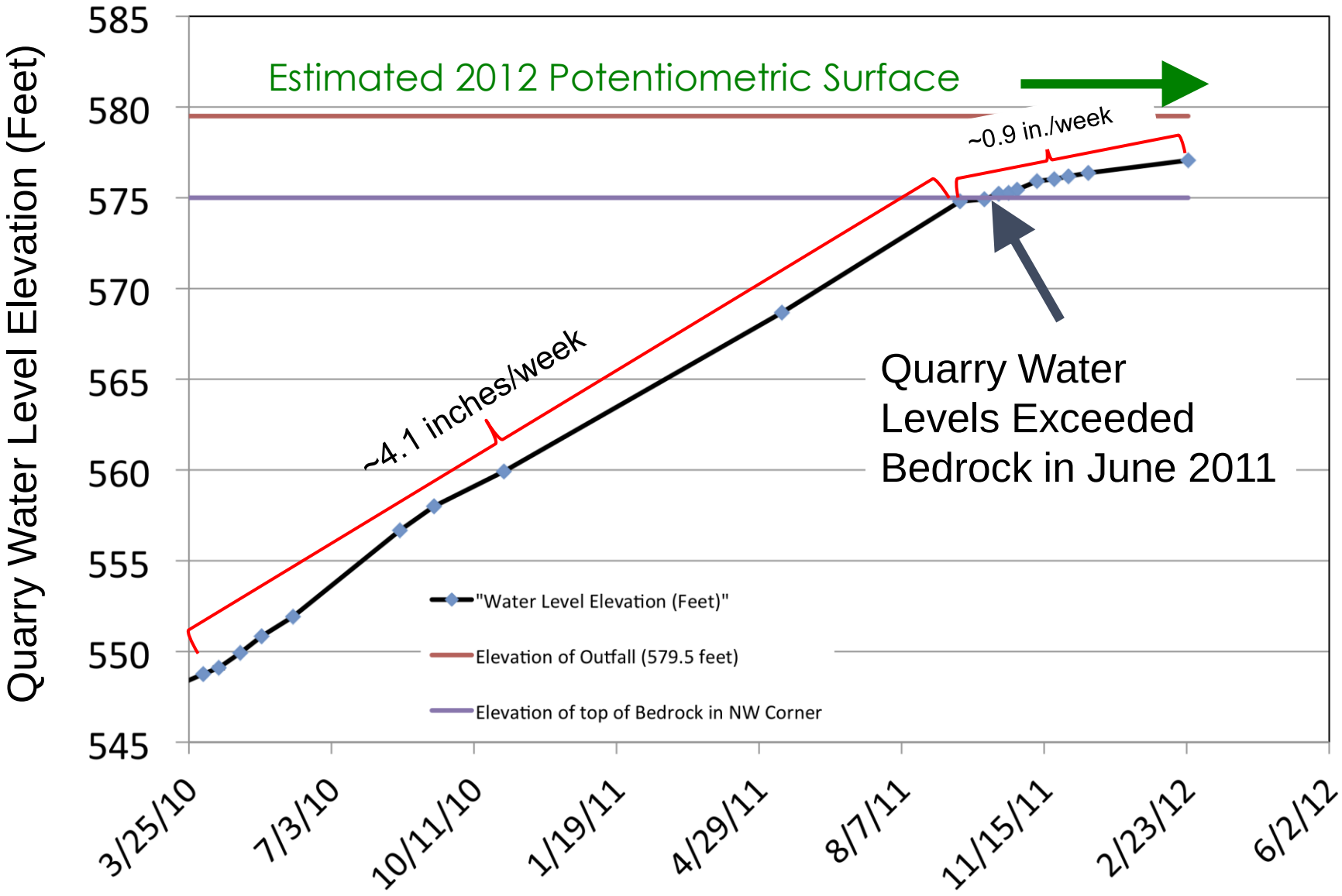
EARLY: THE RATE OF RISE OF THE QUARRY'S WATER LEVEL INCREASED BY 70%



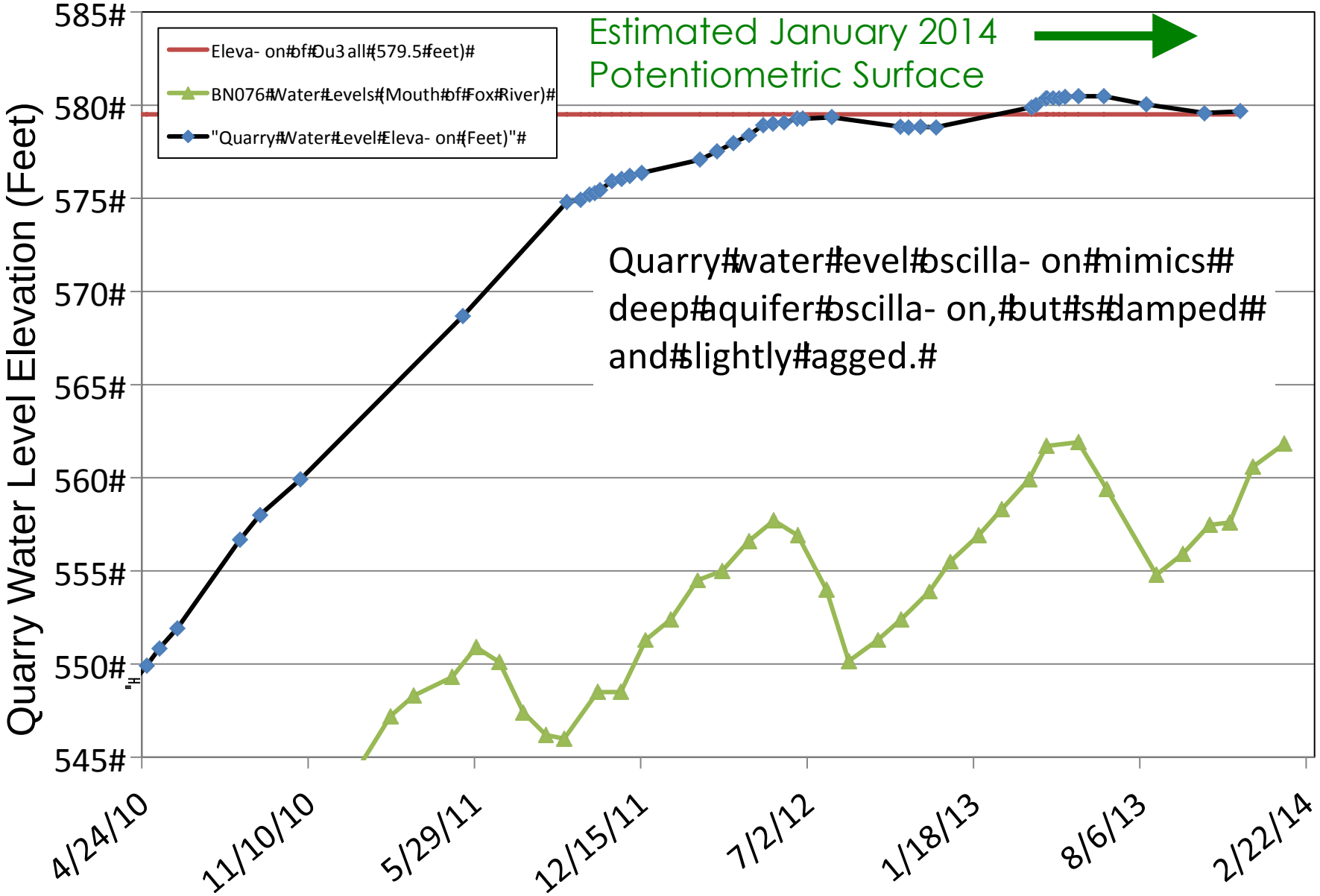
PUMPING CESSATION AFFECTED THE RATE OF WATER LEVEL RISE IN THE QUARRY



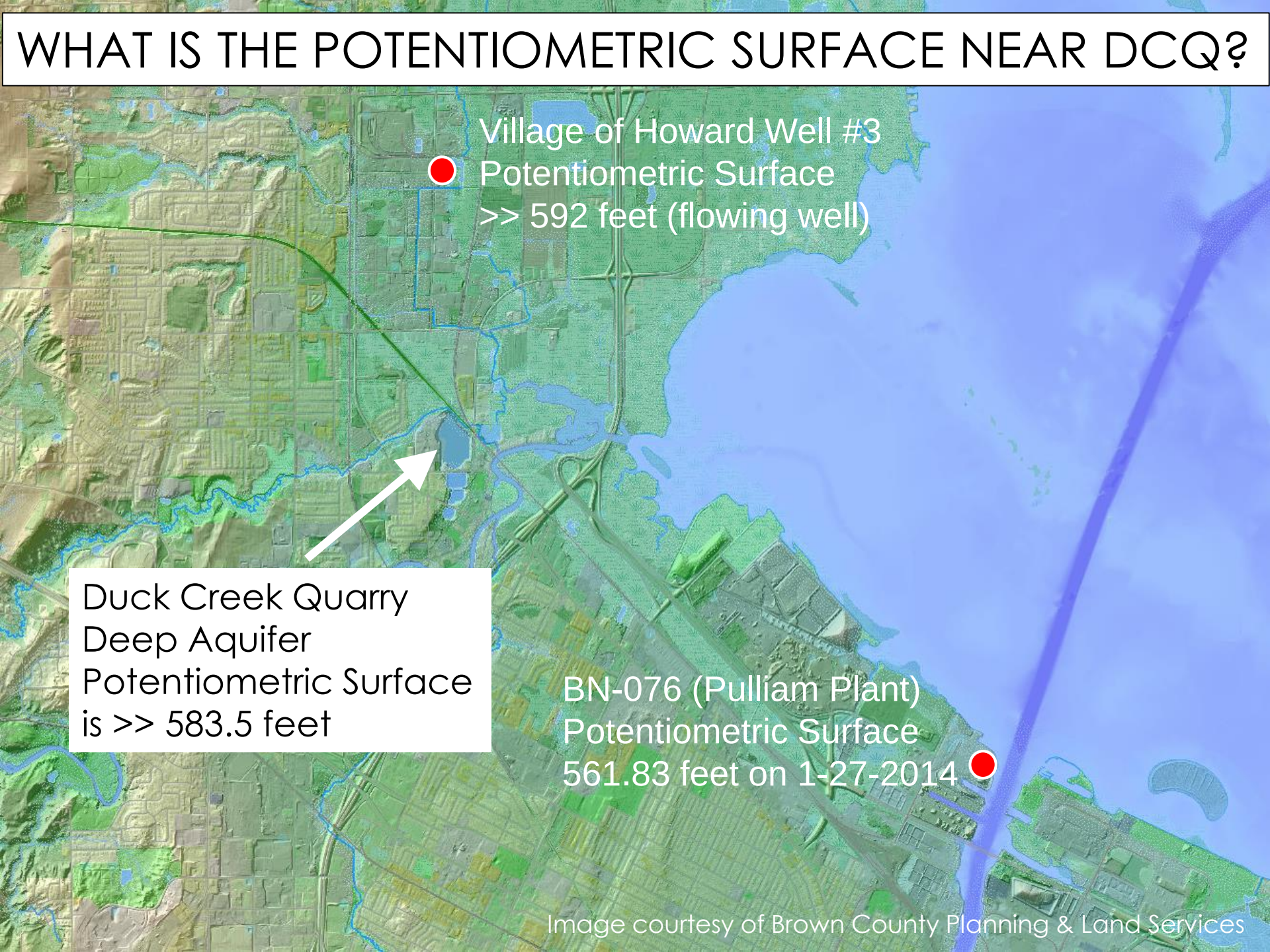
LATER: THE RATE OF RISE SLOWED DUE TO EXCHANGE WITH THE GLACIAL AQUIFER



RECENTLY: QUARRY WATER LEVELS MIMIC DEEP AQUIFER SEASONALITY



WHAT IS THE POTENTIOMETRIC SURFACE NEAR DCQ?



IMPLICATIONS

- It appears that a hydrologic connection exists with the deep aquifer, the potentiometric surface > land surface.
- The Village of Howard installed an outfall to Lancaster Creek in Fall 2011, preventing flooding of land surface.
- During May 2013, a visual estimate of flow depth and velocity suggested a discharge rate of 140,000 gpd!
- Because the deep aquifer recovery is continuing, the rate of discharge should increase in the future and occur over a longer part of the year.

Duck Creek Quarries – Village of Howard (Brown County)

Photo Courtesy of Pictometry International Corp.
November 18, 2006

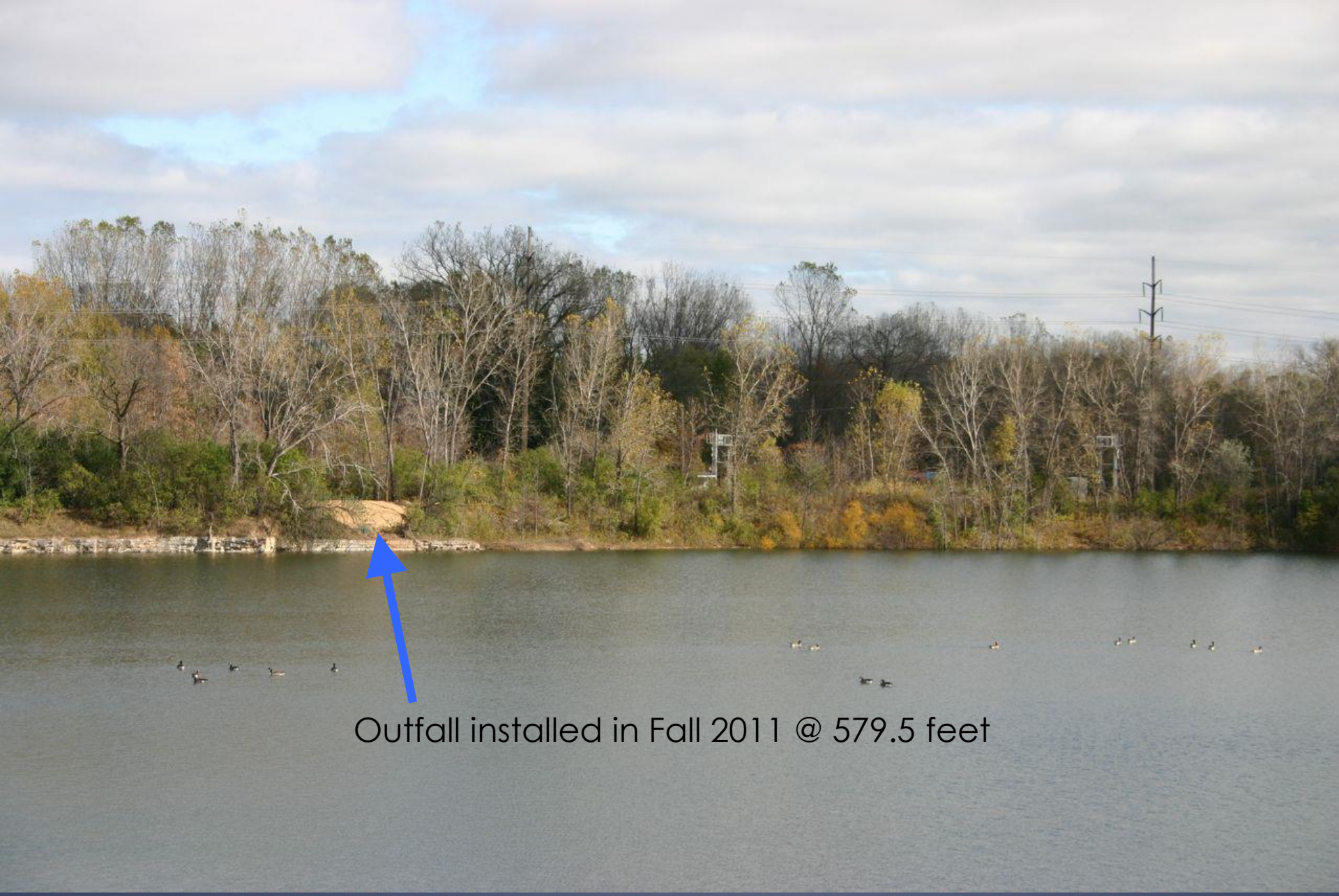


Photo by John Luczaj

Photo by John Luczaj

This is the outfall's intake pipe during June 2013 (half full)

Photo by John Luczaj

Outfall Discharge to Lancaster Creek in May 2013

Photo by John Luczaj

CONCLUSIONS

- Quarry filling was driven (in part) by the recovery of the potentiometric surface in the Deep Aquifer System. *This was an unintended consequence.*

- In 2011, the rate of water level rise slowed due to:
  - flow into the glacial sediments above bedrock
  - diminished shallow aquifer contributions

- The water level in the quarry has now reached a quasi-equilibrium with the aquifer and mimics the deep aquifer water levels (with a damped signal).

- The Quarry is (at times) the largest flowing artesian well in Wisconsin at ~140,000 gpd. This should increase in future.

November 3, 2008 – View looking Southeast

ACKNOWLEDGEMENTS

- Barb Wavrunek and Bill Roderick (SCUBA divers)
- Historical Photographs: Steve Dutch, Marianne, Pigeon, Randy Phillips, Scott Janssen, Pictometry Corp.
- Brown County (Pat Ford and Jeff DuMez)
- Village of Howard (Dave Fonder, Geoff Farr)
- GIS Assistance: Mike Stiefvater
- Gary Wauters (survey help)

Photo by John Luczaj – Green Bay Water Utility Core (199.5 feet) – St. Peter Sandstone