

# Finding Large Capacity Groundwater Supplies for Irrigation

December 14, 2012

Presented by: Michael L. Chapman, Jr., PG



# Irrigation Well Site Evaluation

## Background Investigation

- Identify Hydrogeologic Conditions
  - Bedrock Aquifer(s) Groundwater Production Potential
  - Unconsolidated Aquifer(s) Groundwater Production Potential
  - Review Well Logs and other published documentation
- Withdrawal Assessment (Michigan)

## Field Investigation

- Fracture Trace Analysis
- Surficial Geophysics
- Test Drilling
  - Lithology Sampling & Well Design
  - Borehole Geophysics
- Aquifer Performance Testing

# Background Investigation

Goal: Identify published sources of information from the USGS, MDEQ, EPA and graduate studies that are relevant to the site of interest.

- Type of aquifer(s) available for groundwater resource development;
- Hydraulic parameter values;
- Thickness and continuity of aquifer(s);
- Location of potential sources of contamination;
- Potentiometric surface and flow directions.

# Background Investigation

Purpose: To construct a conceptual model of the aquifer system and identify potential sources of sustainable groundwater production.

- Bedrock vs Unconsolidated (Sand and Gravel);
- Confined vs Unconfined Aquifer;
- Potential for Adverse Impact to Surface Water;
- Identify appropriate method for Field Investigation.

# Background Investigation

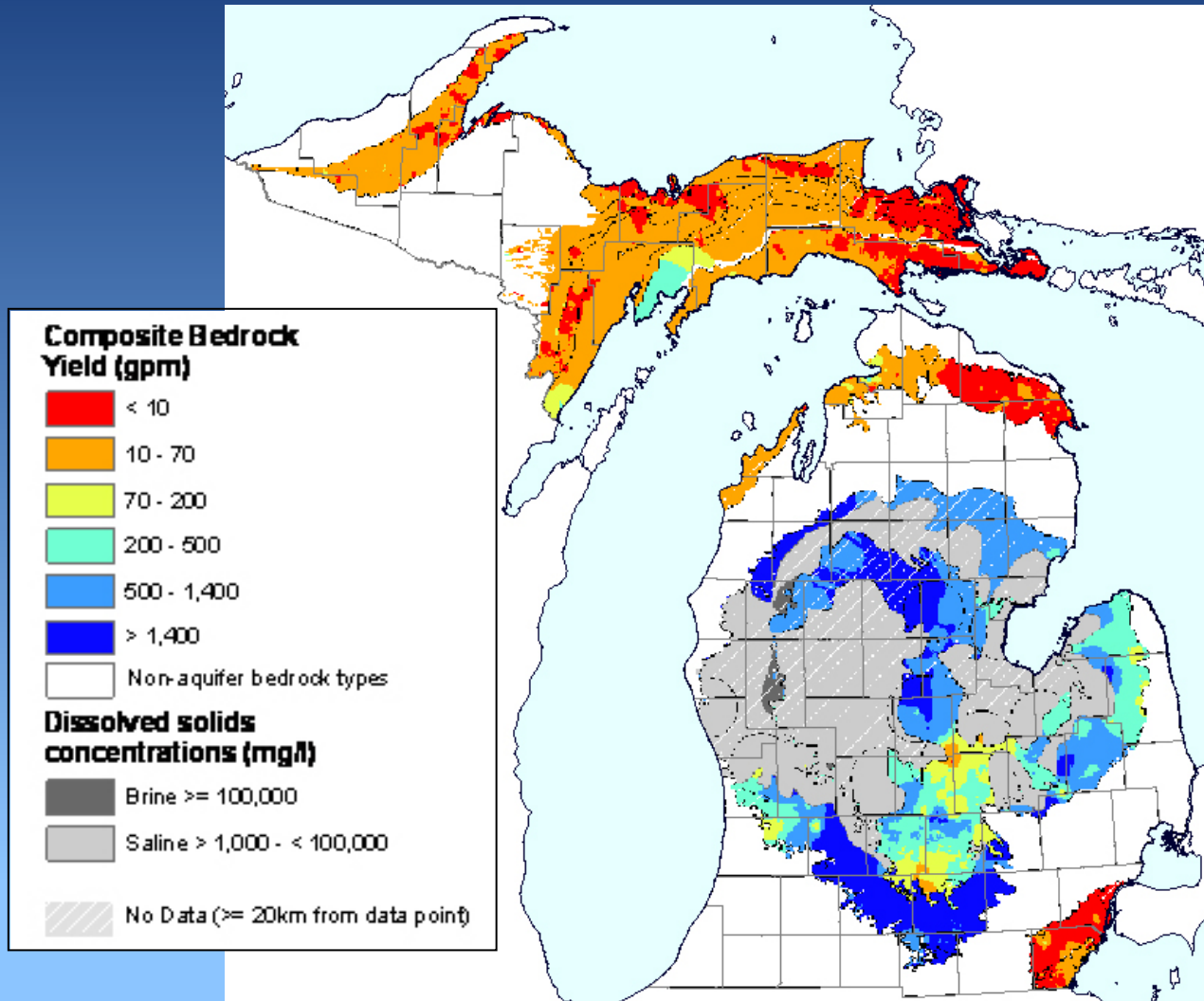
## Bedrock Geology





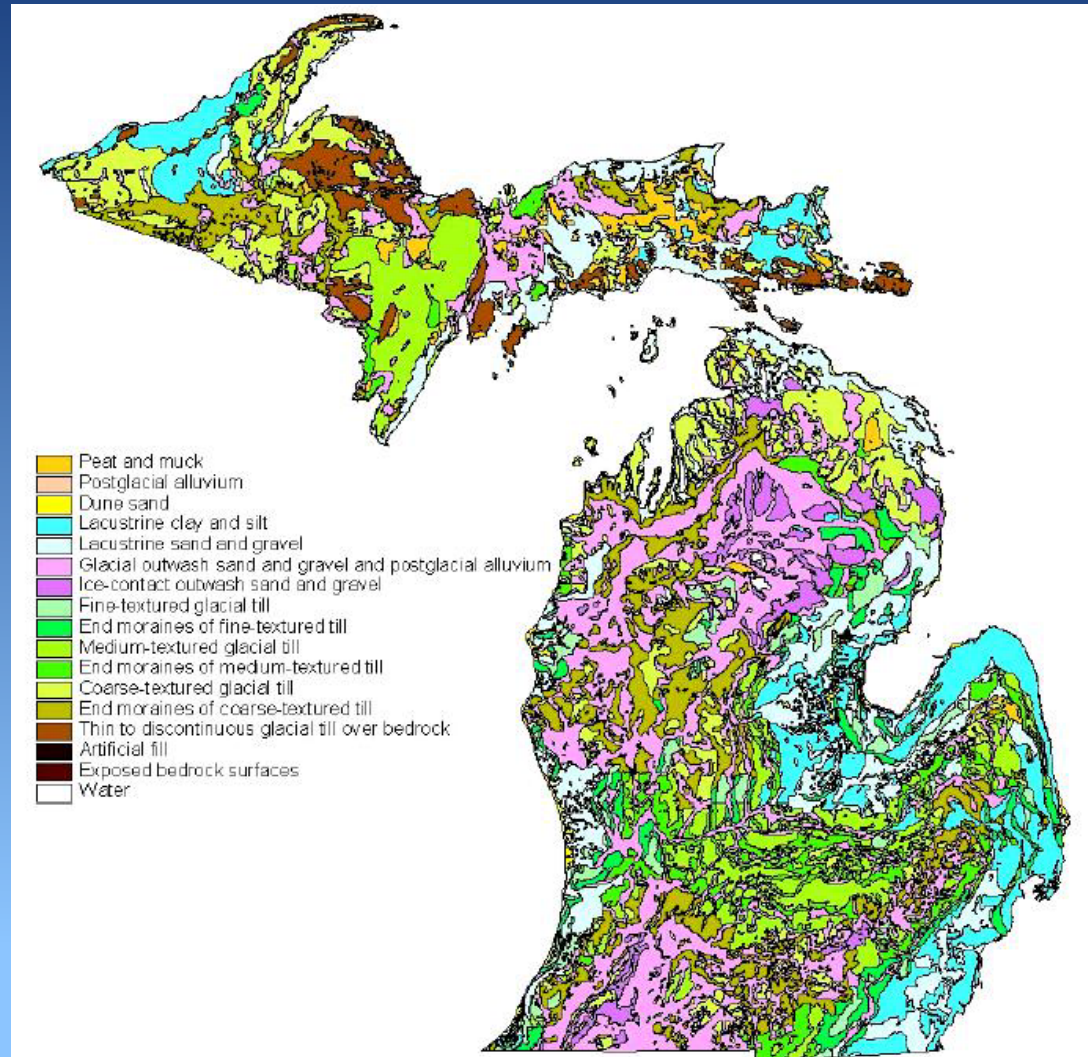
# Background Investigation

## Bedrock Groundwater Availability



# Background Investigation

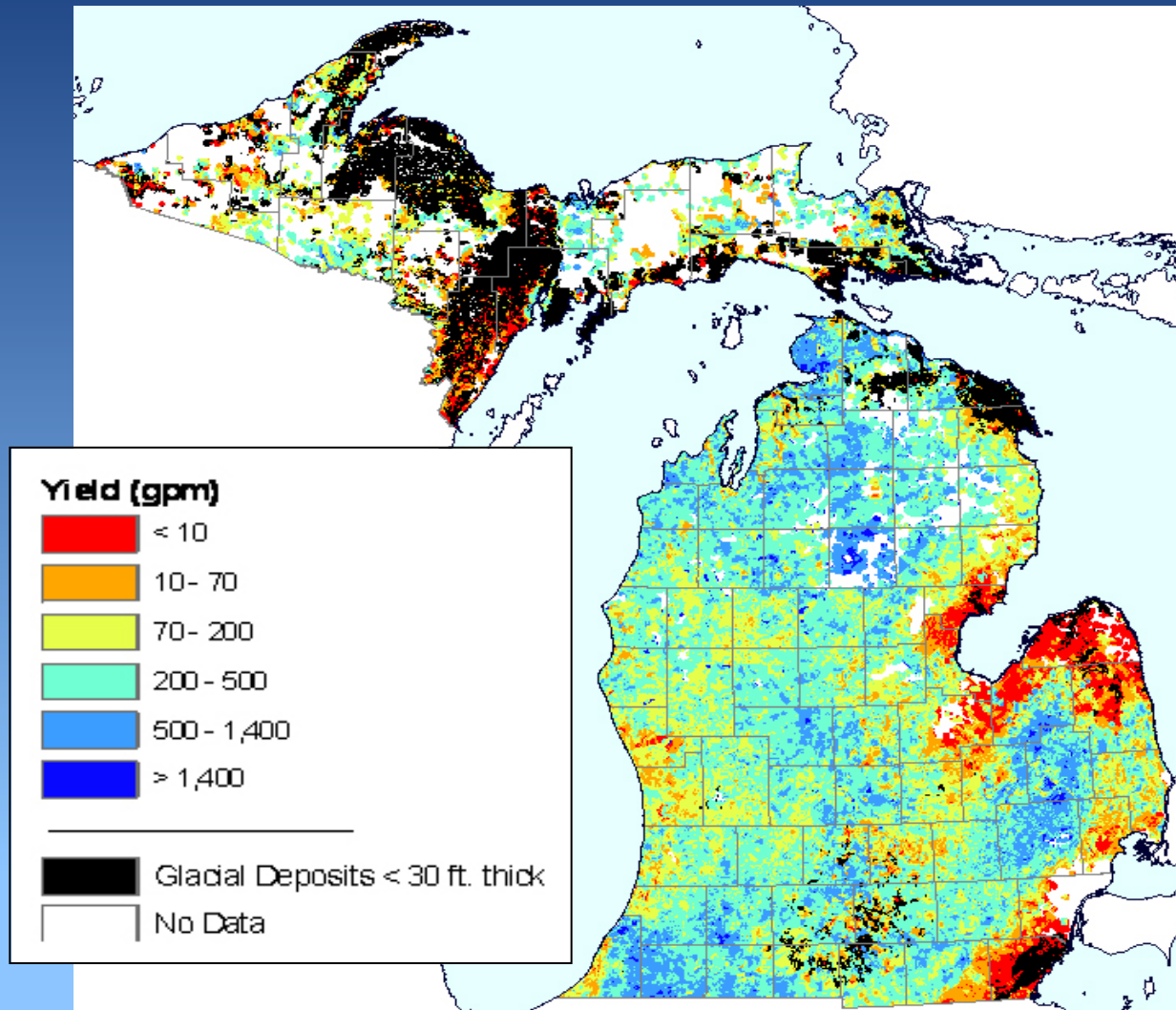
## Surficial Geology





# Background Investigation

## Unconsolidated Groundwater Availability



# Background Investigation Bedrock Geology & Groundwater Availability

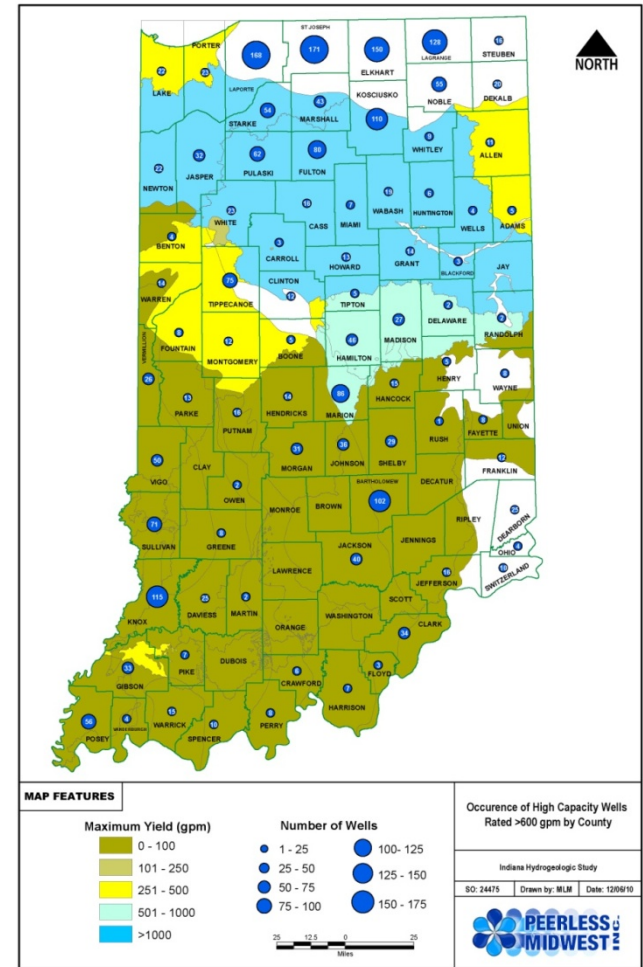
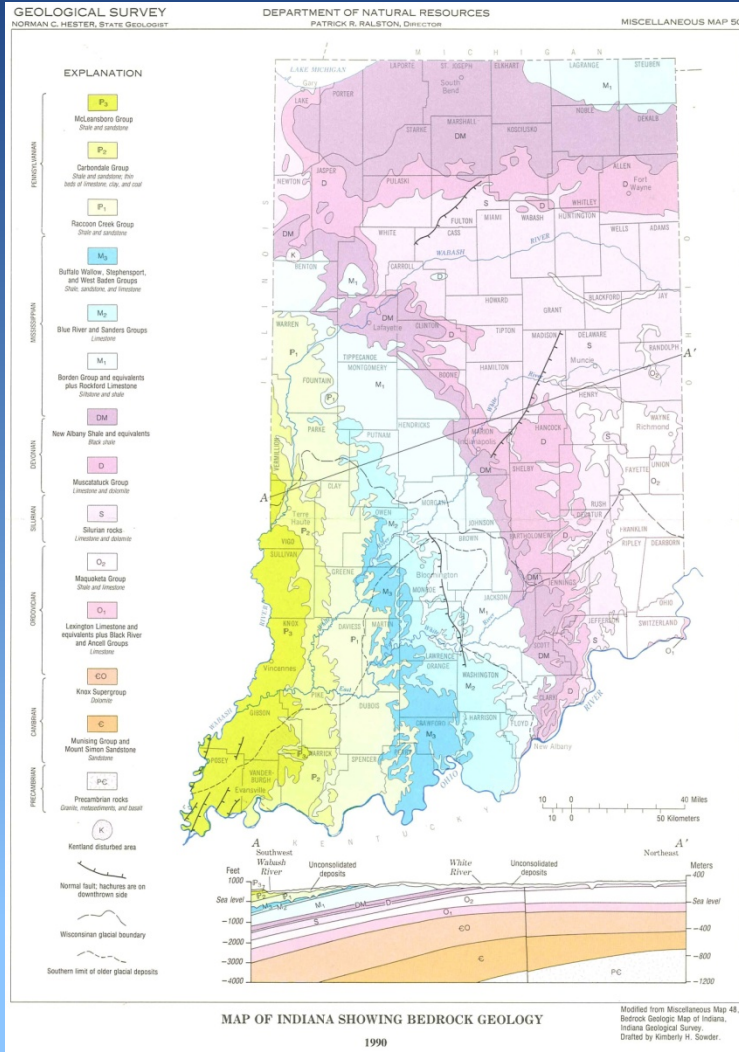
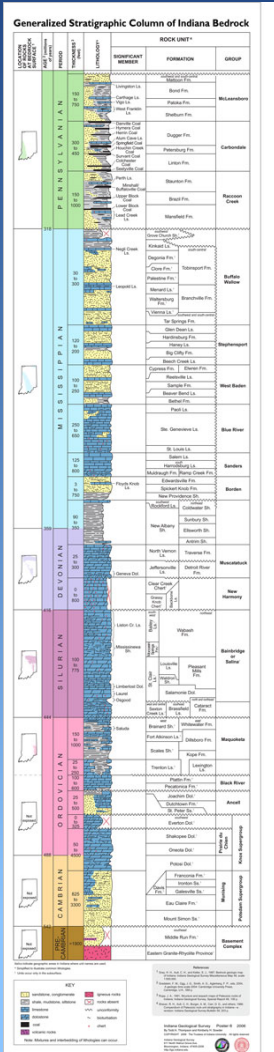


FIGURE 1

# Background Investigation Surficial Geology & Groundwater Availability

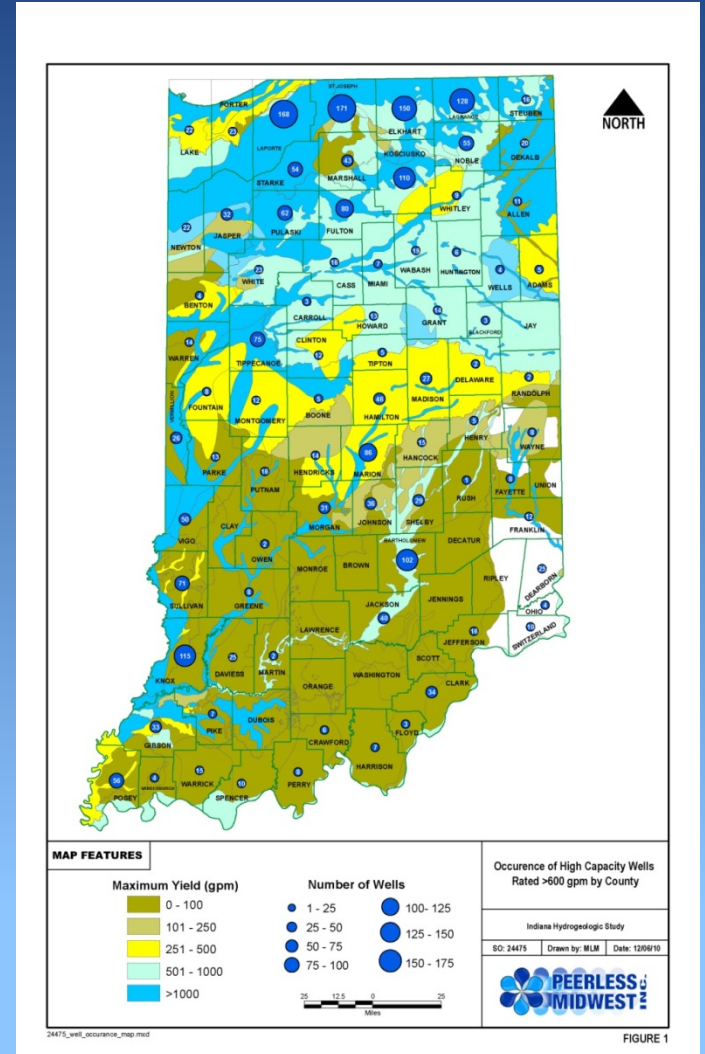
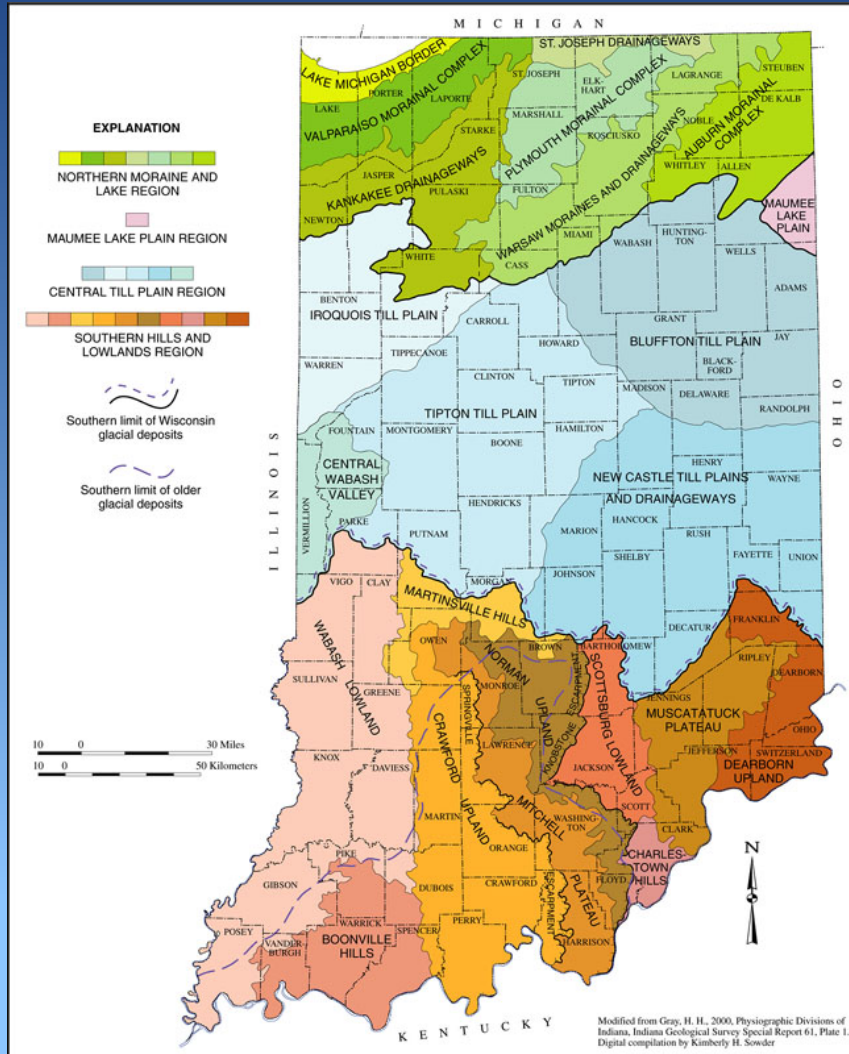


FIGURE 1

# Geologic Cross-Sections

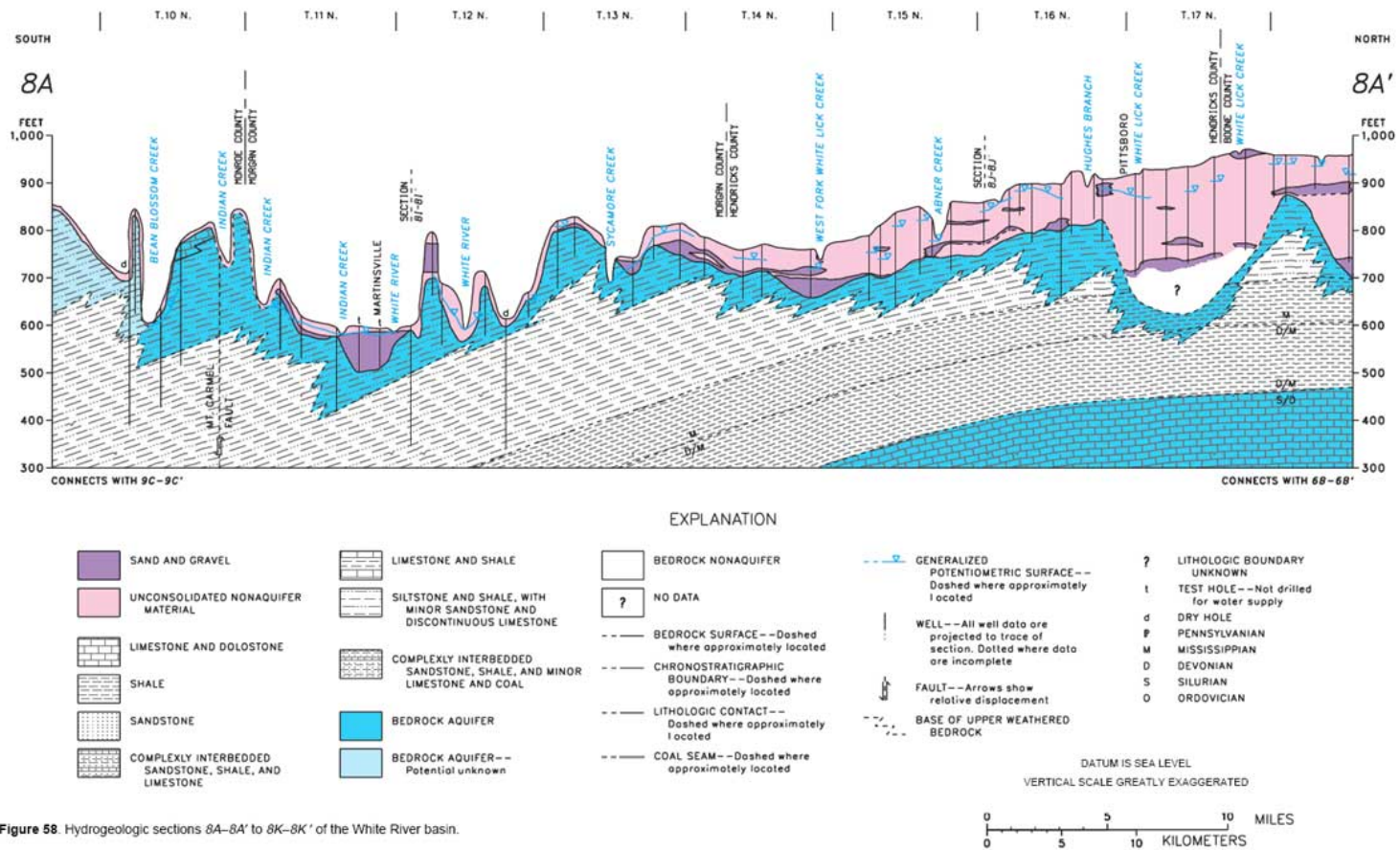


Figure 58. Hydrogeologic sections 8A-8A' to 8K-8K' of the White River basin.

# Aquifer System Characteristics

## Hydraulic Conductivity (K)

One-dimensional

Measures the rate that water moves past a point in time

Typical units of feet per day (ft/day)

$K = T/b$  (where  $T$  = transmissivity &  $b$  = aquifer thickness)

## Transmissivity (T)

Two-dimensional

Refers to how fast water is moving past a cross-sectional area of the aquifer

Typical units of square feet per day

$T = K/b$  ( $K$  = hydraulic conductivity &  $b$  = aquifer thickness)

## Storativity ( $S/S_y$ )

How much water is in pore spaces (or fractures) of aquifer that can be removed

Dimensionless

Confined aquifer = storativity

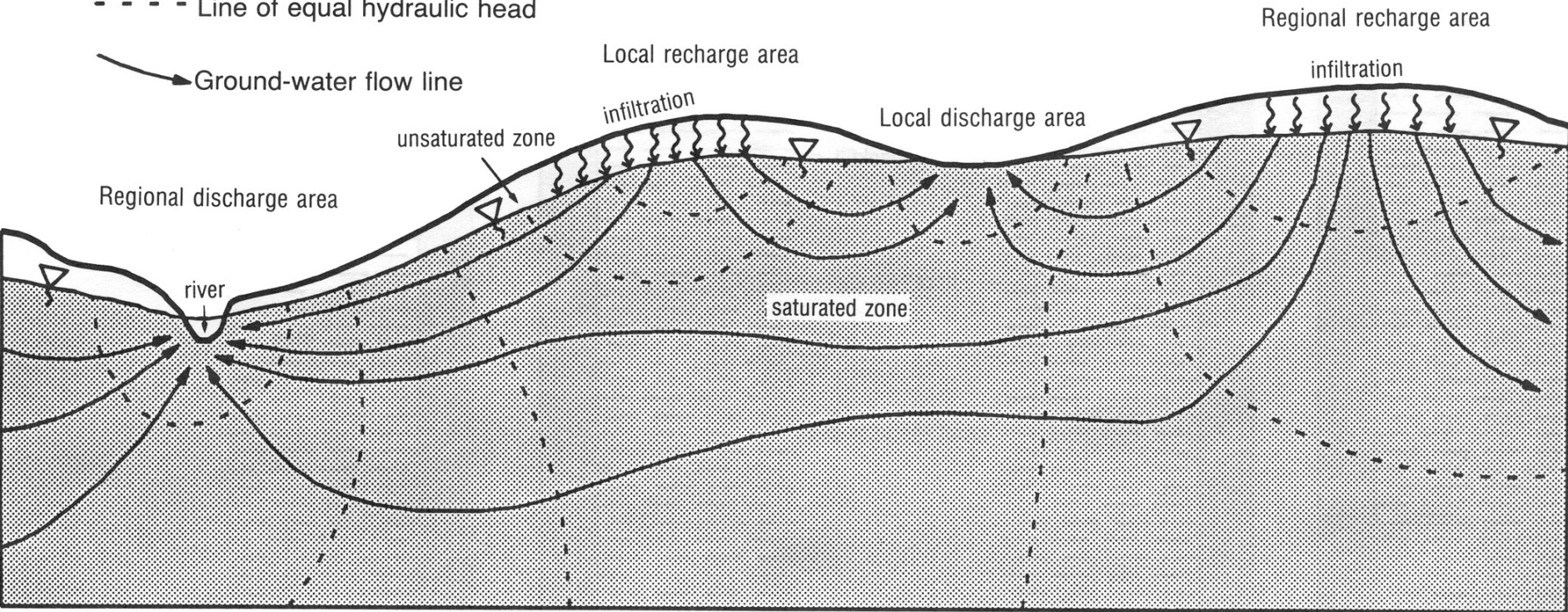
Unconfined aquifer = storage coefficient or specific yield

Need  $K$  &  $T$  to calculate storativity

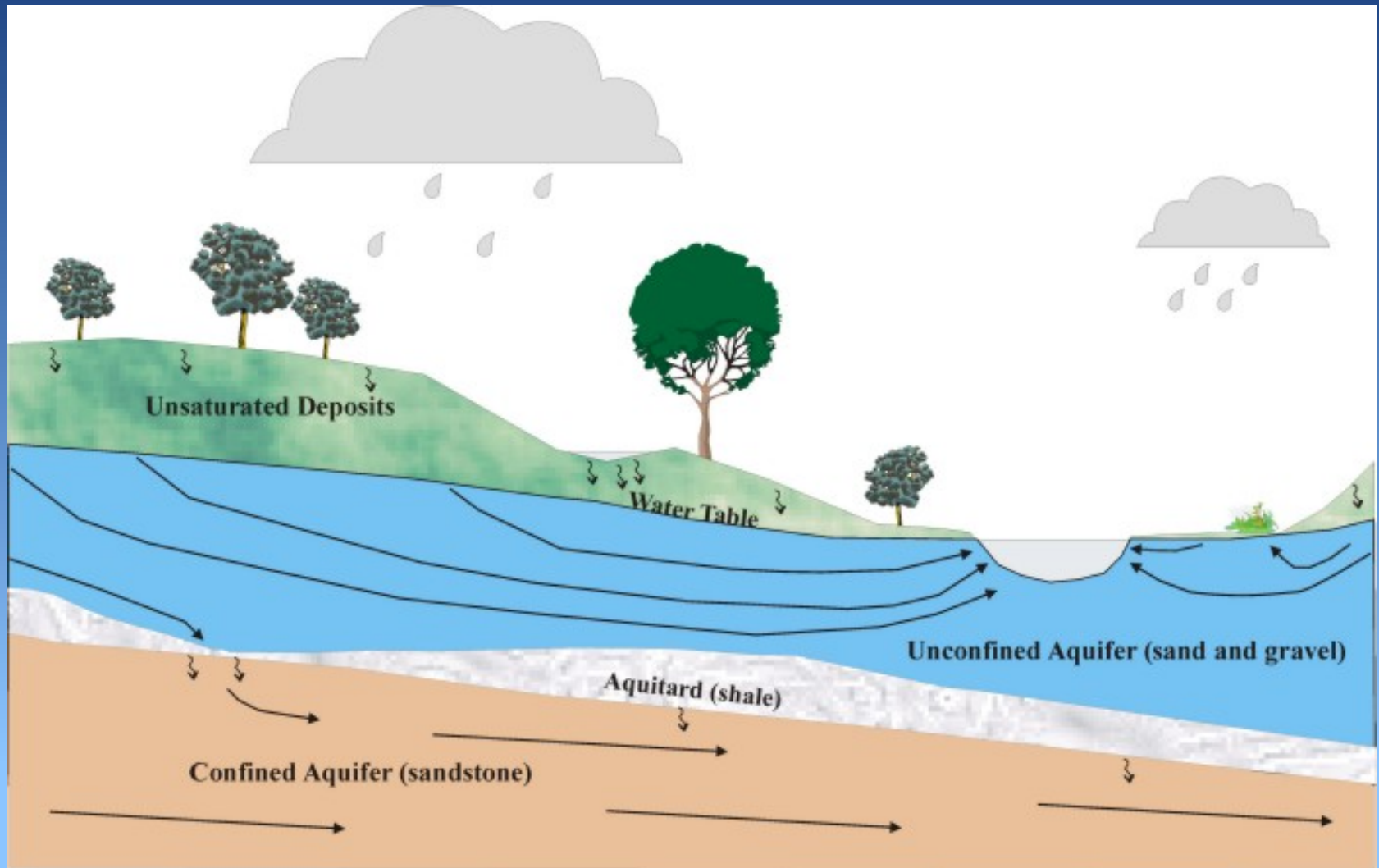
# Aquifer System Characteristics

## EXPLANATION

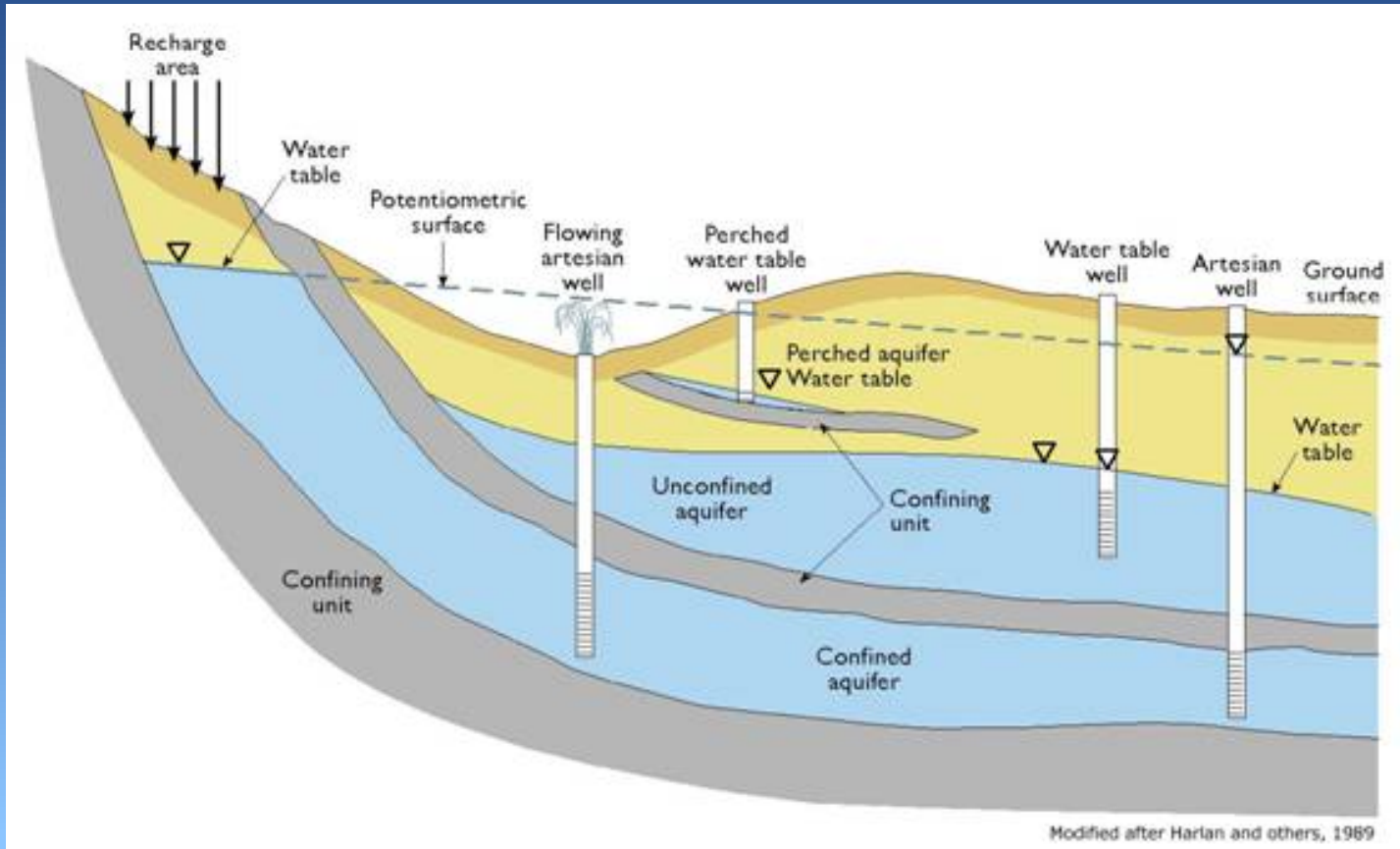
- ▽— Water table
- - - - Line of equal hydraulic head
- Ground-water flow line



# Aquifer System Characteristics



# Aquifer System Characteristics





# Aquifer System Characteristics

The screenshot shows a web browser window with the URL [www.mwwat.org/start.asp](http://www.mwwat.org/start.asp). The browser's address bar and tabs are visible at the top. The website's main heading is "WATER WITHDRAWAL ASSESSMENT TOOL". Below the heading is a navigation menu with a "Home" link. The page is divided into two main columns. The left column contains a "Related Articles" section with links to "Education Material" and "Tool Introduction", and a "Collaborators" section listing the Department of Environmental Quality, Department of Natural Resources, United States Geological Survey, and Institute of Water Research. The right column is titled "Choosing a New or Existing Registration" and features two large blue buttons: "I am Assessing a New Withdrawal" and "I am Modifying an Existing Registration". Below these buttons is a section titled "What should I choose?" which provides instructions for new versus existing registrations. At the bottom of the page, a footer reads "Institute of Water Research, all rights reserved © 2006".

Michigan's Water Withdrawal

www.mwwat.org/start.asp

Mike's Favorites maps.indiana.edu Indiana Geological Sur... Benton County, Indiana Indiana Spatial Data P... IndianaMap Viewer ASC Scientific Researc...


## WATER WITHDRAWAL ASSESSMENT TOOL


[Home](#) |


### Related Articles


- [Education Material](#)
- [Tool Introduction](#)

### Collaborators

 Department of Environmental Quality

 Department of Natural Resources

 United States Geological Survey

 Institute of Water Research

### Choosing a New or Existing Registration

[I am Assessing a New Withdrawal](#)

[I am Modifying an Existing Registration](#)

#### What should I choose?

If you are assessing a new withdrawal or proposing to register a new withdrawal for the first time, choose "New Withdrawal" above.

If you are modifying an existing registration you have made through the water withdrawal assessment tool, choose "Modify Existing Registration" above.

Note: Modifying an existing registration is required when the actual withdrawal construction deviates from what was proposed during the initial registration. This includes modifications such as: changing your location, well depth, capacity, etc.

Institute of Water Research, all rights reserved © 2006

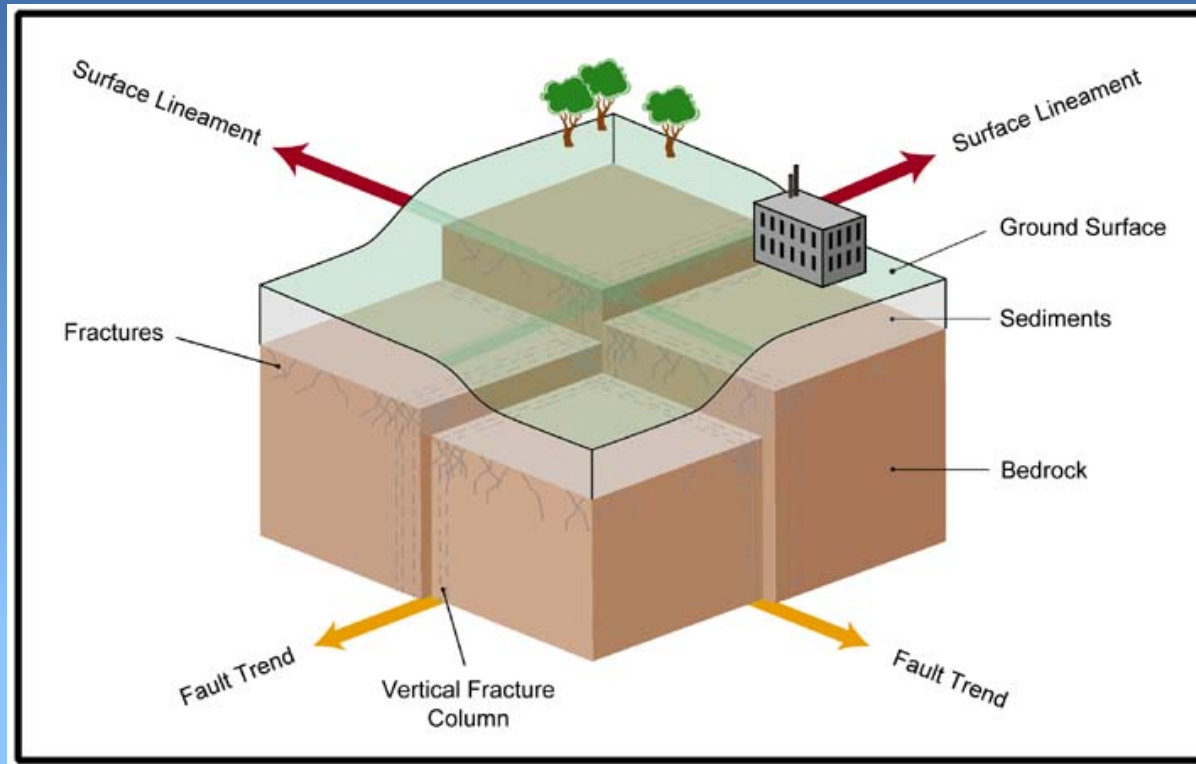
# Field Investigation

**Goal: Develop a Sustainable Irrigation Water Supply.**

- **Fracture Trace Analysis**
- **Surficial Geophysics**
- **Test Drilling**
- **Lithology Sampling**
- **Borehole Geophysics**
- **Well Construction**
- **Aquifer Performance Testing**

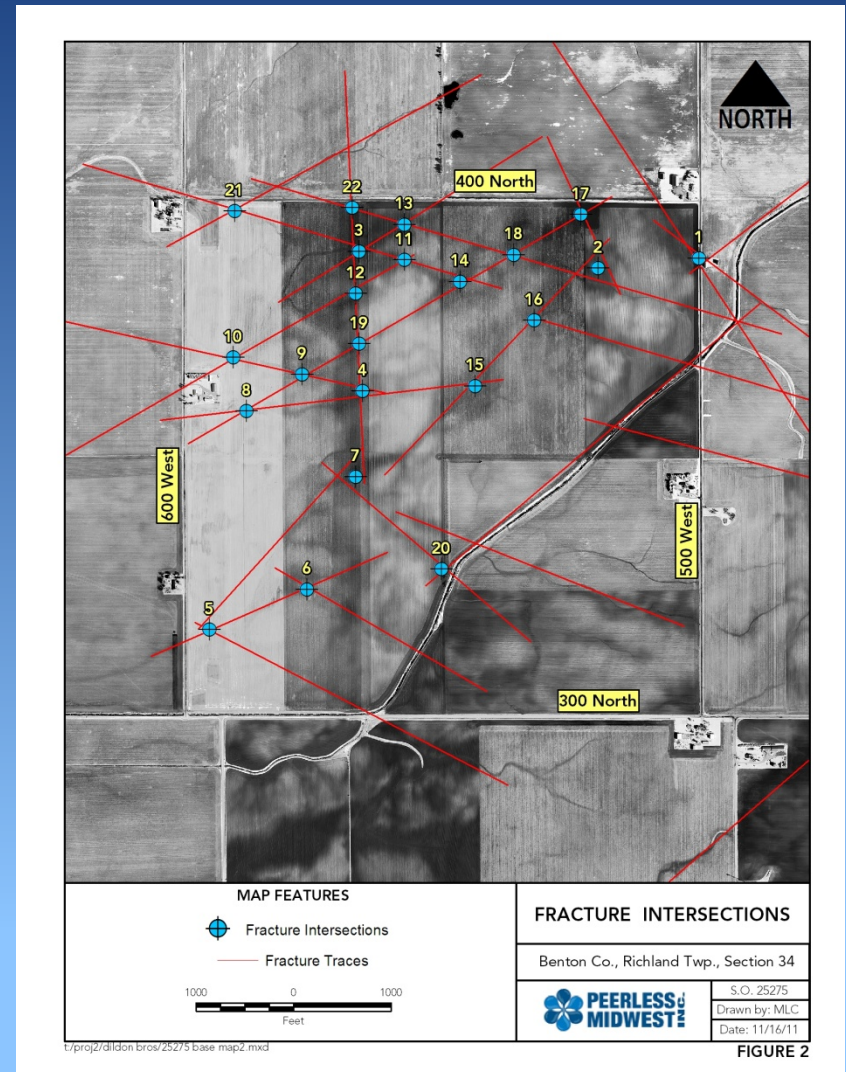
# Fracture Trace Analysis

Lineaments are linear features that are identifiable on stereographic pairs of aerial photographs. They are identified based upon subtle changes in topography and shading at the ground surface. Fractures and faults in bedrock or basement rocks are often propagated up through unconsolidated sediments to the surface as failure planes. These features are often expressed as lineaments that have subtle surface expressions. Lineaments usually result from the minor reactivation of fractures and faults that occurs because of occasional seismic activity.



# Fracture Trace Analysis

Lineaments are identified using stereographic pairs of aerial photographs.



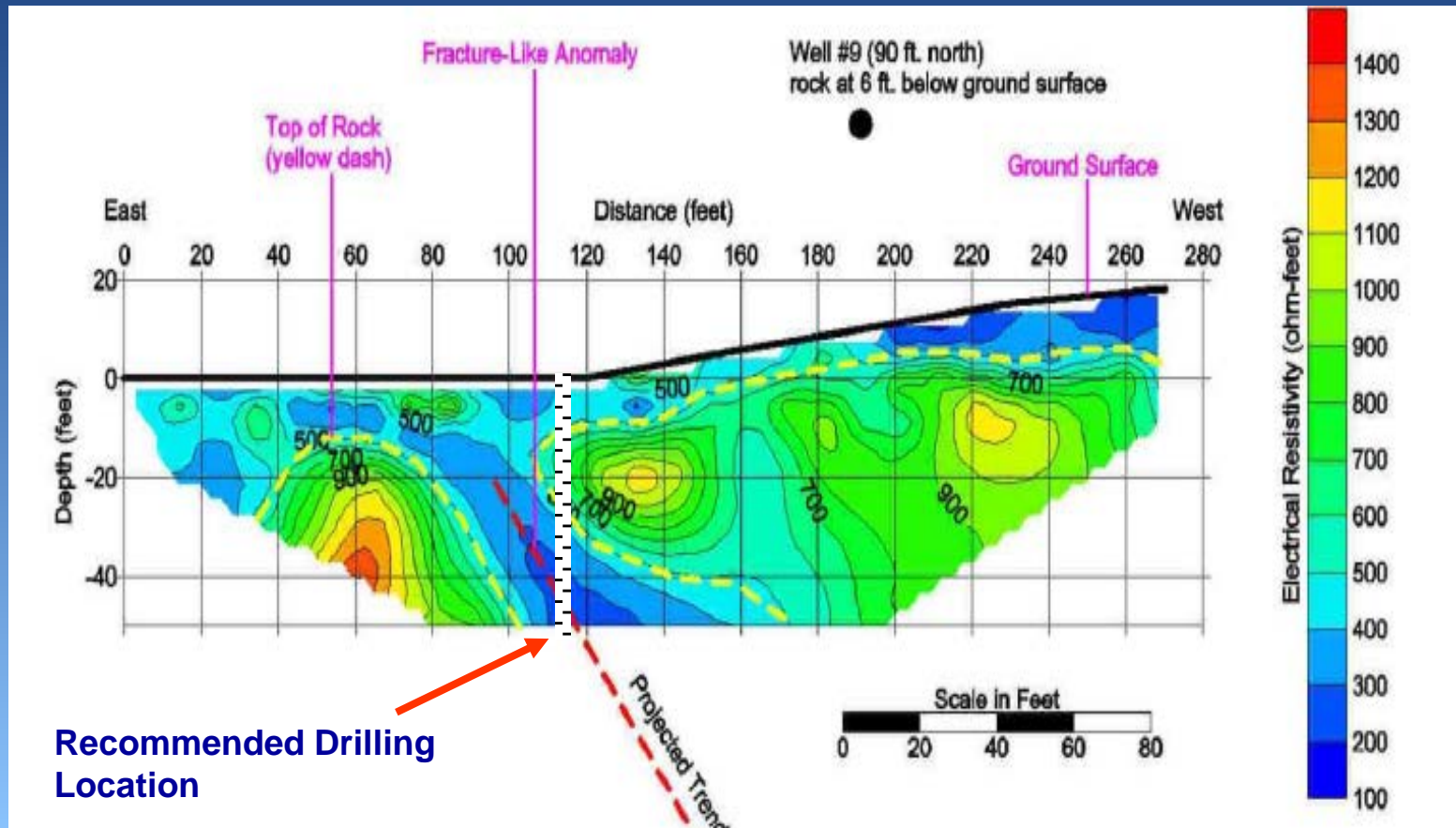
# Electrical Resistivity Surveying

## ER Detects:

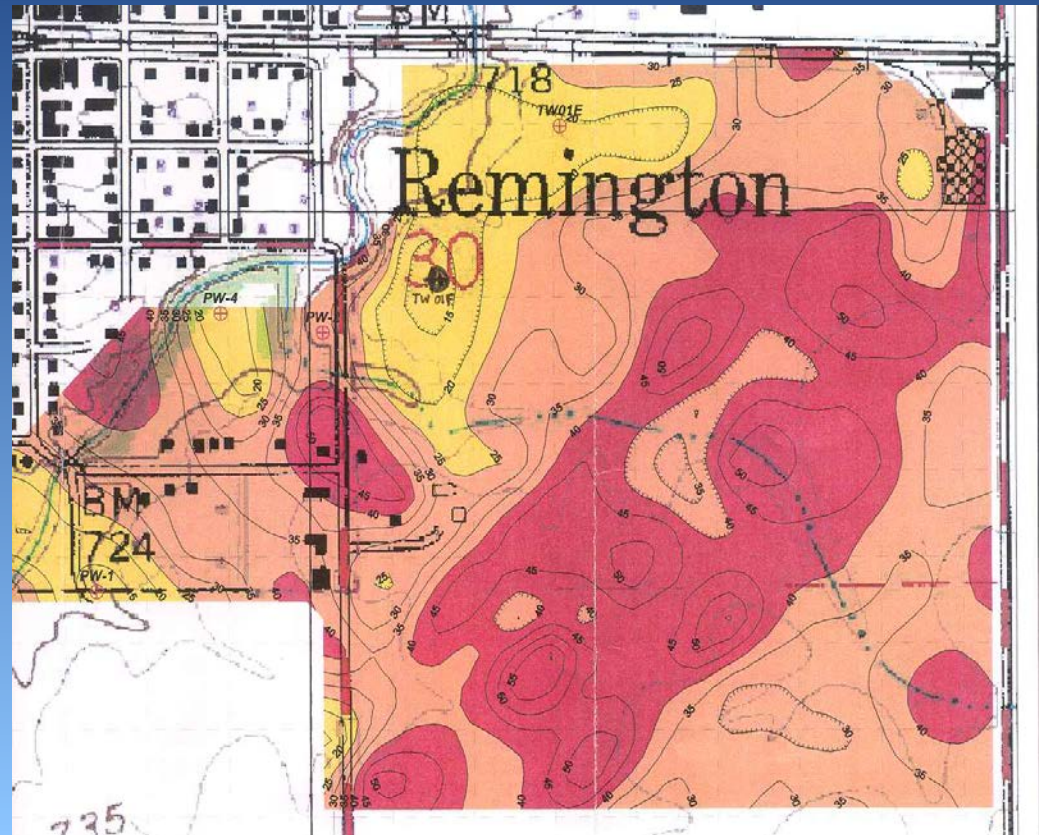
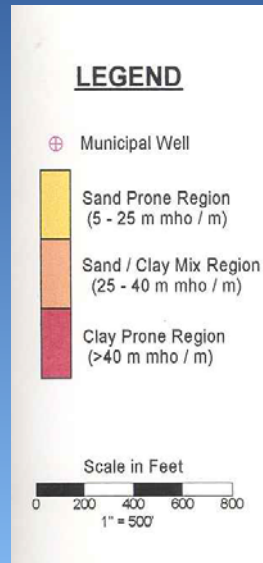
- Stratigraphic horizons and continuity;
- Boundary Conditions
- Bedrock weathering and faulting
- Clay and water content



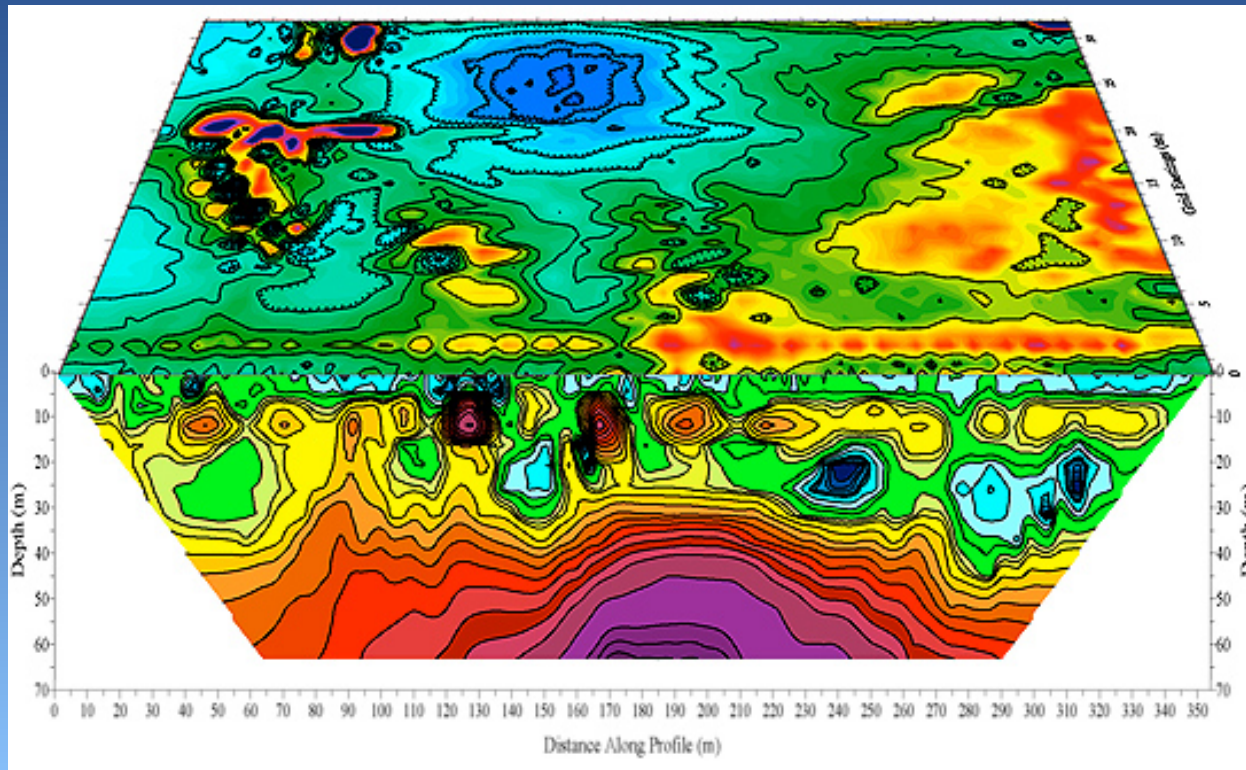
# Electrical Resistivity Surveying



# Electrical Resistivity Surveying



# Electrical Resistivity Surveying





# Test Drilling

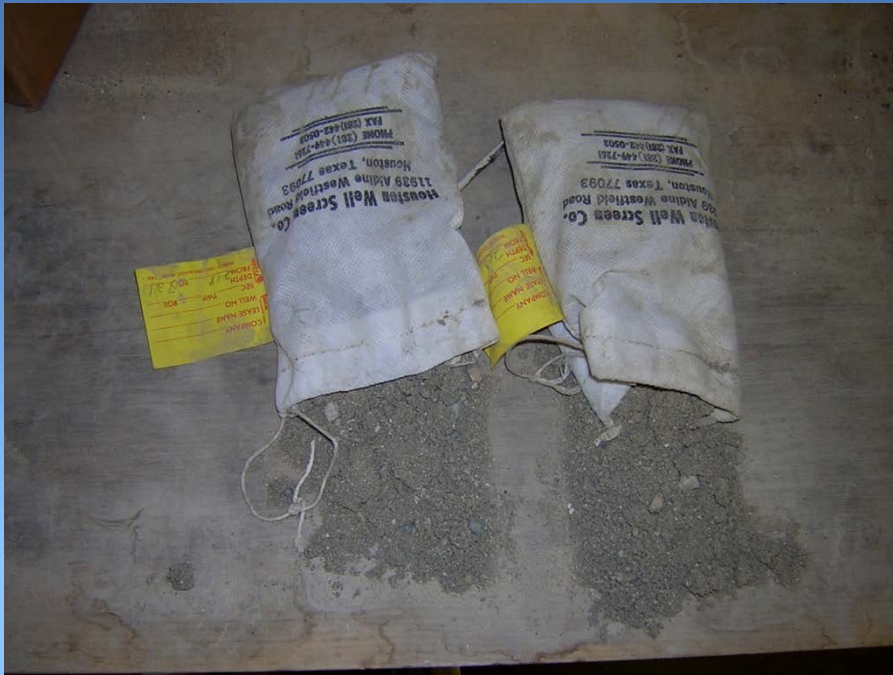
## Mud Rotary Drilling

- Bentonite clay used as drilling fluid
- Lithology samples collected at 5 ft intervals
- Borehole advanced to base of available aquifer(s)



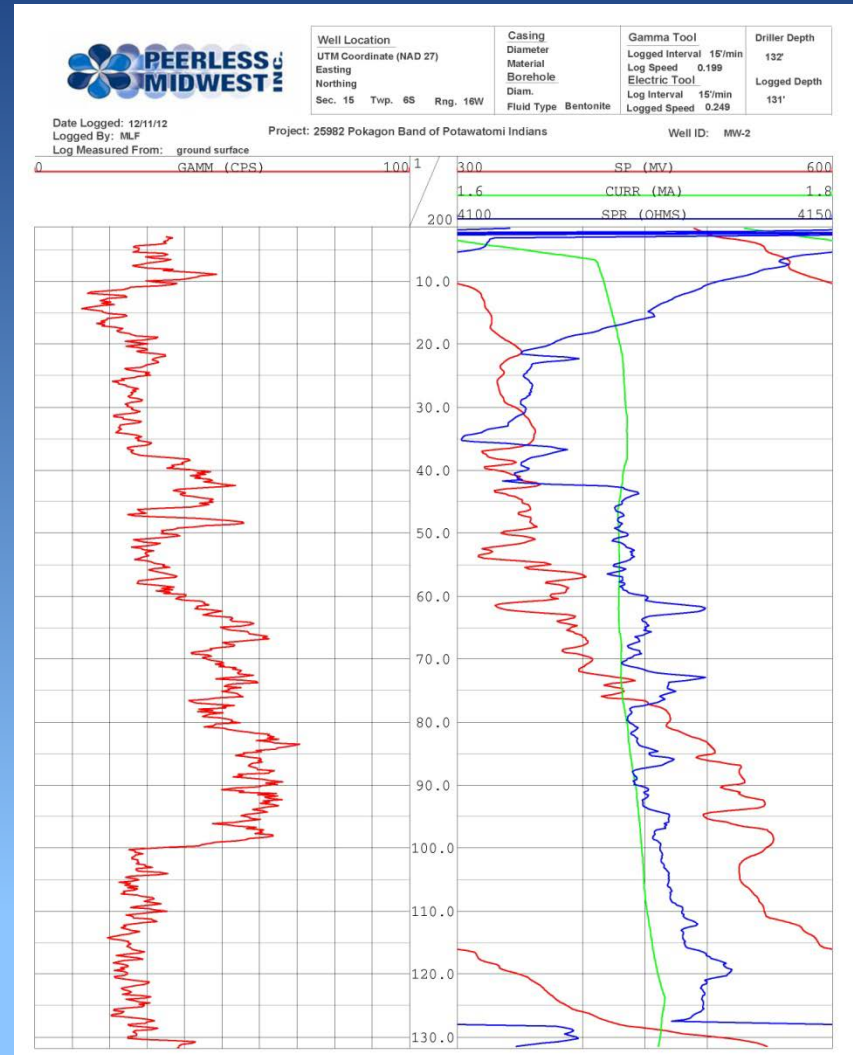
# Lithology Sampling

- Lithology samples collected at 5 ft intervals within aquifer formations
- Samples are bagged and labeled for review and sieve analysis

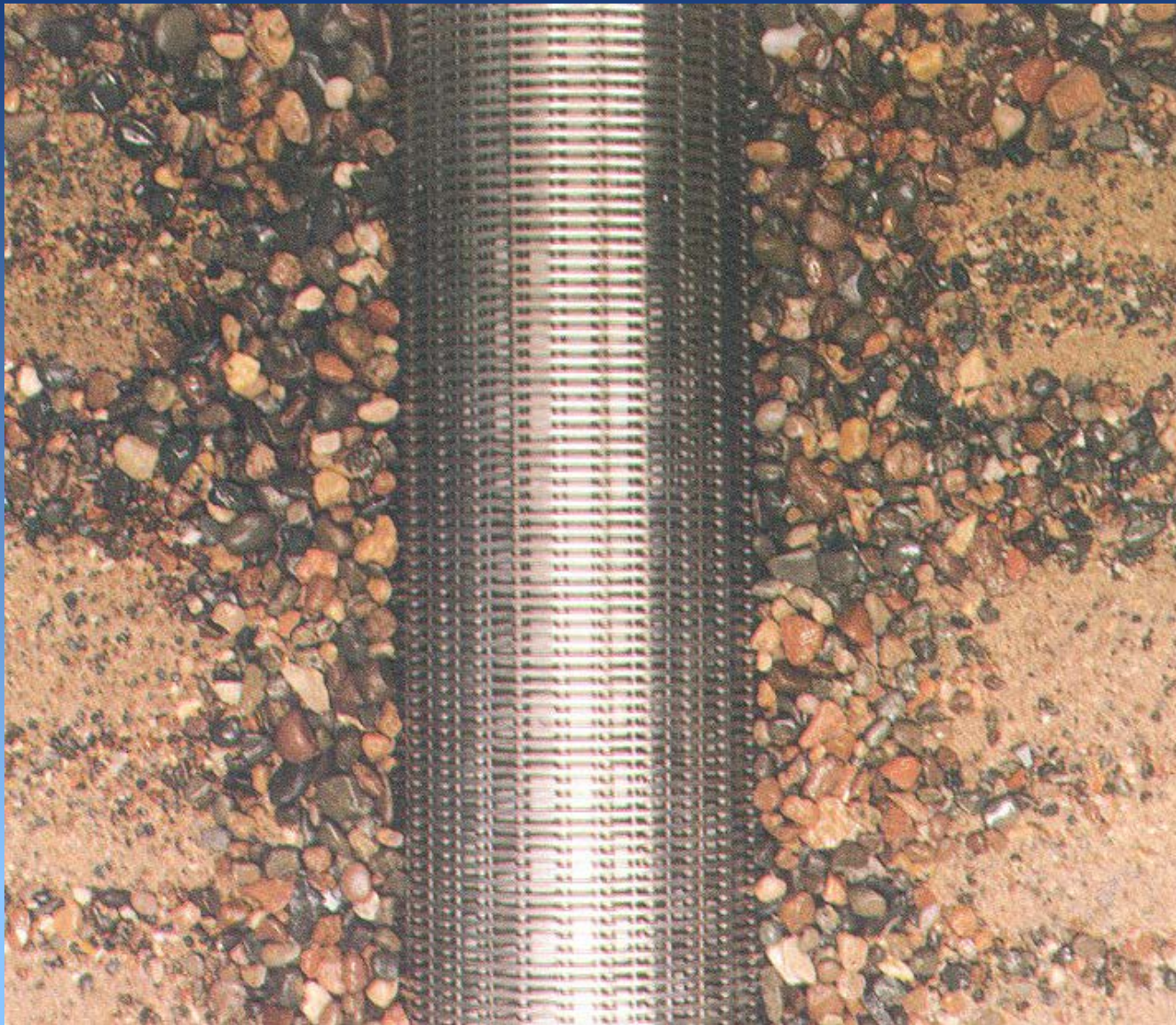


# Borehole Geophysics

- Natural gamma ray & single point resistivity logging conducted to verify aquifer intervals.

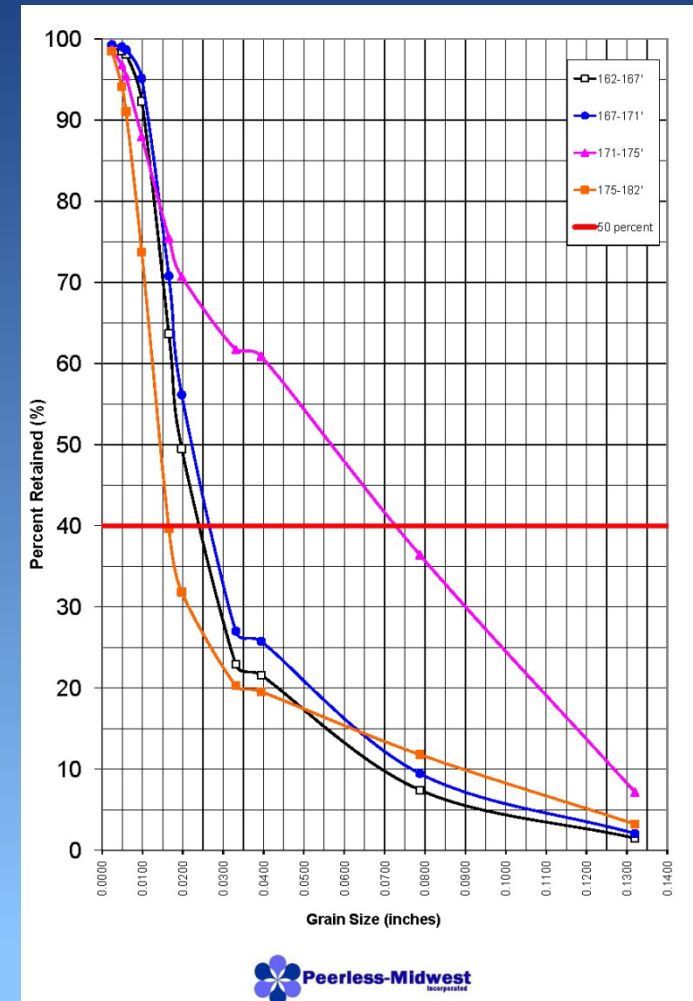


# Sieve Analysis & Screen Selection



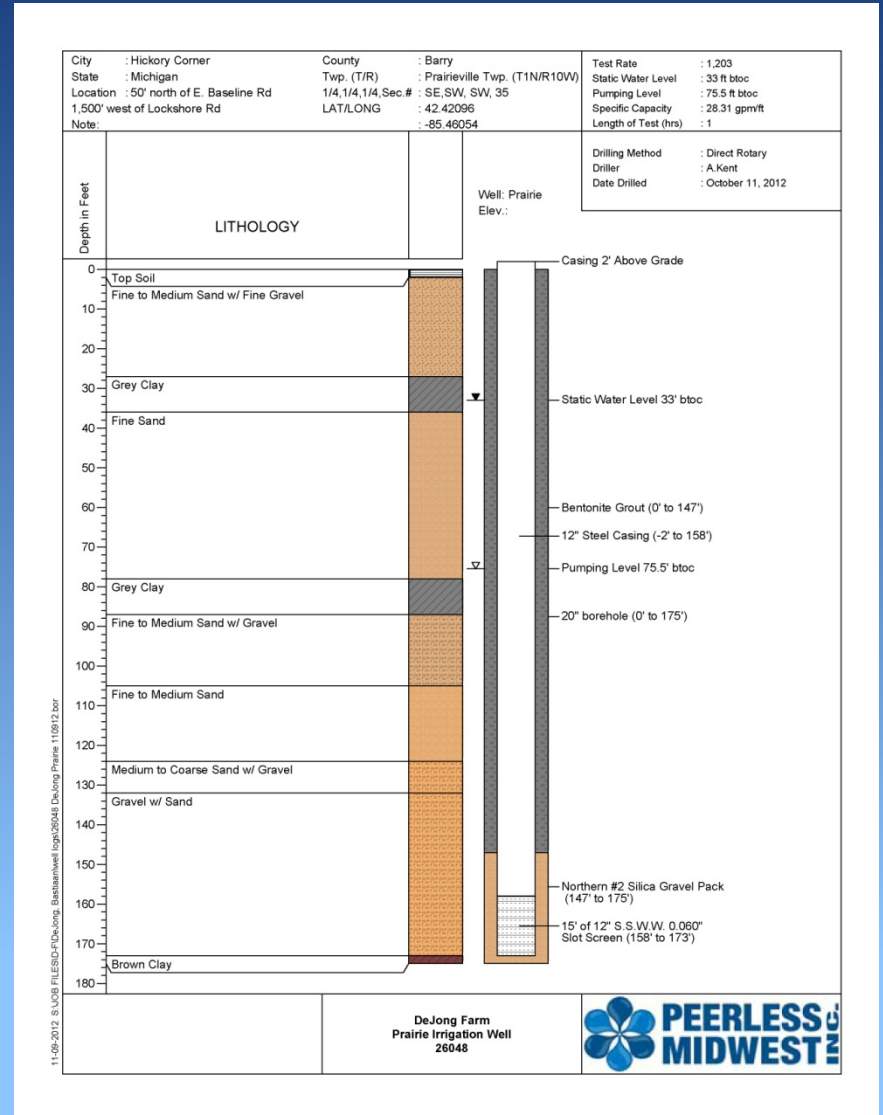
# Sieve Analysis & Screen Selection

Sample ID		W-20				
Interval (ft)		145-155	155-165	165-175	175-185	185-190
U.S. Screen	Inches Opening	ACC % Retained	ACC % Retained	ACC % Retained	ACC % Retained	ACC % Retained
6	0.132	0.1%	0.2%	0.0%	0.0%	0.0%
9	0.0784	0.4%	1.4%	0.0%	0.4%	0.1%
16	0.0394	1.2%	8.6%	0.8%	1.7%	0.8%
20	0.0331	1.4%	10.1%	1.6%	2.8%	1.2%
35	0.0197	14.7%	43.7%	37.5%	30.9%	17.1%
40	0.0165	48.4%	61.7%	44.7%	41.8%	39.4%
60	0.0098	87.4%	90.7%	85.8%	88.5%	89.5%
100	0.0059	94.7%	97.2%	97.1%	97.6%	97.0%
120	0.0049	96.3%	97.7%	97.8%	98.6%	98.0%
230	0.0024	98.5%	99.2%	99.3%	99.7%	99.5%
pan	<0.0024	100.0%	100.0%	100.0%	100.0%	100.0%

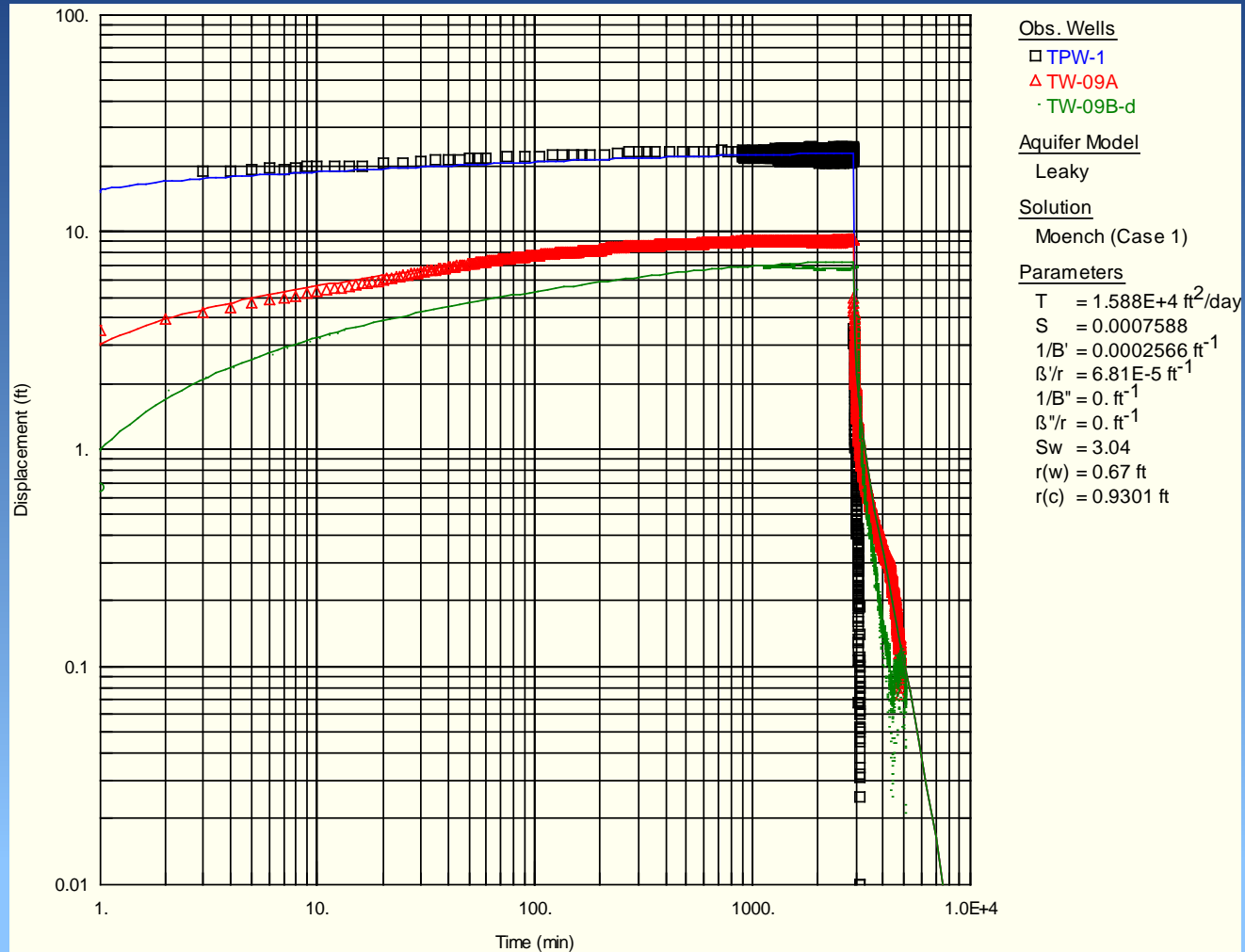


# Test/Production Well Construction

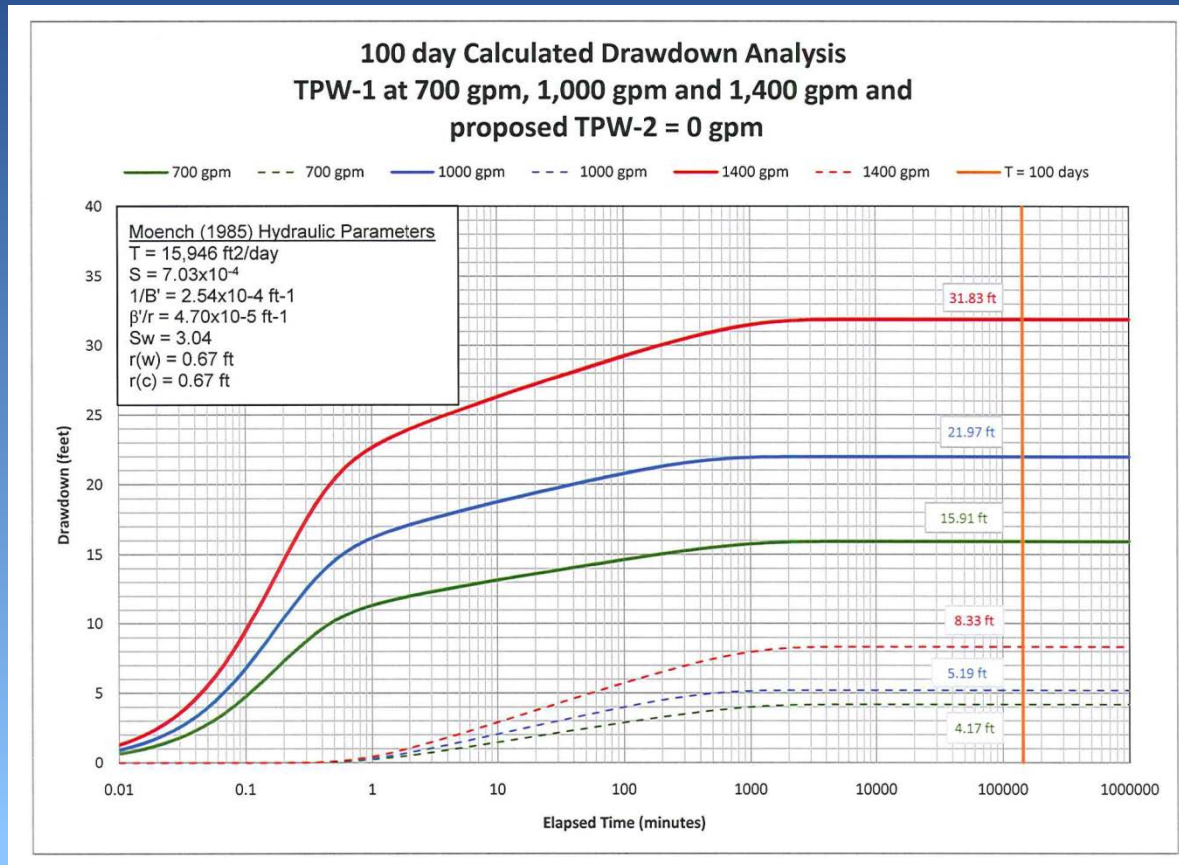
- Large diameter borehole drilled
- Well screen and casing installed.
- Annular space back filled with gravel pack and grout
- Well is then developed and tested



# Aquifer Performance Test



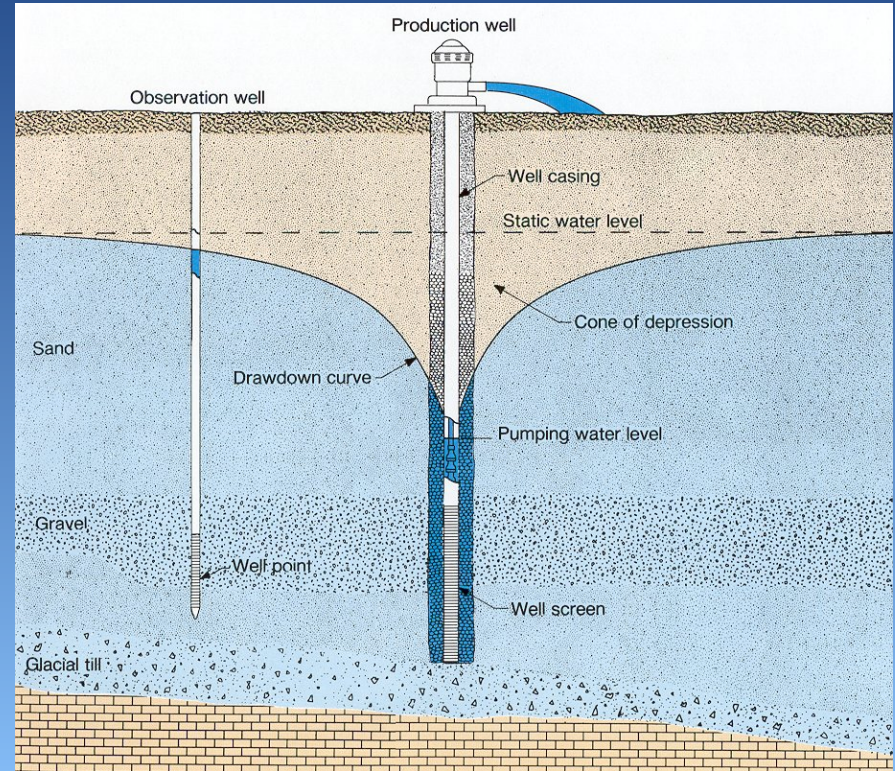
# 100 Day Safe Yield Calculation





# Aquifer System Characteristics

- **Aquifer hydraulic parameters used to calculate sustainable yield;**
- **Pumps designed based upon total dynamic head, well diameter, available drawdown.**



# Sustainable Irrigation



# Finding Large Capacity Groundwater Supplies for Irrigation

December 14, 2012

Presented by: Michael L. Chapman, Jr., PG

