Ball State University Ground-Source Geothermal Fields

Baseline hydrogeologic characteristics of the ground-source geothermal fields at Ball State University (Muncie, IN)

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BSU Annual Utility Use

- Coal 36,000 tons
- Electricity 110x10^6 kwh (or 11x10^3 homes)
- Natural Gas 150x10^6 cf (or 1.6x10^3 homes)

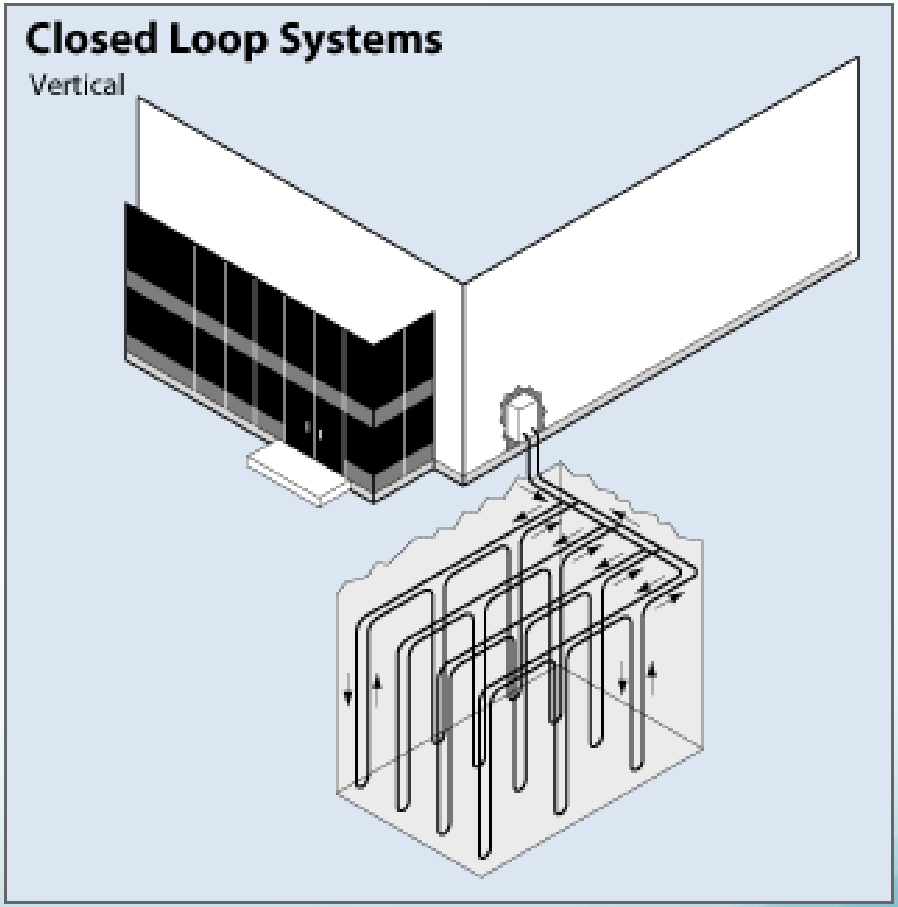
(Source: BSU, pers. comm.)

Geothermal Conversion

- Reduce pollutants
  - CO_2
  - SO_2
  - NO_x
  - CO
  - Particulates
- Reduce carbon footprint by 50% (Lowe et al. 2010)
- Will save $2M annually (Lowe et al. 2010)

Geothermal Systems

- Winter
  - Heat moves from the warmer ground to the cooler buildings
- Summer
  - Heat moves from the warmer buildings to the cooler ground



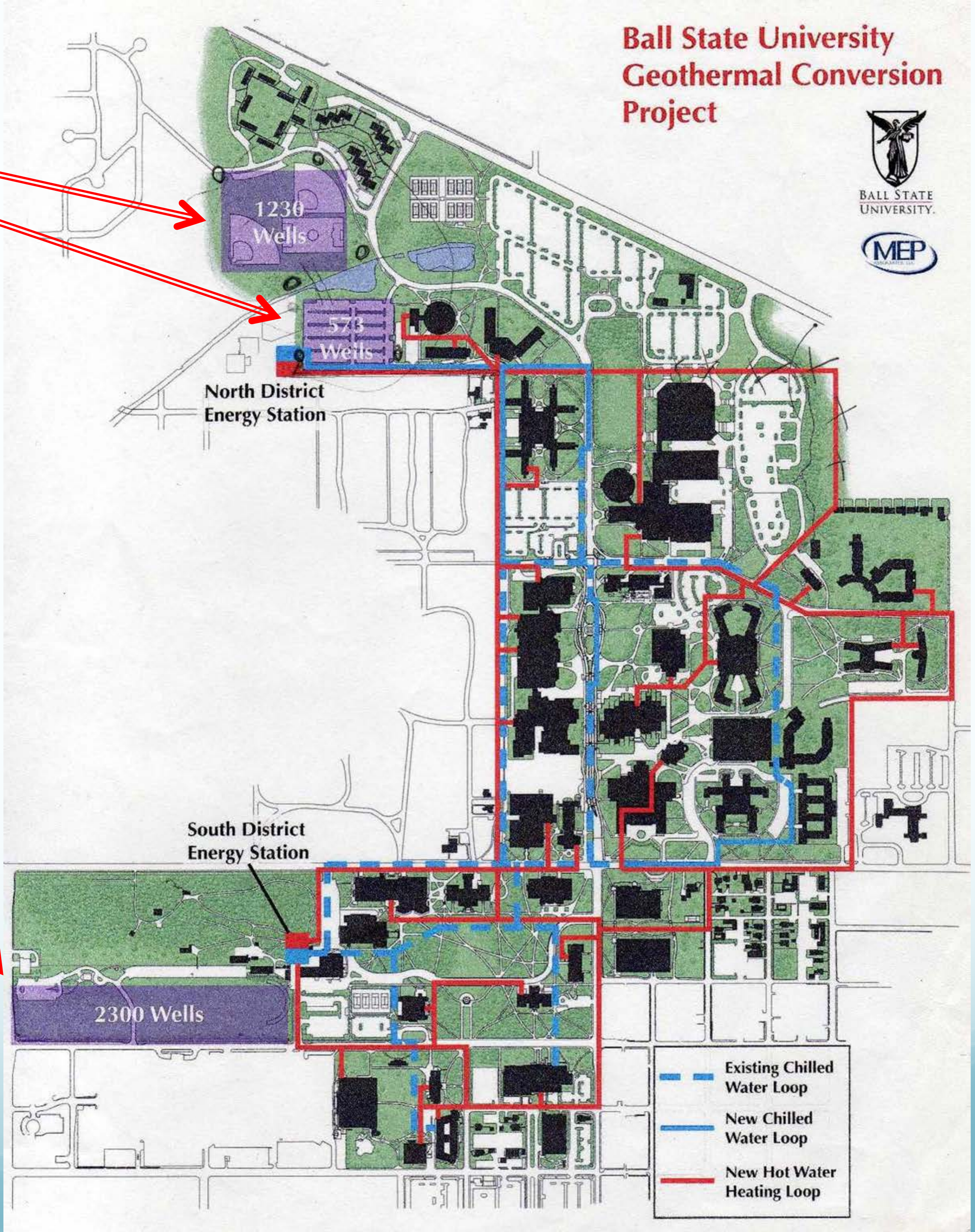
(Department of Energy (n.d.))

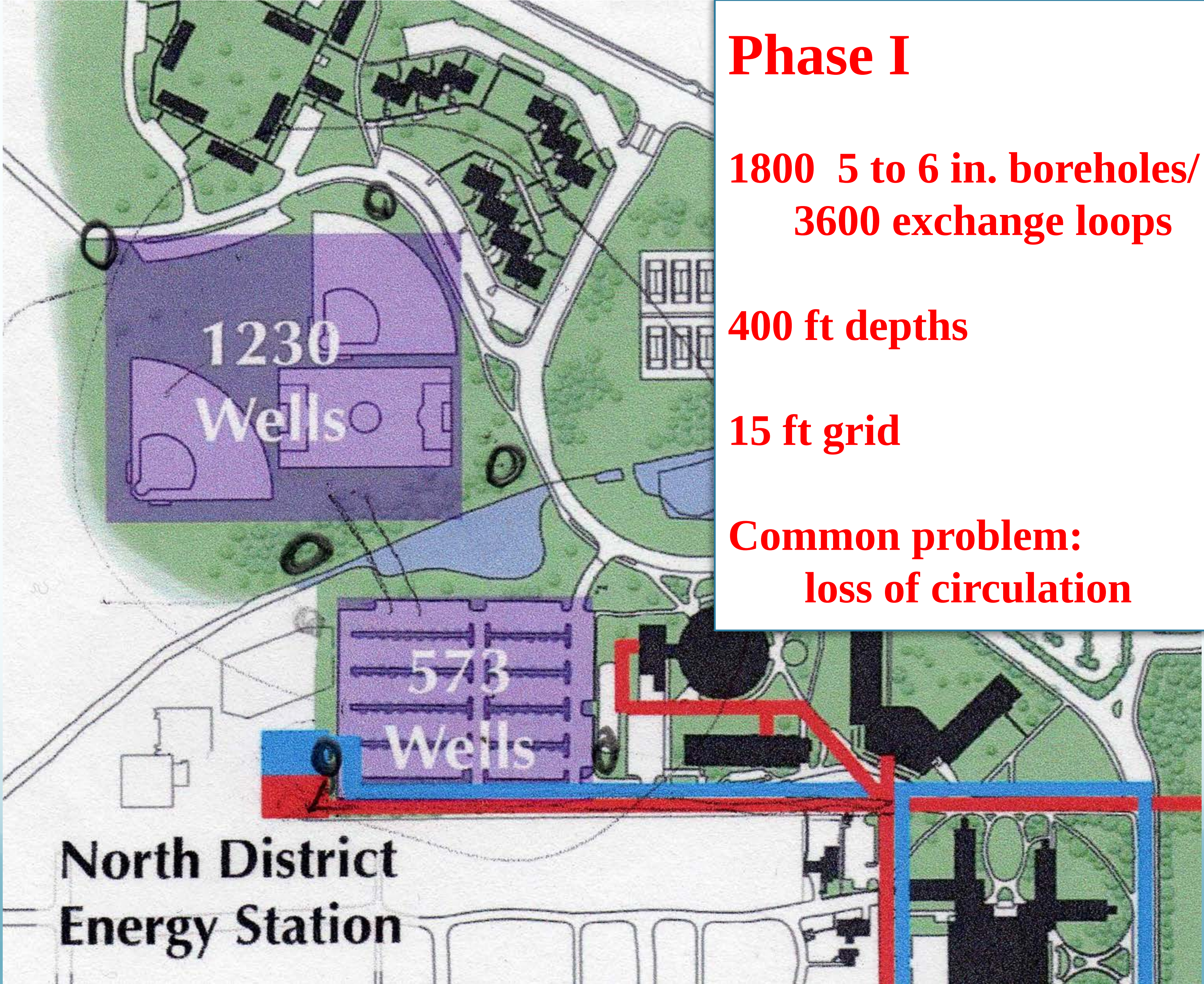
Phase I

Nearing completion, startup this Fall

Phase II

Drilling starting this month





Phase I

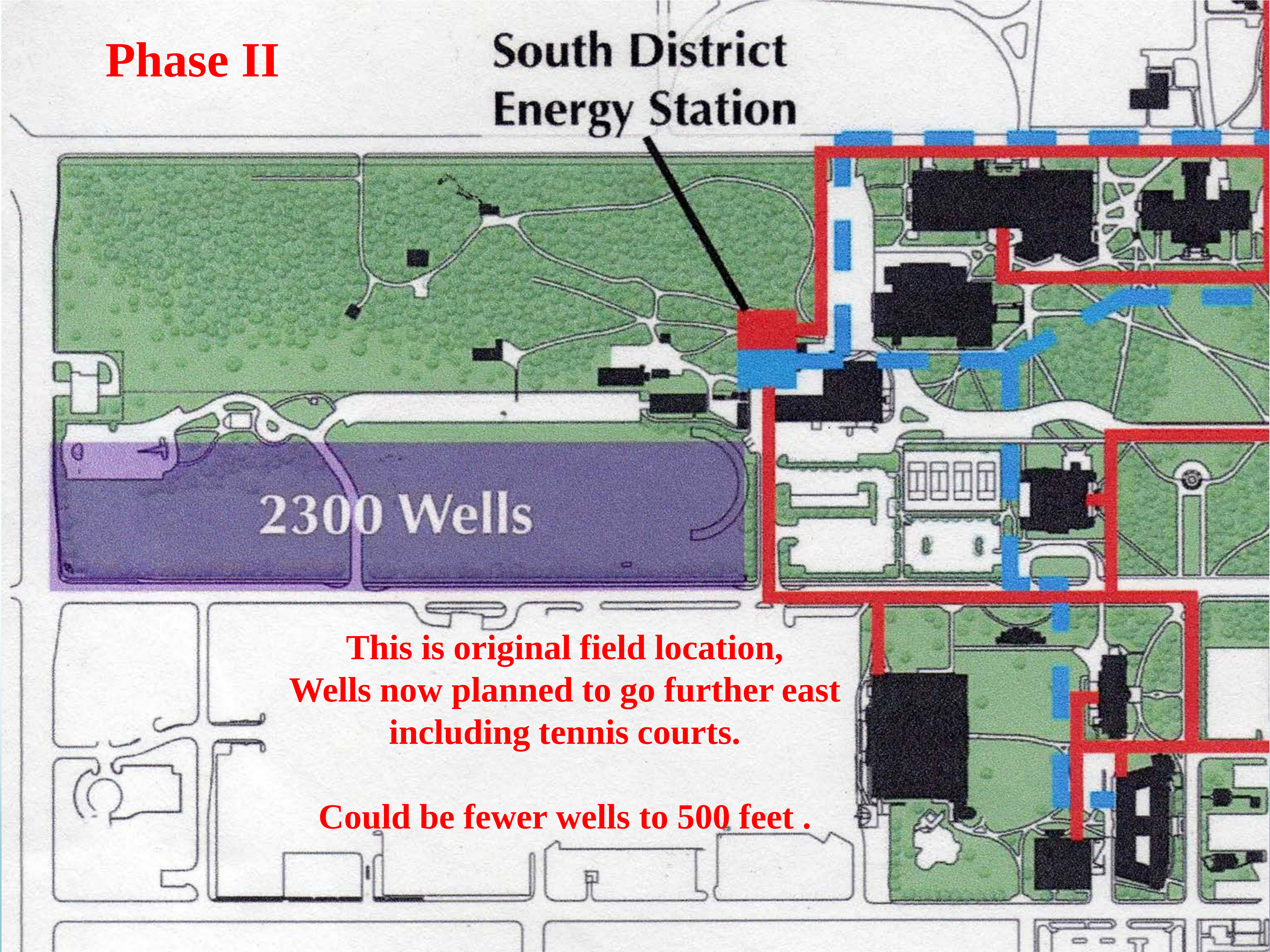
1800 5 to 6 in. boreholes/
3600 exchange loops

400 ft depths

15 ft grid

Common problem:
loss of circulation

Phase II



This is original field location, Wells now planned to go further east including tennis courts.

Could be fewer wells to 500 feet .

Shale shaker filter systems – double screen removes cuttings and lets fluid circulate back in the system

Grout has addition of 300-400 lb of sand to one bag of grout to increase the thermal conductivity


As many as 10 rigs on site at one time


Phase I South field
now completed back
into parking lot.


Parking Lot finished over
Phase I South Field
Pond between North and
South Phase I Fields
South Field
NE Monitor Well
05.27.2011 13:12


Phase I – Energy Conversion Station
05.27.2011 13:09


Regrading for sports fields
over Phase I North Field
05.27.2011 13:16

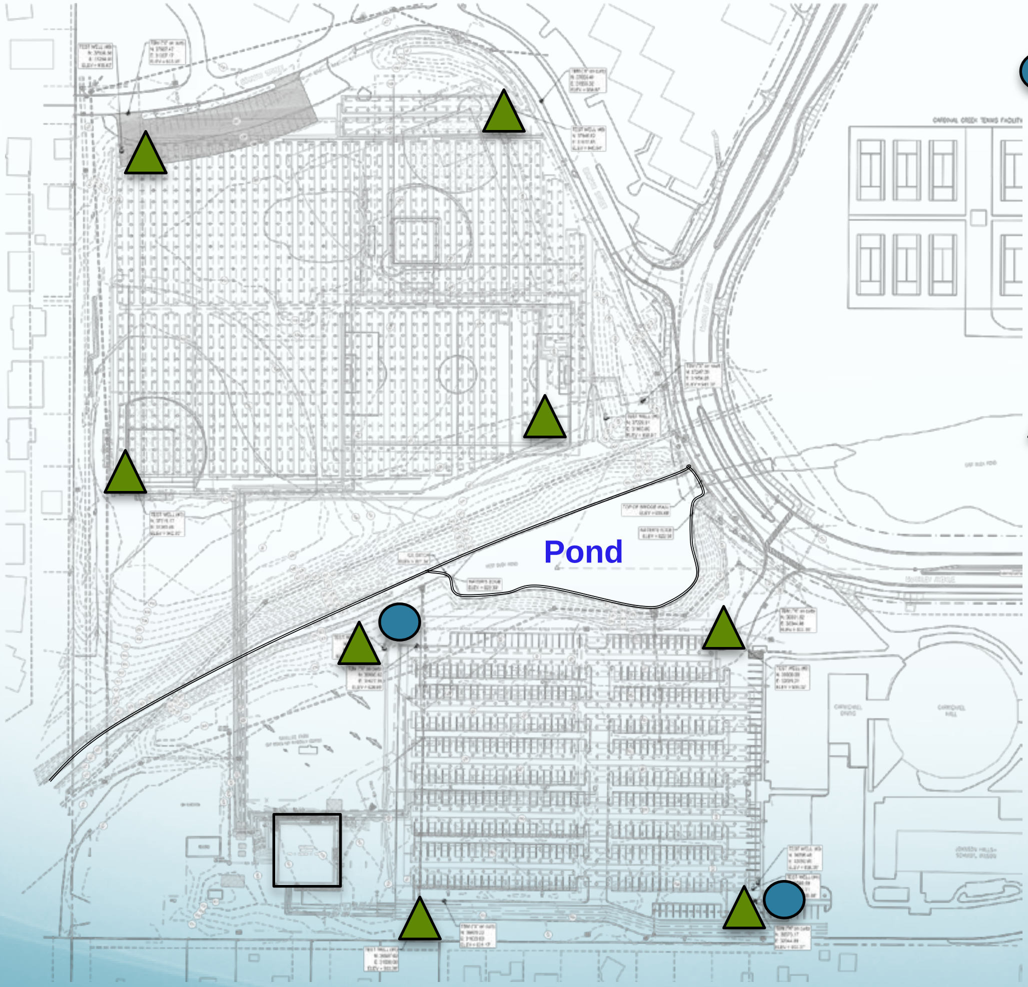

North Field NE
Nested Monitor Wells
Construction for sports fields
over Phase I North Field
05.27.2011 13:13

Dept of Geological Sciences

- Geology Geothermal Team
  - Involved in designing monitoring strategy
  - Involved in design of monitoring wells

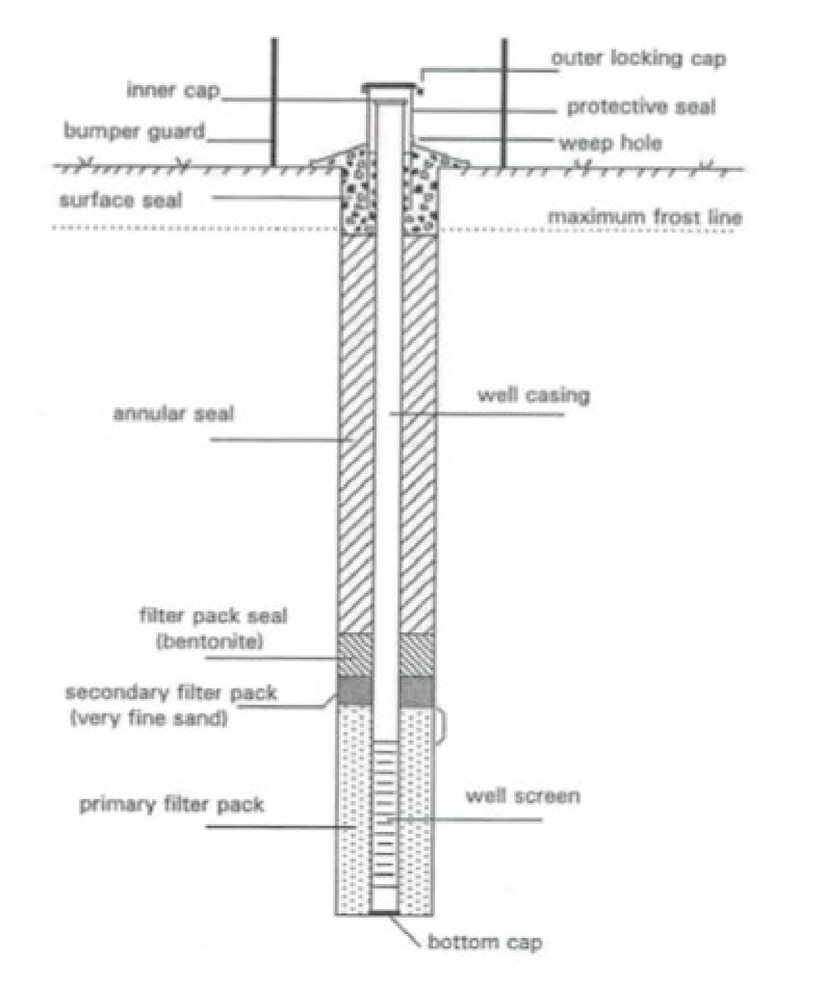
- Student Involvement
  - Research Classes
  - Collect and analyze data and samples
  - Presentations

Monitoring Wells



- 2 Gravel Wells (26-30 ft depth)
- Top of Bedrock Wells (60-90 ft depth)

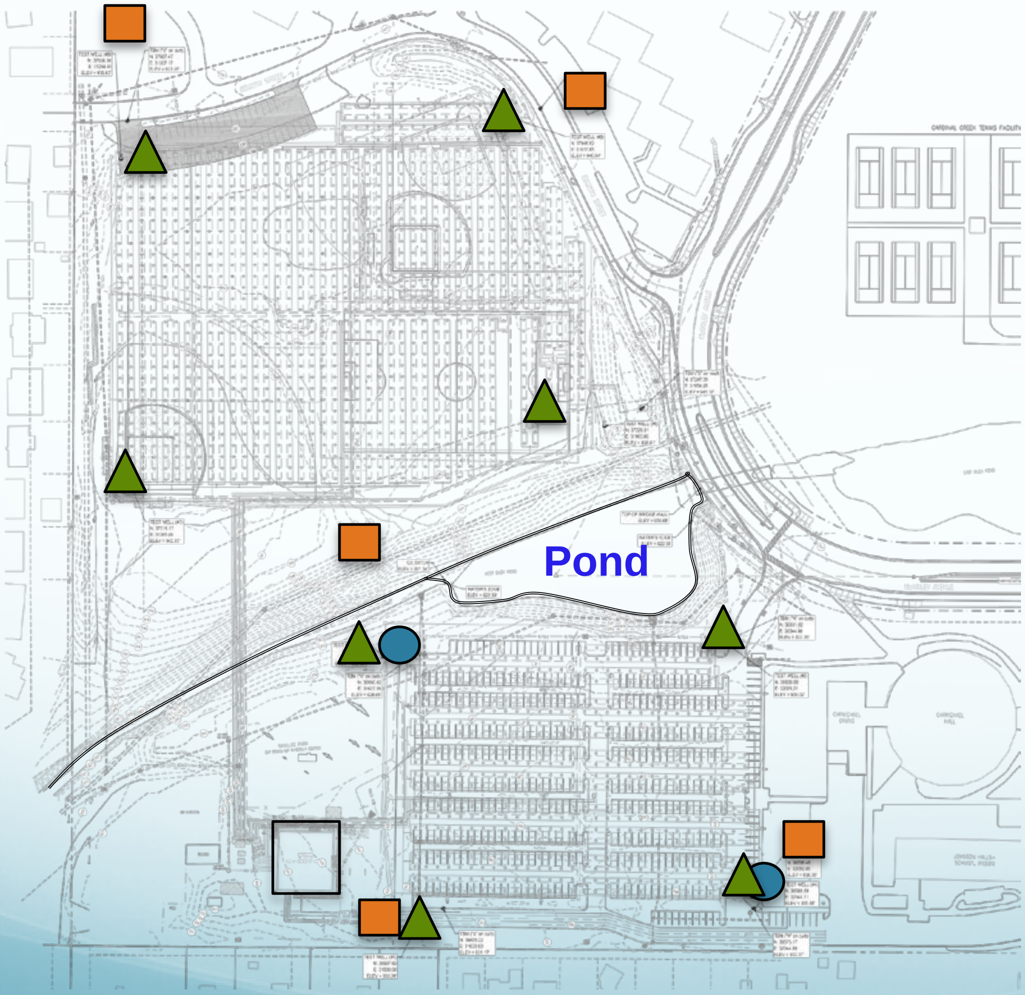
Monitoring Wells



(Courtesy of Ohio EPA, 2008)

- Shallow Gravel Monitors
  - 2 wells
  - 26-30 ft deep
- Top of Bedrock Monitors
  - 8 wells
  - 60-90 ft deep
  - 30 ft screens

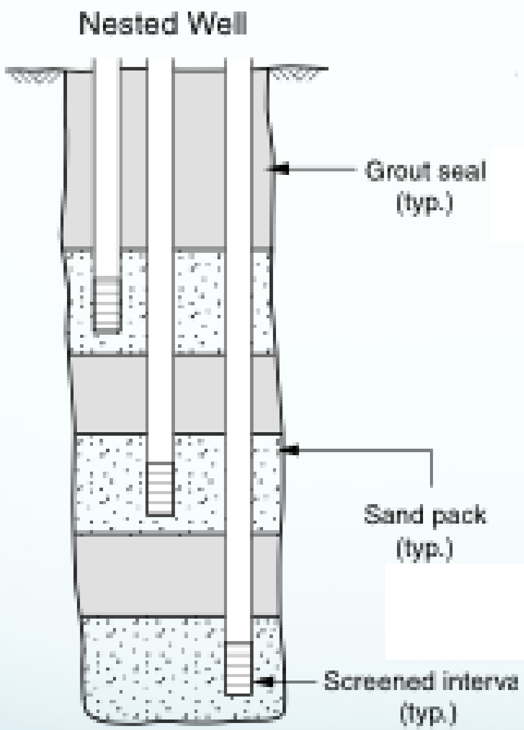
Deeper Nested Monitoring Wells



- shallow gravel wells
  - 2 monitors
- top of bedrock wells
  - 8 monitors
- nested bedrock wells
  - 5 nests to 400 ft
  - 5 screens each

Drilling Nested Wells

Nested Wells



(Einarson 2005)

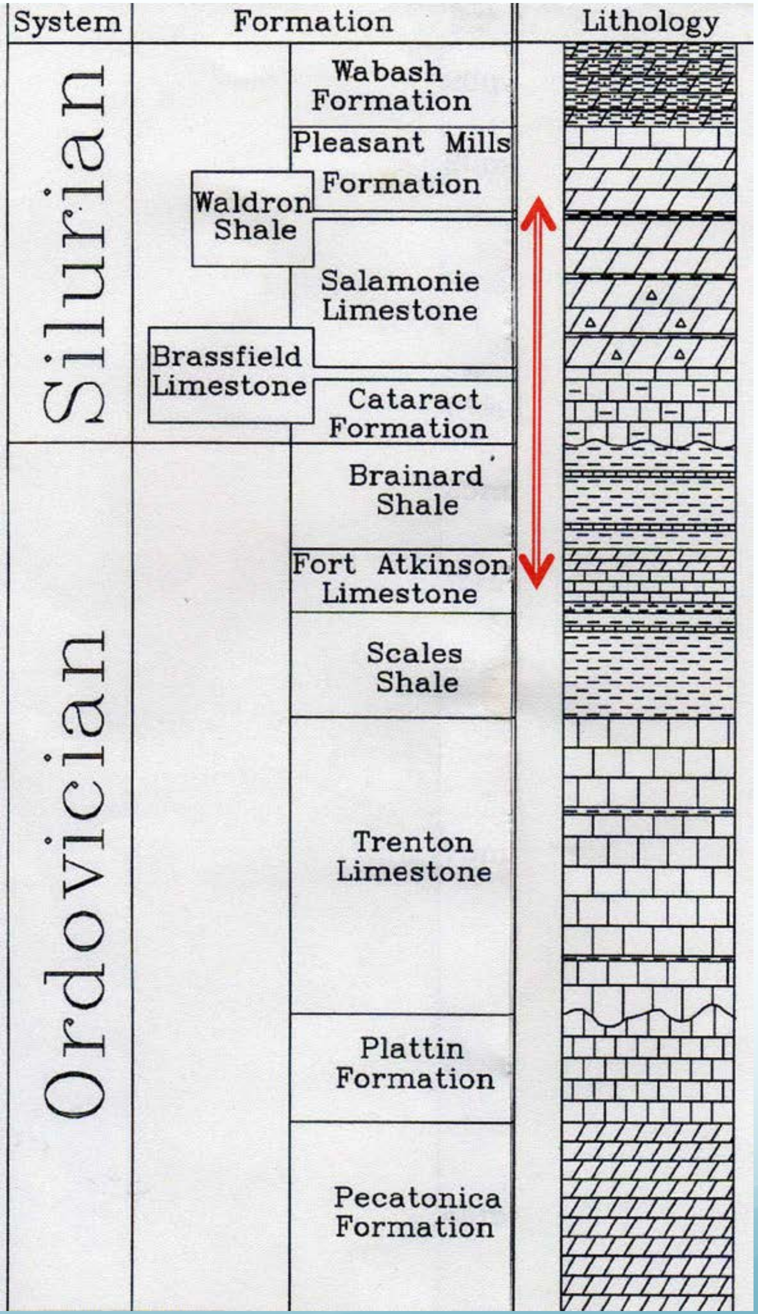
- Single 8” Borehole
- 5 Piezometers
  - 70—95 ft
  - 160—165 ft
  - 230—240 ft
  - 325—330 ft
  - 400 ft
- 30 ft screens
- Placement based on results of horizontal water flow gradients from the 8 original monitors
- Depths based on drilling logs, gamma logs, and bagged samples

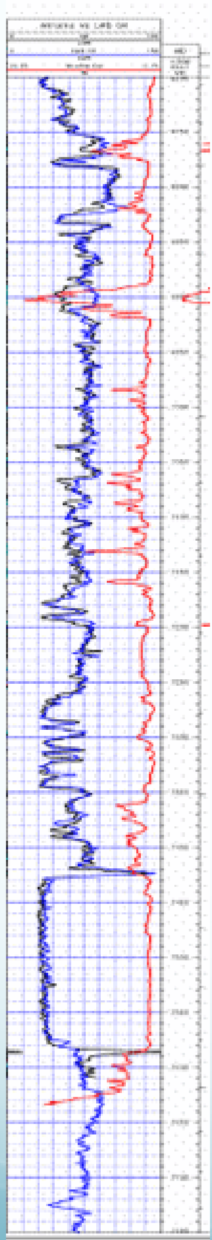

Nested
Monitors
05.27.2011 13:09


Large Casing
Monitors
05.27.2011 13:18

Composite Bedrock Stratigraphy of East Central Indiana

(we are concerned with the section indicated by arrows)



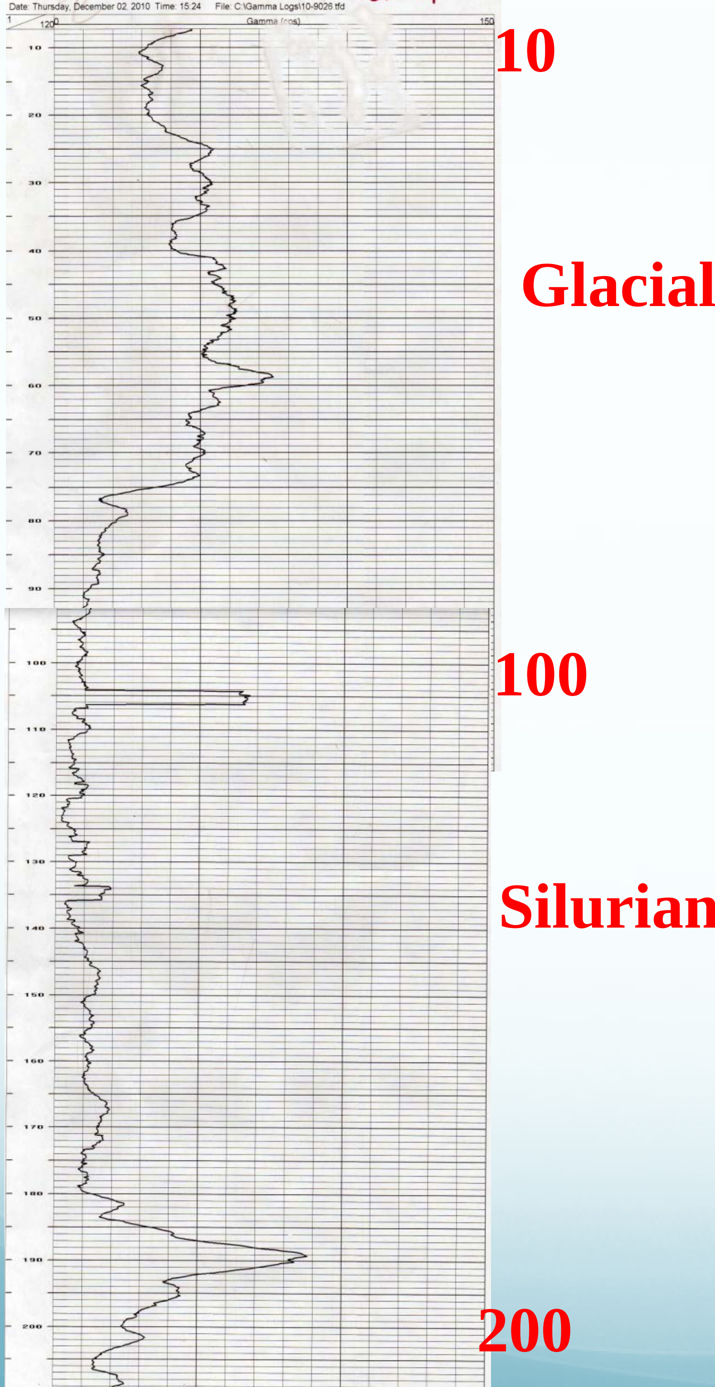


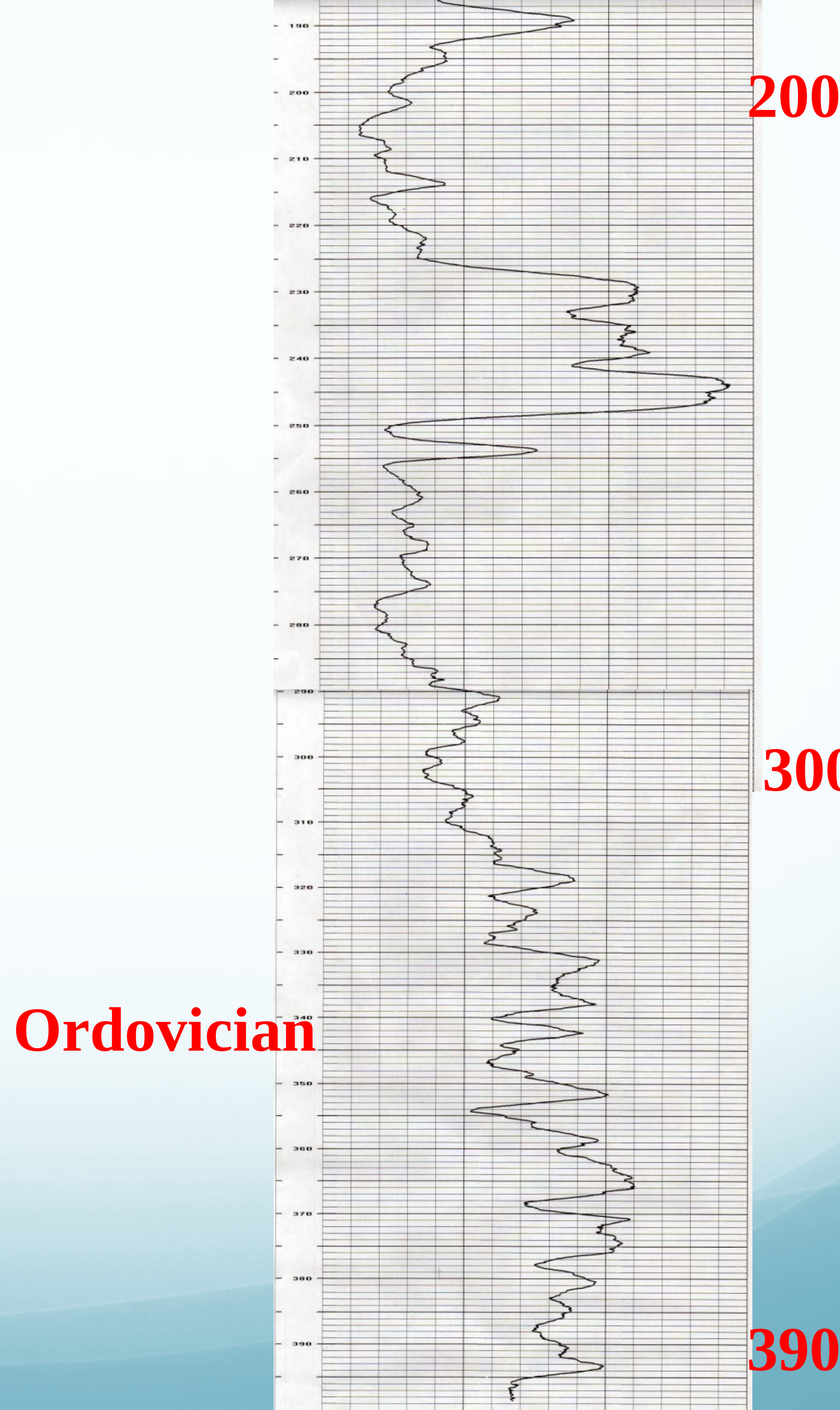
Gamma Ray Logging

- Rock Identification and Strata Correlation
- A downhole instrument is lowered in the borehole (prior to well installation)
- Measures the natural radiation
- Different rocks emit different amounts of radiation
  - Shale: More
  - Sandstone: Less

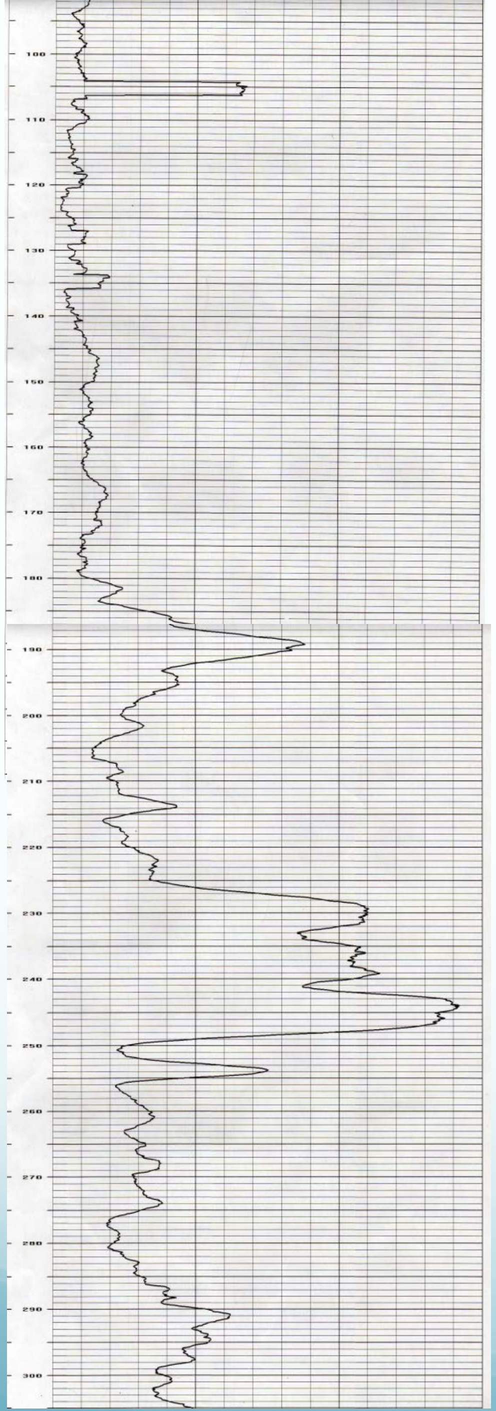
Gamma-Ray Logging

Dr. Marni Karaffa,
Indiana Geological Survey


Date: Thursday, December 02 2010 Time: 15:24 File: C:\Gamma Logs\10-9026.tfd
Gamma (cps)
10
Glacial
100
Silurian
200


200
300
Ordovician
390

100

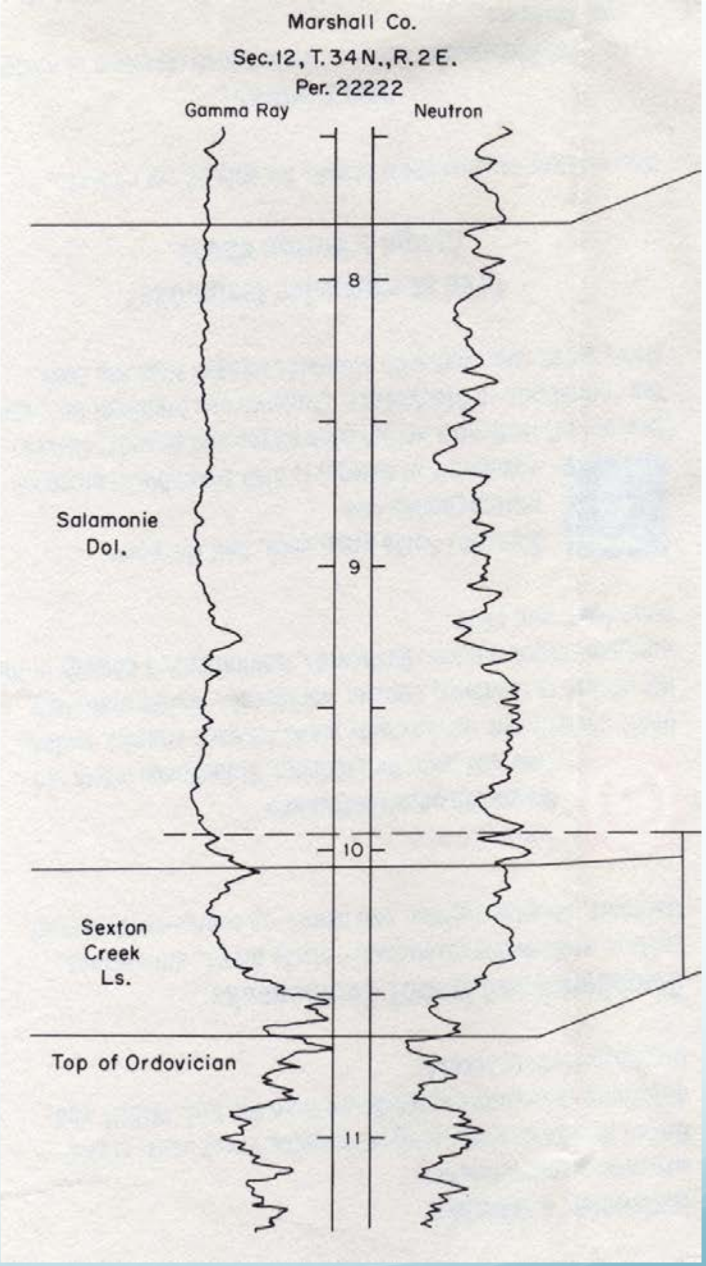


Silurian

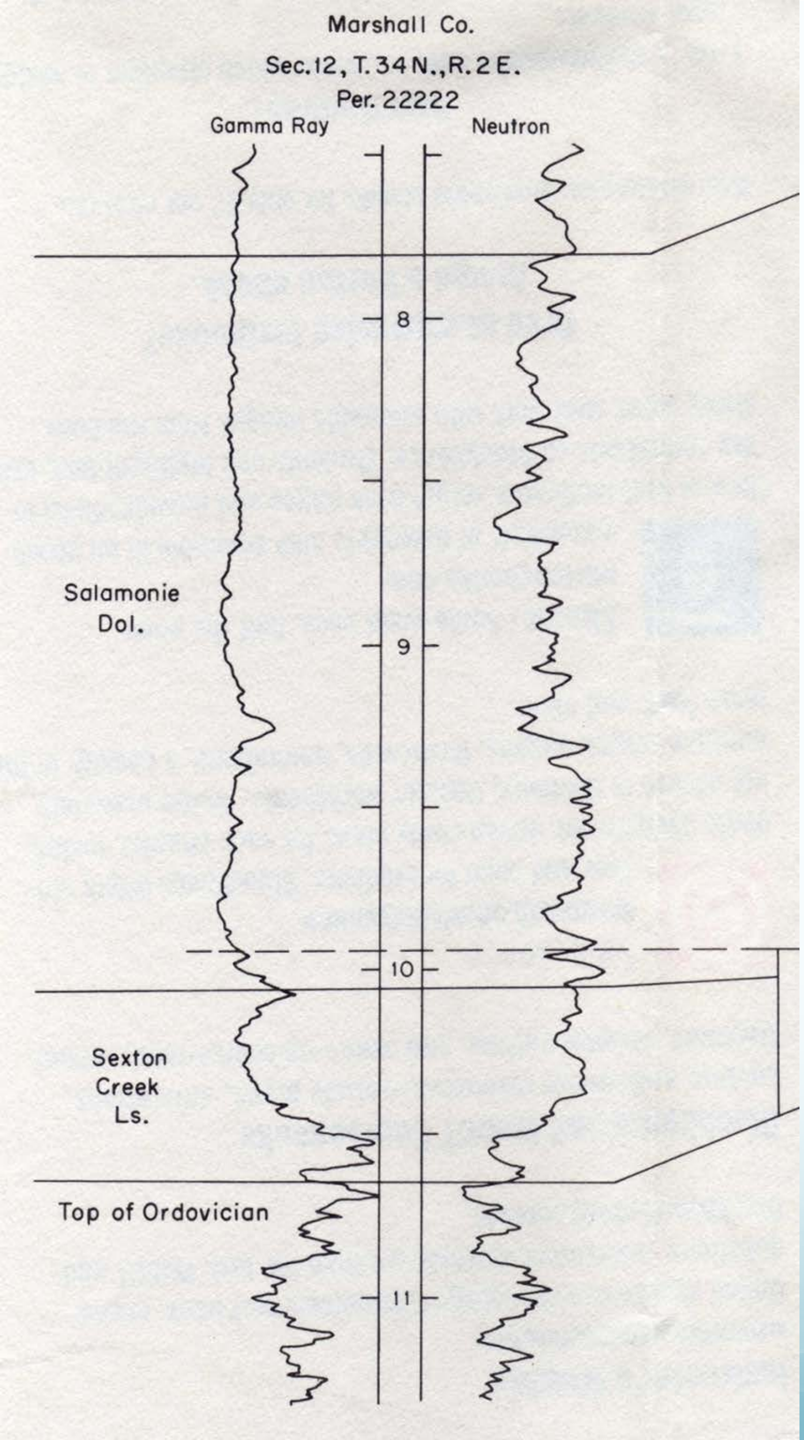
200

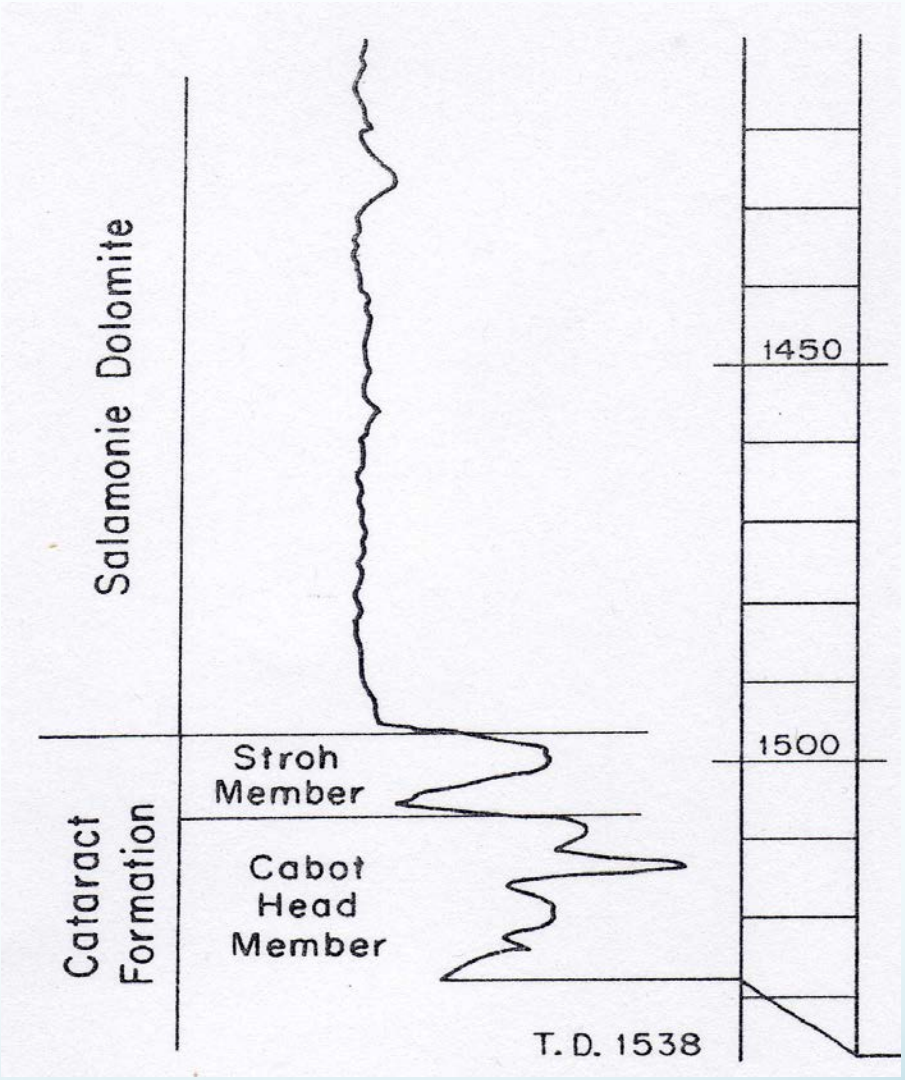
300

Ordovician

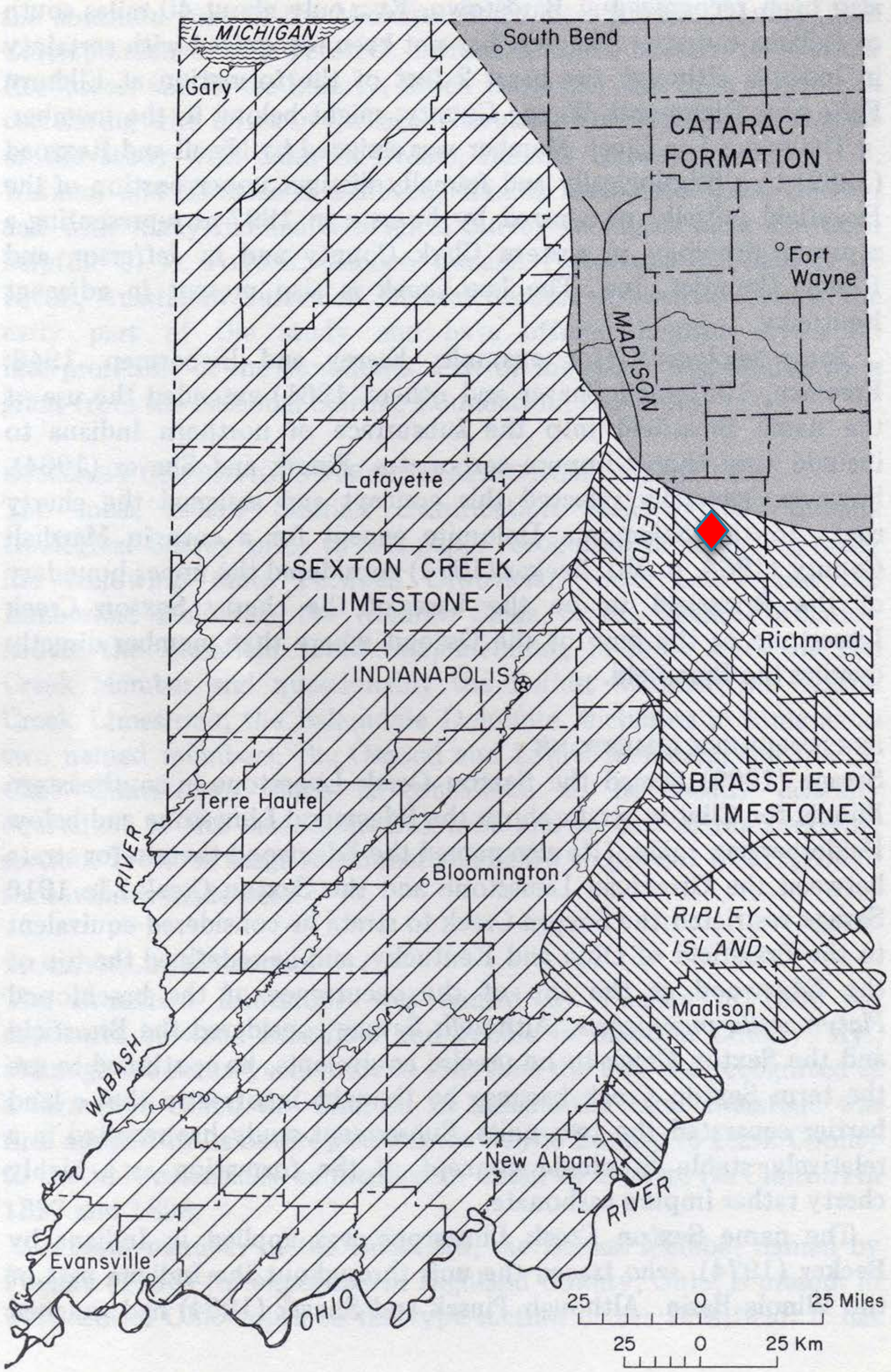


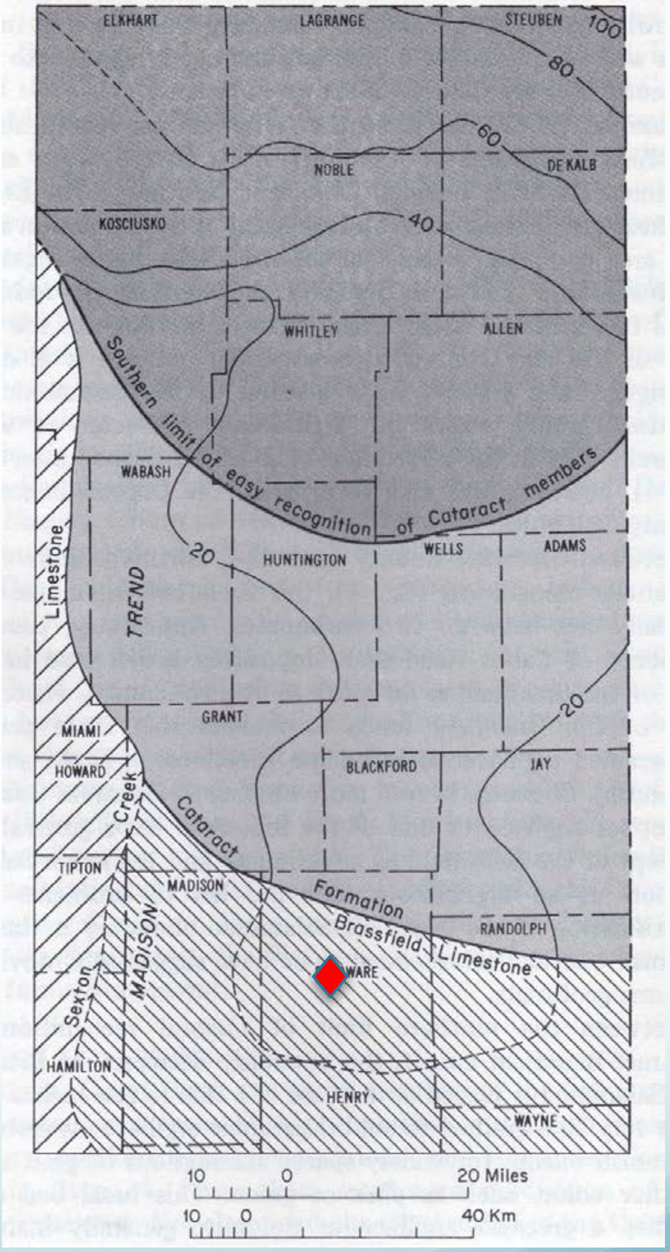
From IGS Bulletin 58, Lower Silurian, Rexroad, 1980





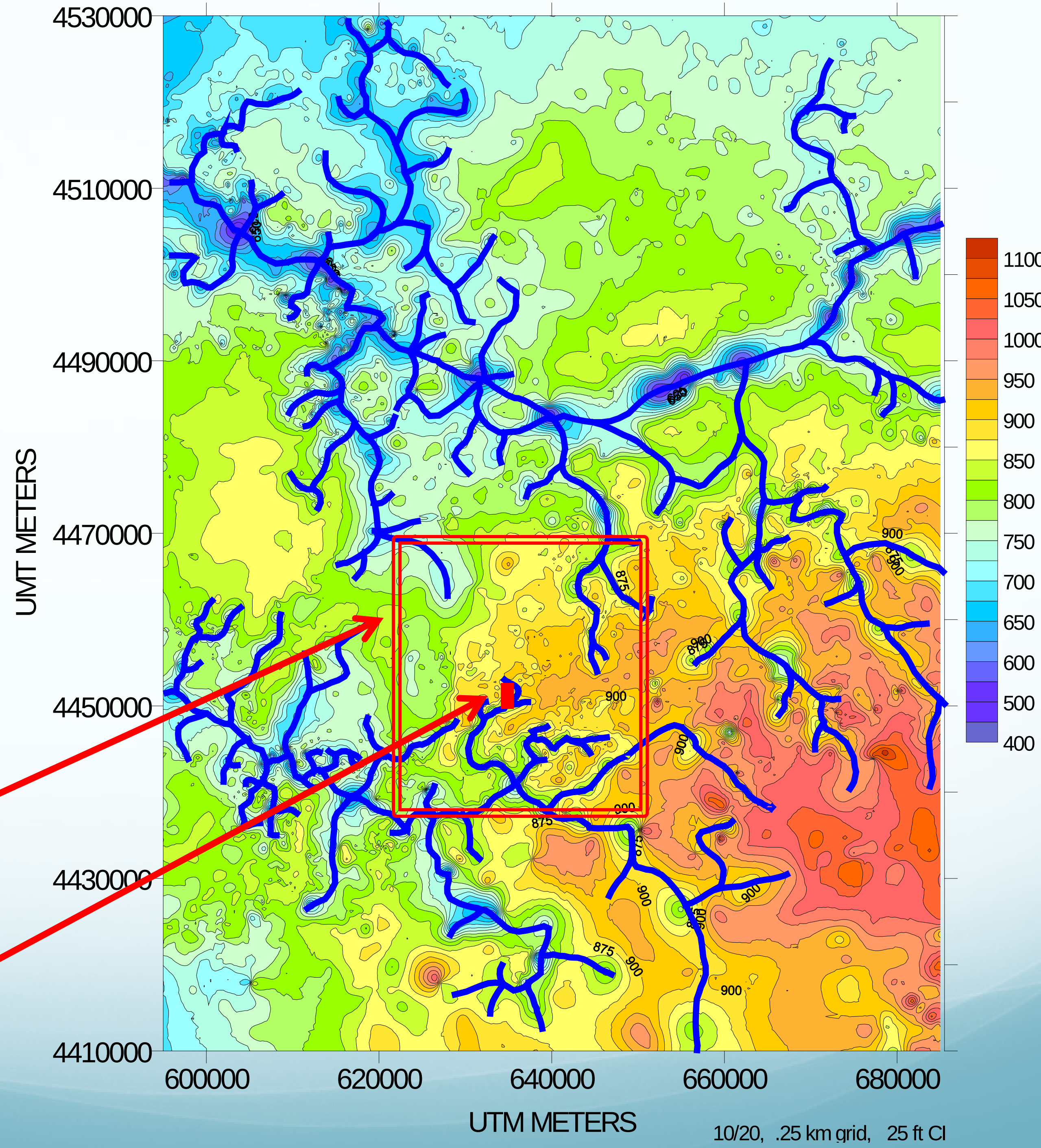
From IGS Bulletin 58, Lower Silurian, Rexroad, 1980





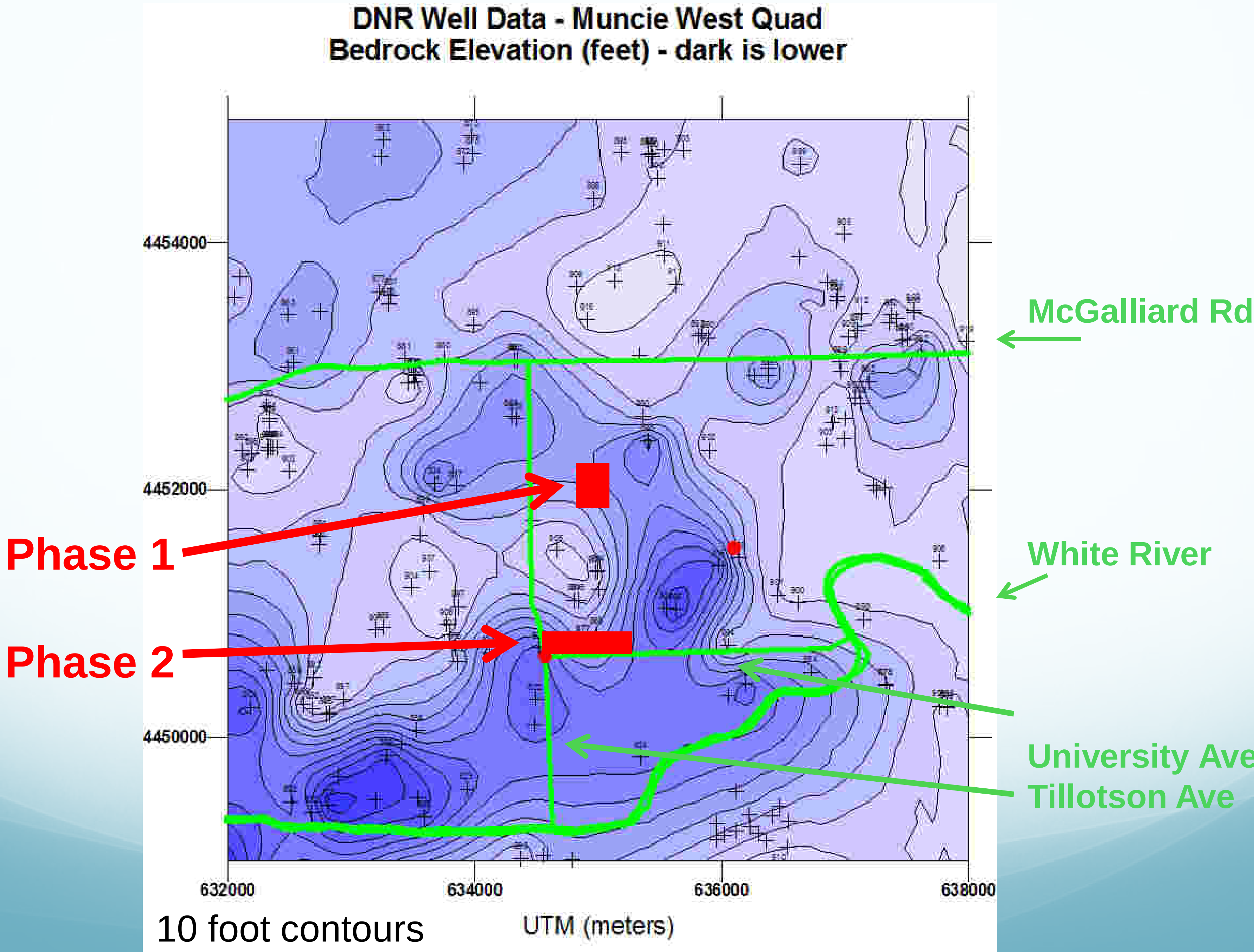
From IGS Bulletin 58, Lower Silurian, Rexroad, 1980

Teays (north) and Anderson Buried Valleys on Bedrock Surface Elevation

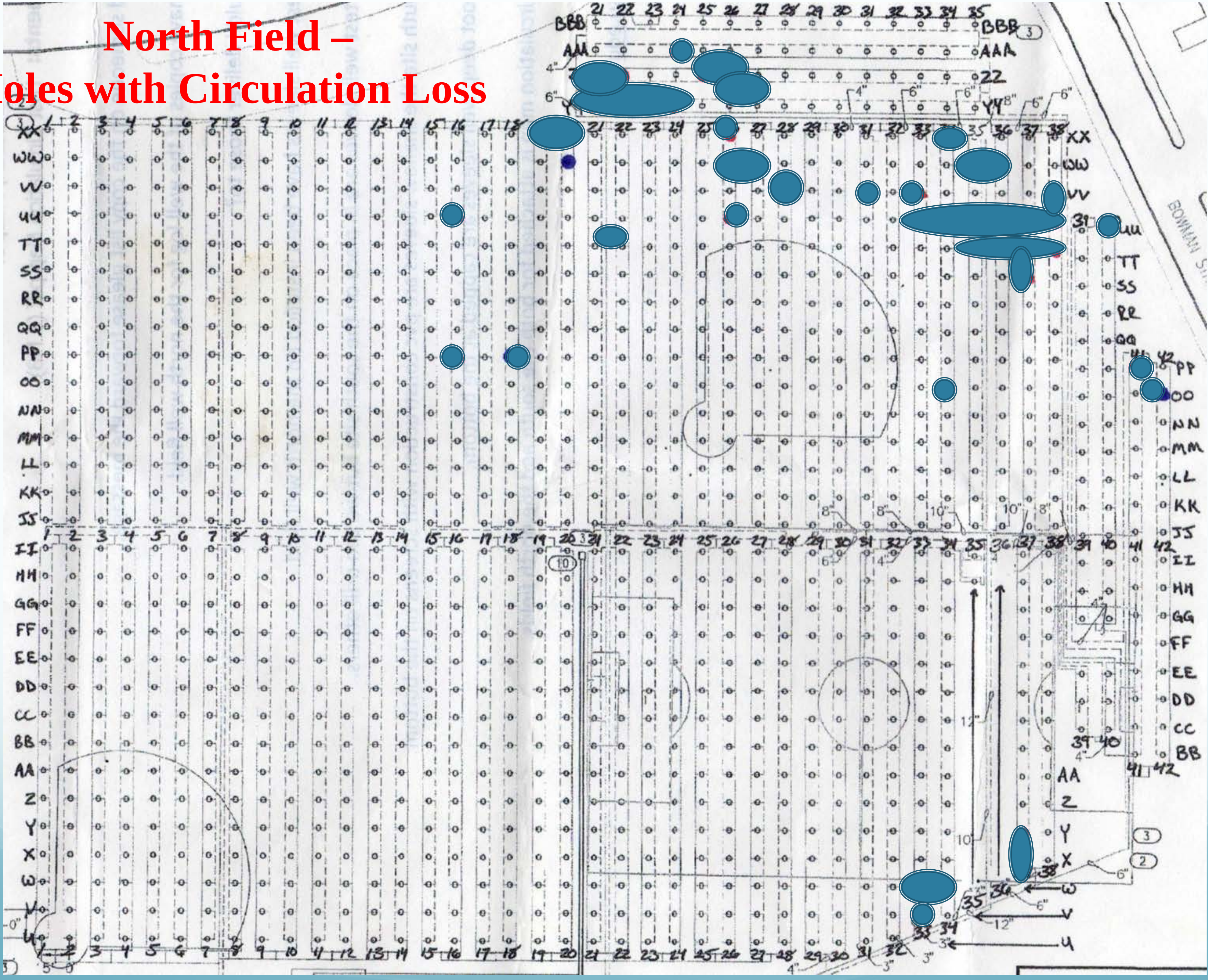


Delaware Co

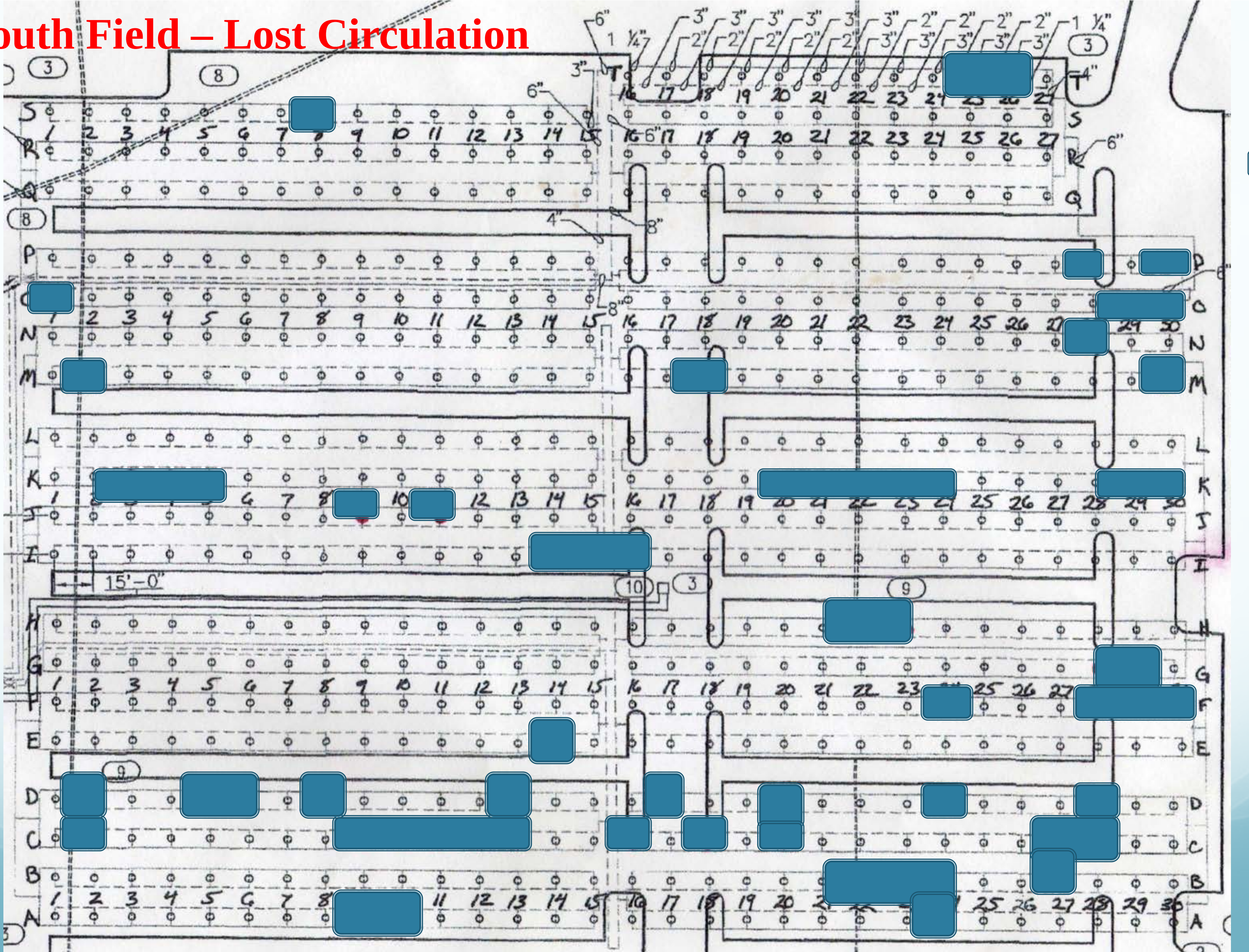
Geothermal Fields


DNR Well Data - Muncie West Quad
Bedrock Elevation (feet) - dark is lower
4454000
4452000
4450000
632000
634000
636000
638000
UTM (meters)
10 foot contours
McGalliard Rd
White River
University Ave
Tillotson Ave
Phase 1
Phase 2

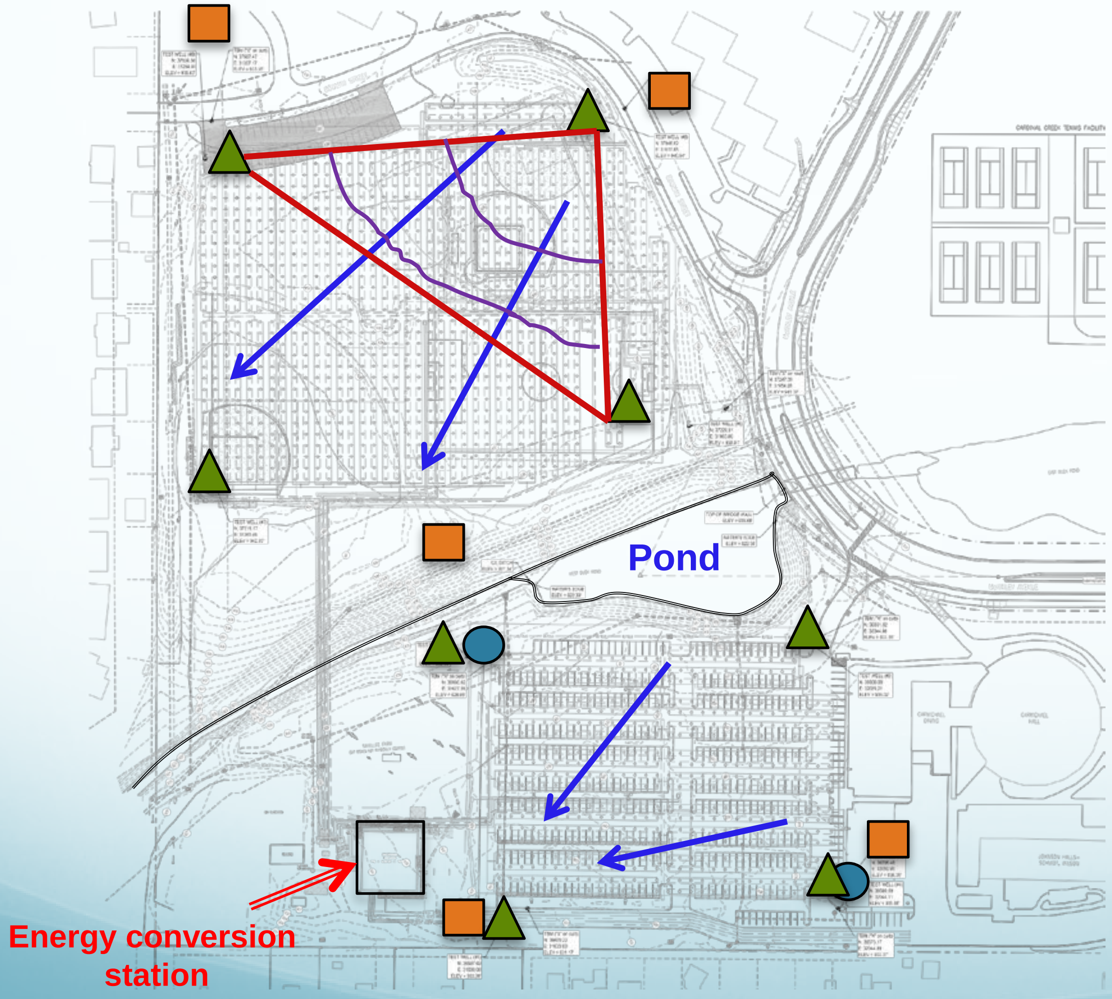
North Field – Holes with Circulation Loss



South Field – Lost Circulation

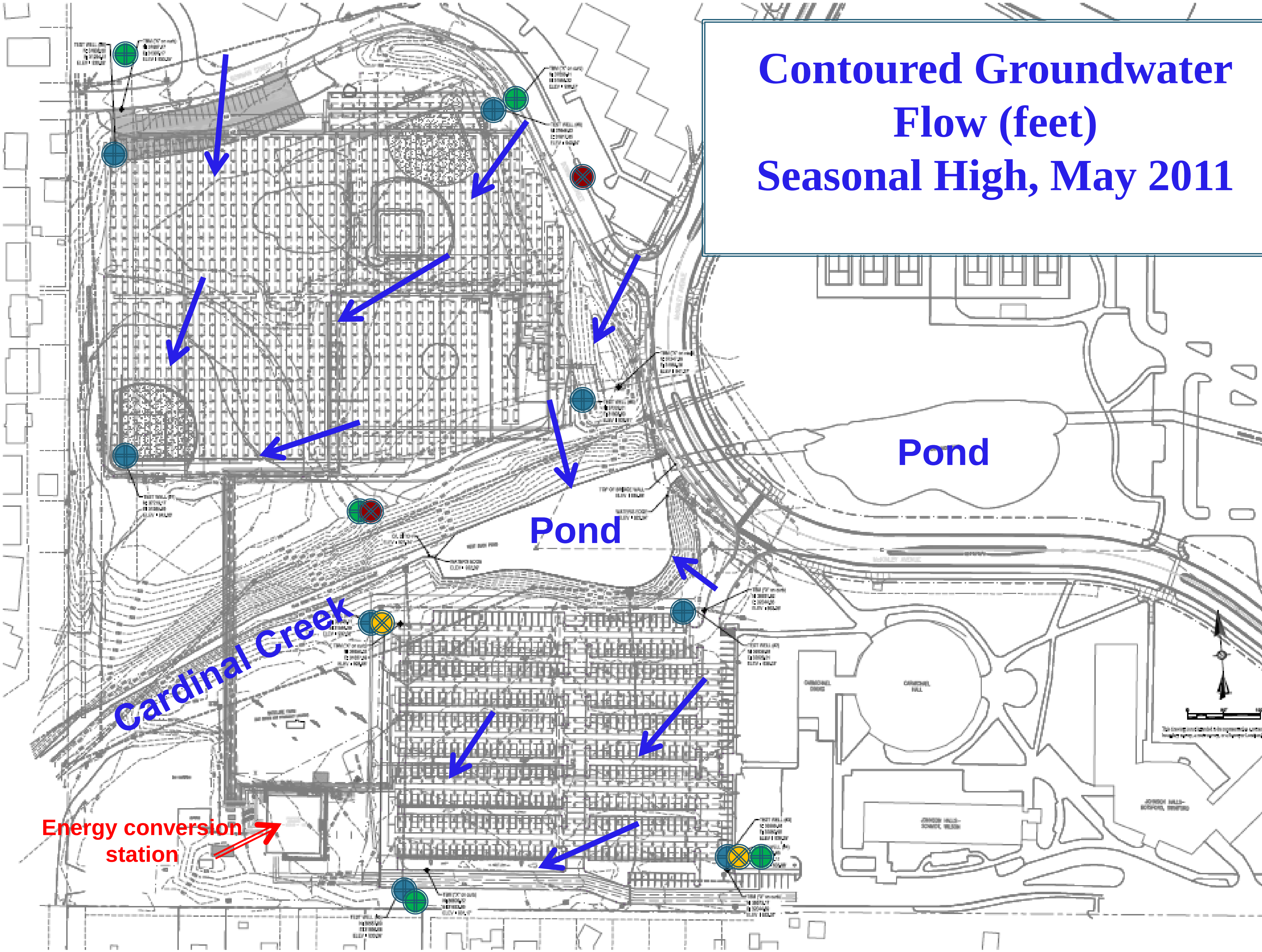


Three-Point Problem



- shallow wells
- stone wells
- nested wells

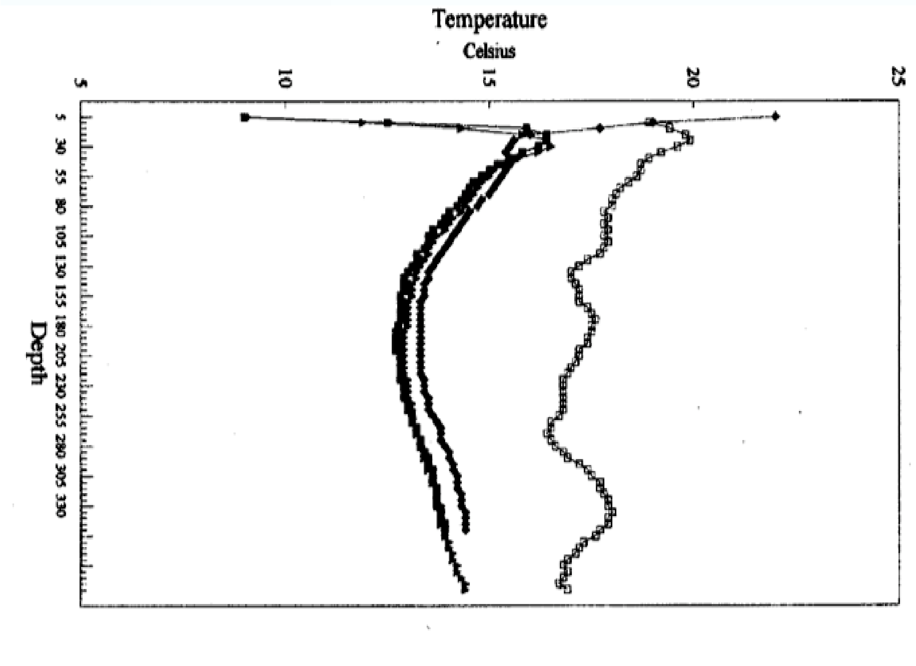
Contoured Groundwater Flow (feet) Seasonal High, May 2011

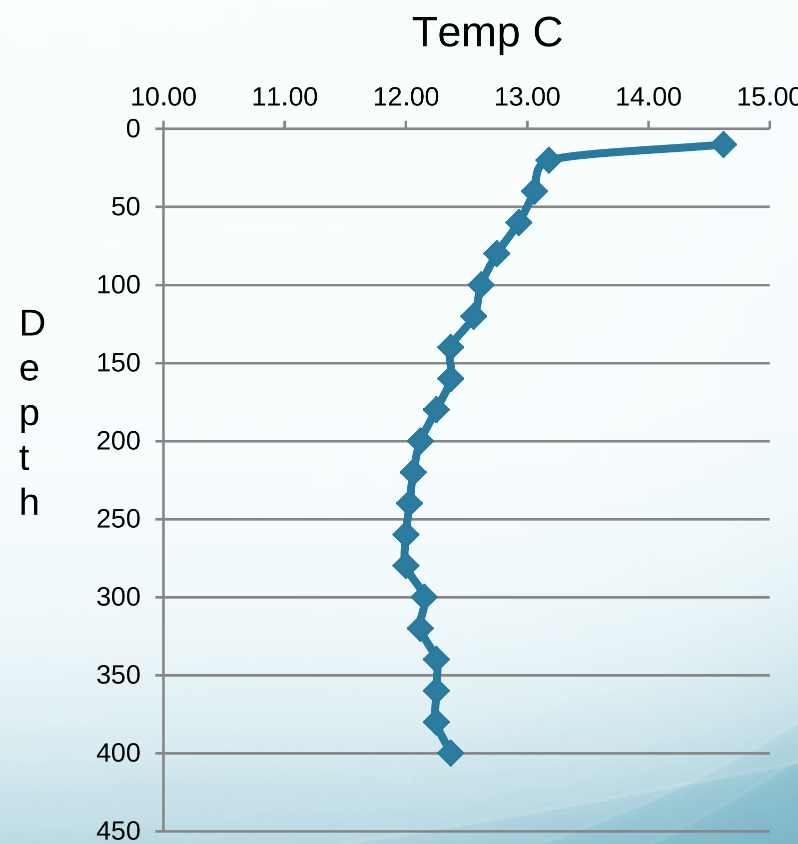


Vertical Temperature Gradients

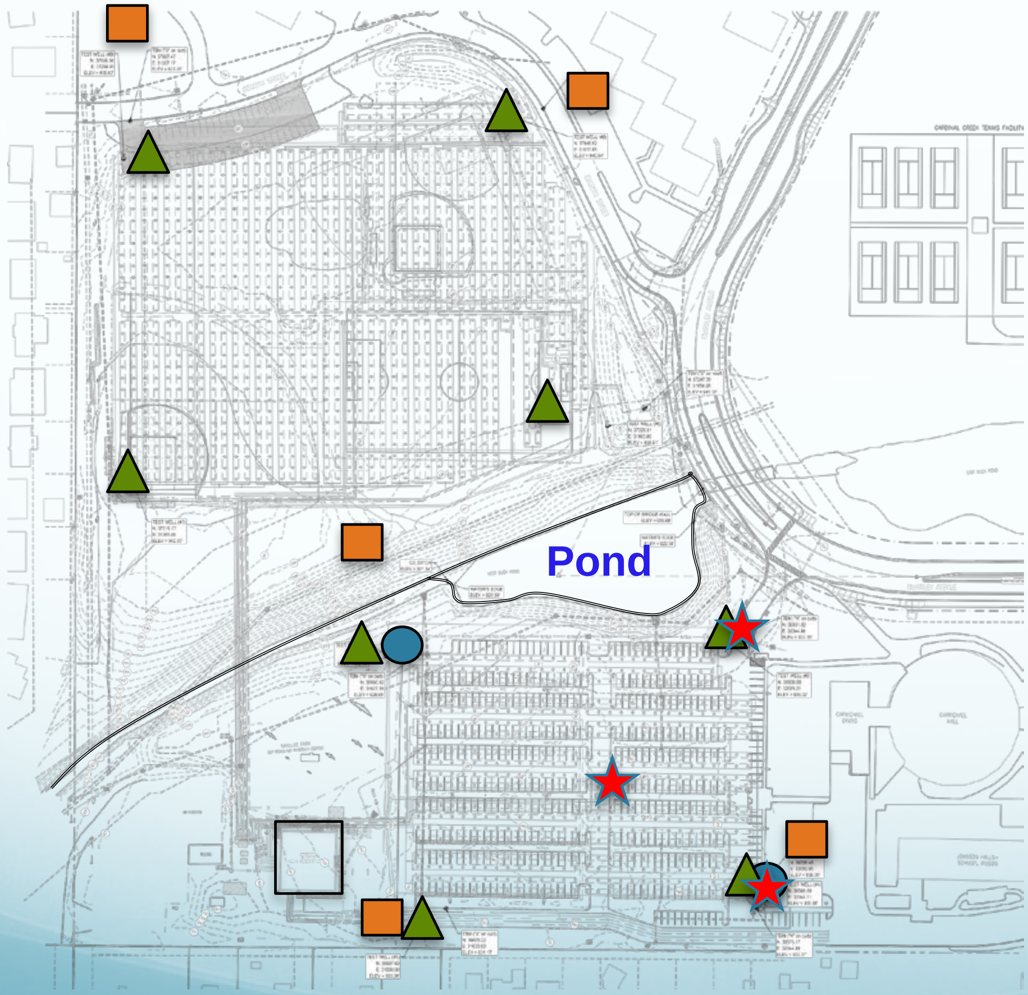
- Stockton College, NJ

Ball State, 5/23/11





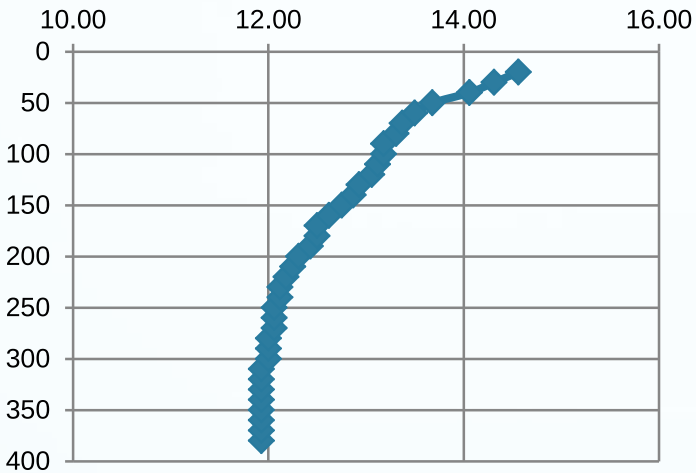
Monitoring Wells Plus 3 Metal Thermal Borings



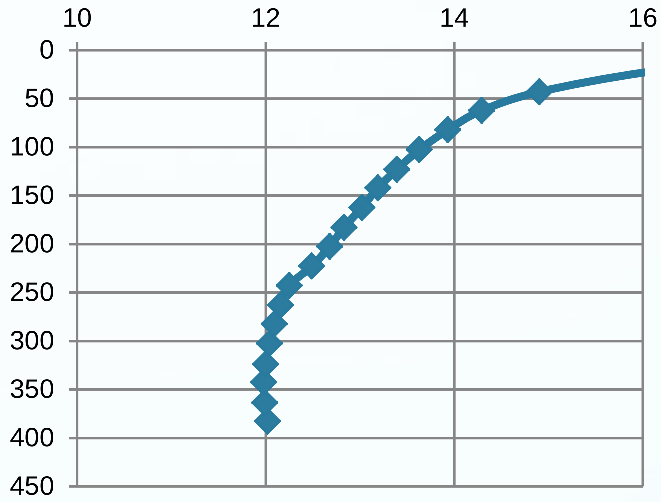
- shallow gravel wells
  - 2 monitors to 26-30 ft
- top of bedrock wells
  - 8 monitors to 60-90 ft
- nested bedrock wells
  - 5 nests up to 400 ft
  - 5 screens each
- unscreened metal pipes
  - to 400 ft depth

Thermal Profiles SE Corner of South Phase 1 Field (depth in feet vs. temp in degrees C)

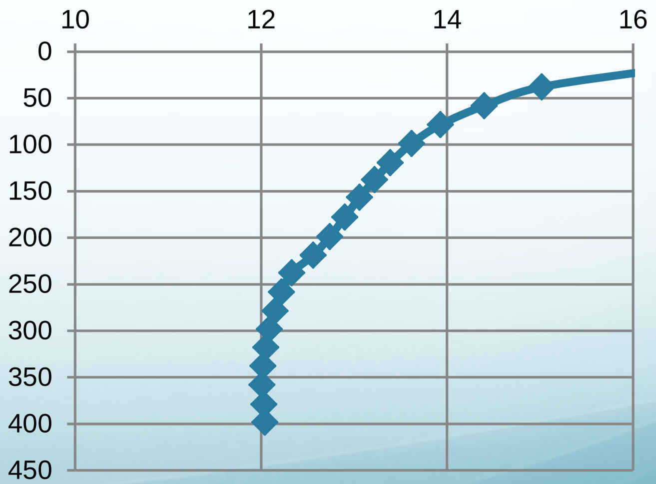
5/12/11



10/27/11



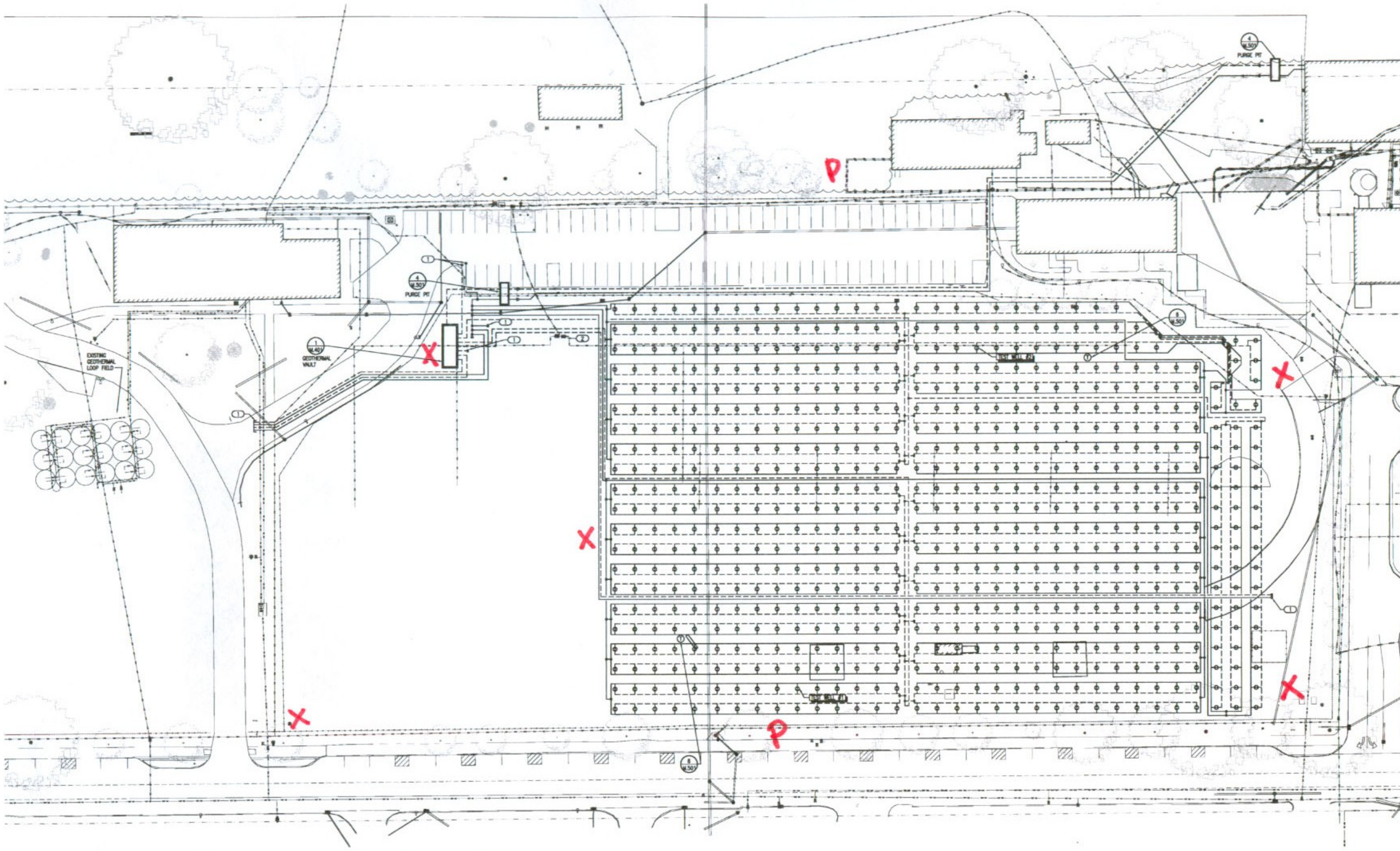
SE metal pipe



Phase 2 Site as of Nov. 7 2011

University Ave (bottom) is really straight on this panorama

Monitoring Wells
8 Sep 2011



1 SOUTH WELL FIELD UTILIZATION - PHASE NO. 1 BORES (BASE BID - 675 BORES)
1" = 30'-0"

NORTH

X: Nested Wells

P: Potential Well Locations

GENERAL NOTES

1. GLHE CONTRACTOR TO COORDINATE VERTICAL AND HORIZONTAL LOOP PIPING WITH NEW AND EXISTING SITE UTILITIES AND PIPING.
2. GEOTHERMAL TEST WELLS TO BE TIED INTO THE GEOTHERMAL PIPING CIRCUIT.
3. GLHE CONTRACTOR TO COORDINATE THE ELECTRICAL CIRCUIT TO THE VAULT WITH THE ELECTRICAL CONTRACTOR.

KEYED NOTES

1. CAPPED FOR FUTURE CONNECTION.
2. IRRIGATION WELL.

ENGINEER
MEP
CONSULTANT
SEALS
PROJECT
BALL STATE UNIVERSITY

GEOTHERMAL CONVERSION - SOUTH WELL FIELD
BALL STATE UNIVERSITY, MUNCIE, INDIANA

PROJECT
CAD: LAD
IN CHARGE: JAU
QA: JAU
ISSUE: CD
DATE: 08.01.2011

MARK	DATE	DESCRIPTION

BSU Project #: 2011-043.01 XU
MEP Project #: 820.10.01-13

ISSUE
SOUTH WELL FIELD UTILIZATION PHASE NO.1 BORES

CONTENTS
M.101
SHEET NUMBER

Current and Future Work

- Shallow and Limestone Wells:
  - Continue seasonal monitoring, data analysis
- Nested Wells
  - Collection of water levels, temperature, and conductivity
  - Currently starting to use equipment for continuous monitoring and for pump sampling from the deeper small diameter nested wells
- Stratigraphic description
  - Current study of bagged cutting samples (every 10 feet)

Current Concerns

- Will differences in hydraulic conductivities in Silurian aquifers and tighter Ordovician play impact heat exchange?
- Have there been changes in natural transmissivity by quantities of injected grout?
- Has there already been a change in water flow through or around the fields due to drilling and grout?
- How much will flow directions change when dewatering can be discontinued at the energy exchange station?
- How constant will the thermal profile be through the seasons and following years?
- Will we be able to place several monitors in the center of the Phase 2 fields?

Acknowledgments

- Fall 2010 GEOL 480 Class
- Individual students Spring to Fall 2011
- James Lowe, Director of Operations, BSU
- Kevin Austin, Ortman Drilling
- Dr. Marni Karaffa, IGS

References

Ball State University (n.d), Geothermal Map, http://cms.bsu.edu/About/Geothermal/FAQ/GeothermalMap.aspx; accessed 15 February 2011.

Department of Energy (n.d.), Geothermal Heat Pumps, http://www.eere.energy.gov/basics/renewable_energy/geothermal_heat_pumps.html; accessed 15 February 2011.

Einargon, M, 2005, Chapter 11: Multilevel ground-water monitoring *in Handbook of Environmental Site Characterization and Ground-Water Monitoring* (ed D. M. Nielsen), CRC Press.

Lowe, J., R. Koester, and P. Sachtleben, 2010, Chapter 17: Embracing the Future: The Ball State University Geothermal Project *in Universities and Climate Change: Introducing Climate Change to University Programmes* (ed W.L. Filho), Springer-Verlag, Berlin, DOI 10.1007/978-3-642-10751-1_17.

Ohio EPA, 2008, Chapter 7: Monitoring Well Design and Installation *in Technical Guidance Manual for Ground Water Investigations*, Columbus, OH.

Rexroad, Carl, 1980, Stratigraphy and Conodont Paleontology of the Cataract Formation and the Salamonie Dolomite (Silurian) in Northeastern, Indiana, Indiana Geological Survey Bulletin 58, 83p.