Geothermal Energy from Mature Gas Reservoirs; an Analysis of the Frio and Vicksburg Formations, South Texas, Hidalgo County*

Colgan Smith[1], Matt Uddenberg[1+], Andrew Setchko[1], Bruce Cutright[1], Adam Stater[1], Shadiya Bello[1], and Kyle Kampa[1]

Search and Discovery Article #80235 (2012)**
Posted July 2, 2012

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, USA, April 22-25, 2012

[1]Bureau of Economic Geology, University of Texas at Austin, Austin, TX (colgan.smith@gmail.com)
[+]Presenter

Abstract

Over the past decade there has been an increasing interest in developing renewable and unconventional energy resources. Of the many renewable energy technologies being developed geothermal energy is one of the select few that can provide baseload energy production. In the past geothermal energy has focused on geographically limited magmatic areas, but this may not be true in the future. This investigation examines the potential to develop geothermal energy from natural gas fields which are no longer economically viable to operate. Existing infrastructure, including production and brine injection wells, power supplies, pipelines and the reservoir characteristics available from the producing zones, provides an economic advantage over drilling new geothermal production wells. The authors have conducted a re-assessment of a previous study completed by the Bureau of Economic Geology (Bebout, 1975) for fields in southwest Texas in the Frio and Vicksburg formations. Reservoir properties are re-assessed by analyzing electric logs of nearby wells which penetrate the producing formations. Zones with high gross sandstone thickness and high fluid temperatures are identified. Potential production rates of hot brines from these zones are assessed. Identified reservoir zones are classified, based on their ability to provide high-fluid flow rates and high-temperature fluids. High-quality reservoirs are defined as being located between the 300°F and 350°F isotherms and having in situ permeabilities greater than 10 mD. Low-quality reservoirs are defined as being located between the 200°F and 250°F isotherms and having in situ permeabilities less than 1 mD. Reservoirs found between the 250°F and 300°F isotherms represent moderate-quality reservoirs. Using this assessment approach, an approximation of geothermal production can be made, using a simple block model analysis. Estimated production values are used to derive the economic viability given current market conditions. The economic analysis includes consideration of geothermal binary heat exchange systems and existing infrastructure, and determines the lowest projected cost of development for particular reservoirs in the Hidalgo County region.

Reference

Bebout, D.G., Dorfman, M.H., and Agagu, O.K., 1975b, Geothermal resources-Frio Formation, South Texas: Univ. Texas, Austin, Bur. Econ. Geology Geol. Circ. 75-1, 36 p.

Blackwell, D.D., and Z. Frone, 2010, Geothermal map of the northeastern United States and the West Virginia thermal anomaly: Geothermal Resource Council Transactions, v. 34, p. 339-343.

Geothermal Energy from Mature Gas Reservoirs; an Analysis of the Frio and Vicksburg Formations, South Texas, Hidalgo County

University of Texas at Austin

Bureau of Economic Geology

National Geothermal Database System

Presentation for AAPG Annual Convention & Exhibition

Long Beach, California

April 24th, 4:45 PM

Presented by Matt Uddenberg

Project Researchers

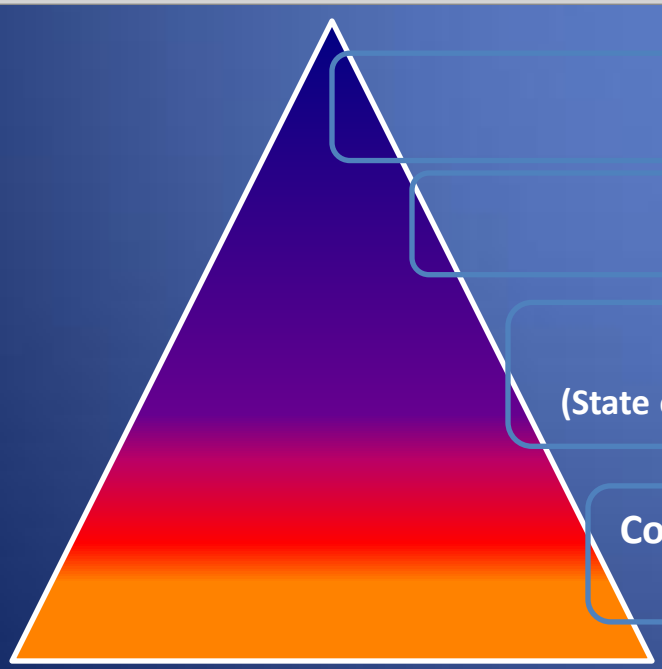
-Bruce Cutright
-Matt Uddenberg
-Colgan Smith
-Adam Stater
-Shadiya Bello
-Kyle Kampa
-Andrew Setchko

ACKNOWLEDGEMENTS:

This project is the result of work conducted within the National Geothermal Database Development Project, Funded by the US Department of Energy And Directed by Dave Blackwell of SMU.

NGDS

National Geothermal Data System



University of Texas - Austin

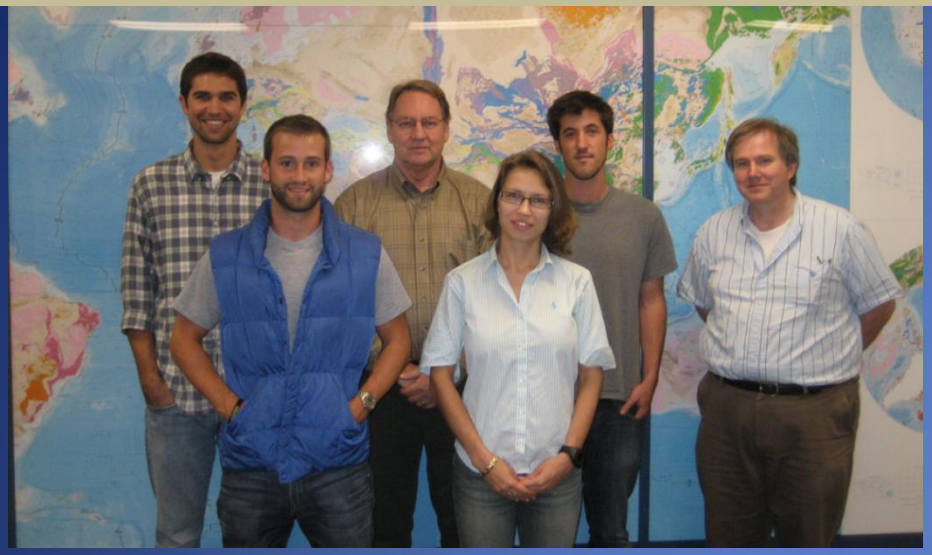
Bureau of Economic Geology

STARR-Geothermal

(State of Texas Advanced Resource Recovery-Geothermal)

Contributions to the National Geothermal Data System

The University of Texas Bureau of Economic Geology – NGDS Project Team



BEG Project Team, *Left to Right*: Cole Smith, Andrew Setchko, Bruce Cutright, Svetlana Ikonnikova, Matt Uddenberg, William Ambrose

Key Focus Areas:

- Sequence Stratigraphy,
- Reservoir Properties,
- Data Quality and Quantity,
- Economic Analysis

Project Staff:

Bruce L. Cutright, Co-Principal Investigator

Ian Duncan, Co-Principal Investigator

Svetlana Ikonniknova, Research Associate Economist (part time)

Colgan Smith, Research Assistant (full time)

Matt Uddenberg, Graduate Research Assistant

Adam Stater, Research Assistant (full time)

Shadiya Bello, Research Assistant (full time)

Kyle Kampa, Research Assistant (1/3 time)

Andrew Setchko, Research Assistant (4/2011-10/2011)

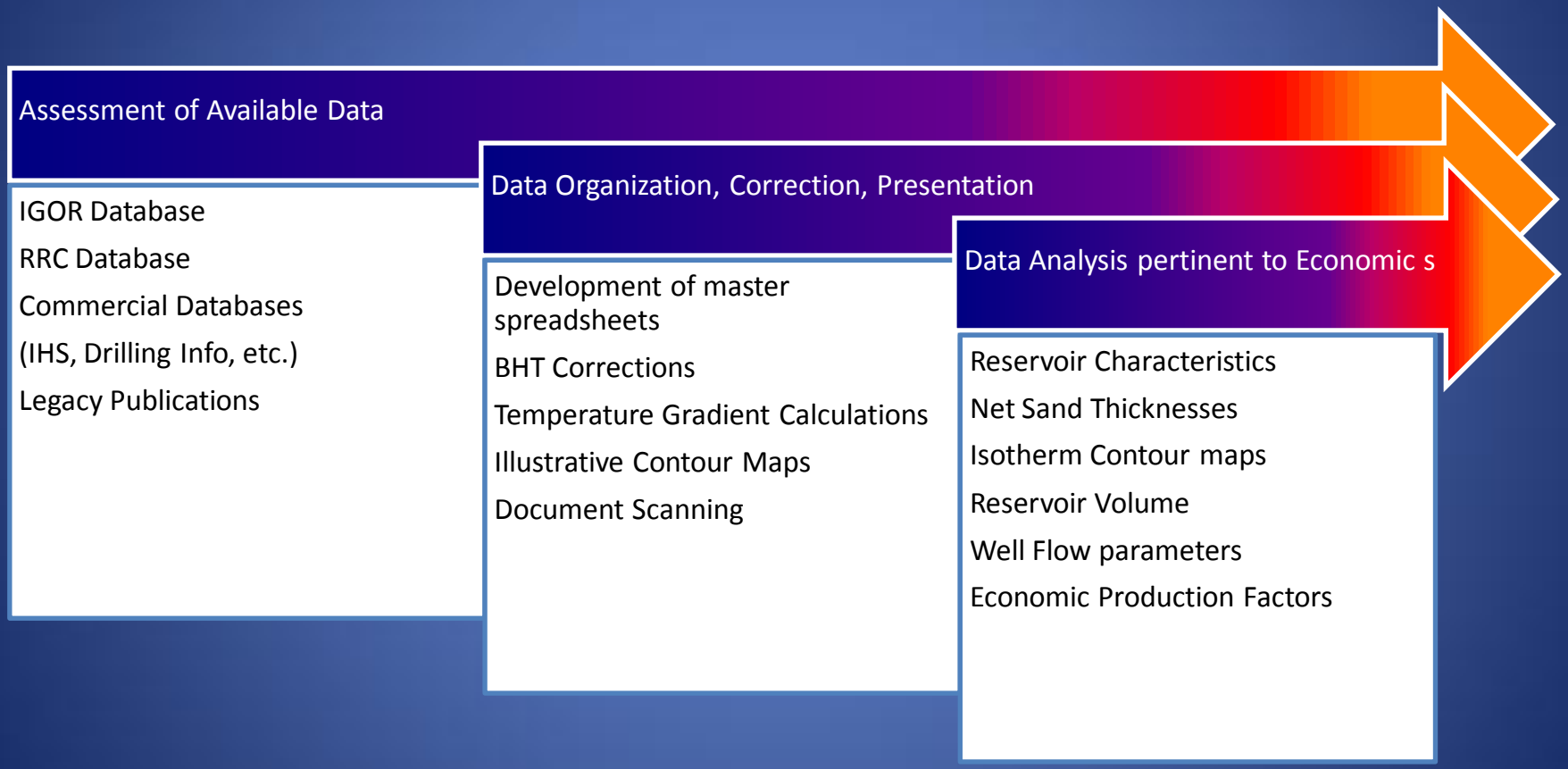
Assistance also provided by:

Sigrid Cliff; Librarian and Public Information Geologist

Aaron Averett; GIS/Programmer

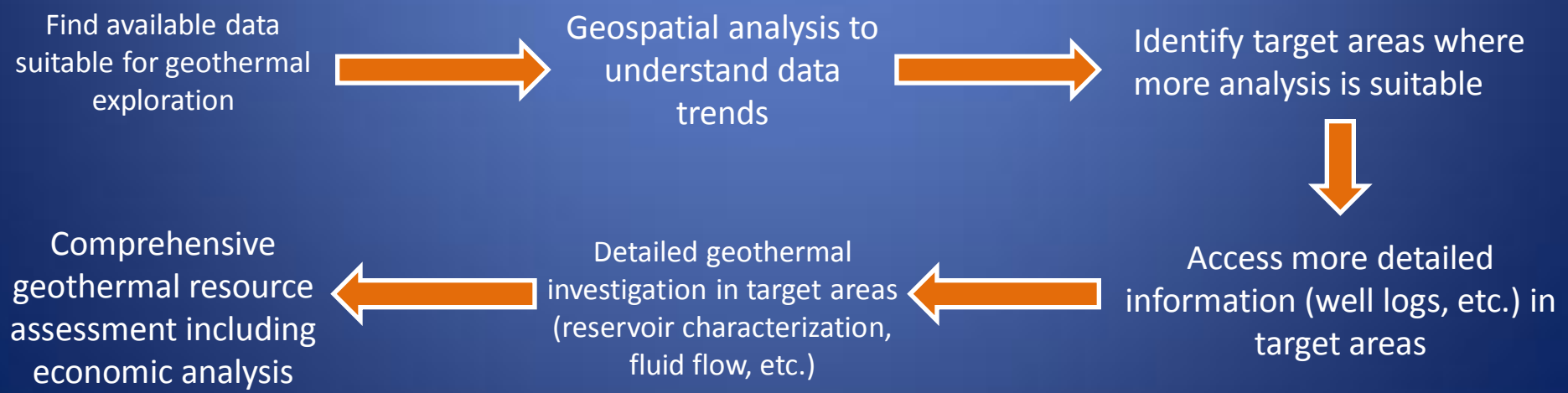
Cari Breton; GIS

The Process


Assessment of Available Data
IGOR Database
RRC Database
Commercial Databases
(IHS, Drilling Info, etc.)
Legacy Publications
Data Organization, Correction, Presentation
Development of master spreadsheets
BHT Corrections
Temperature Gradient Calculations
Illustrative Contour Maps
Document Scanning
Data Analysis pertinent to Economic s
Reservoir Characteristics
Net Sand Thicknesses
Isotherm Contour maps
Reservoir Volume
Well Flow parameters
Economic Production Factors

Available Resources and Assessment

- Bureau of Economic Geology
  - Over 60,000 scanned well logs
  - Over 300,000 organized and catalogued well logs with basic information (lat, long, depth, etc.)
  - Over 1,000,000 paper well logs that are in boxes unorganized waiting to be entered into the IGOR database
  - Access to Petra software and DrillingInfo to provide precise well information and additional scanned well logs, respectively.
  - Association with STARR (State of Texas Advanced Resource Recovery) program and experienced researchers.
- Developed a procedure for detailed analysis of potential geothermal reservoirs that, with appropriate assumptions, estimates yields, in terms of fluid flow rates, temperatures, and megawatt potential, will provide essential baseline information for future development of geothermal energy production.



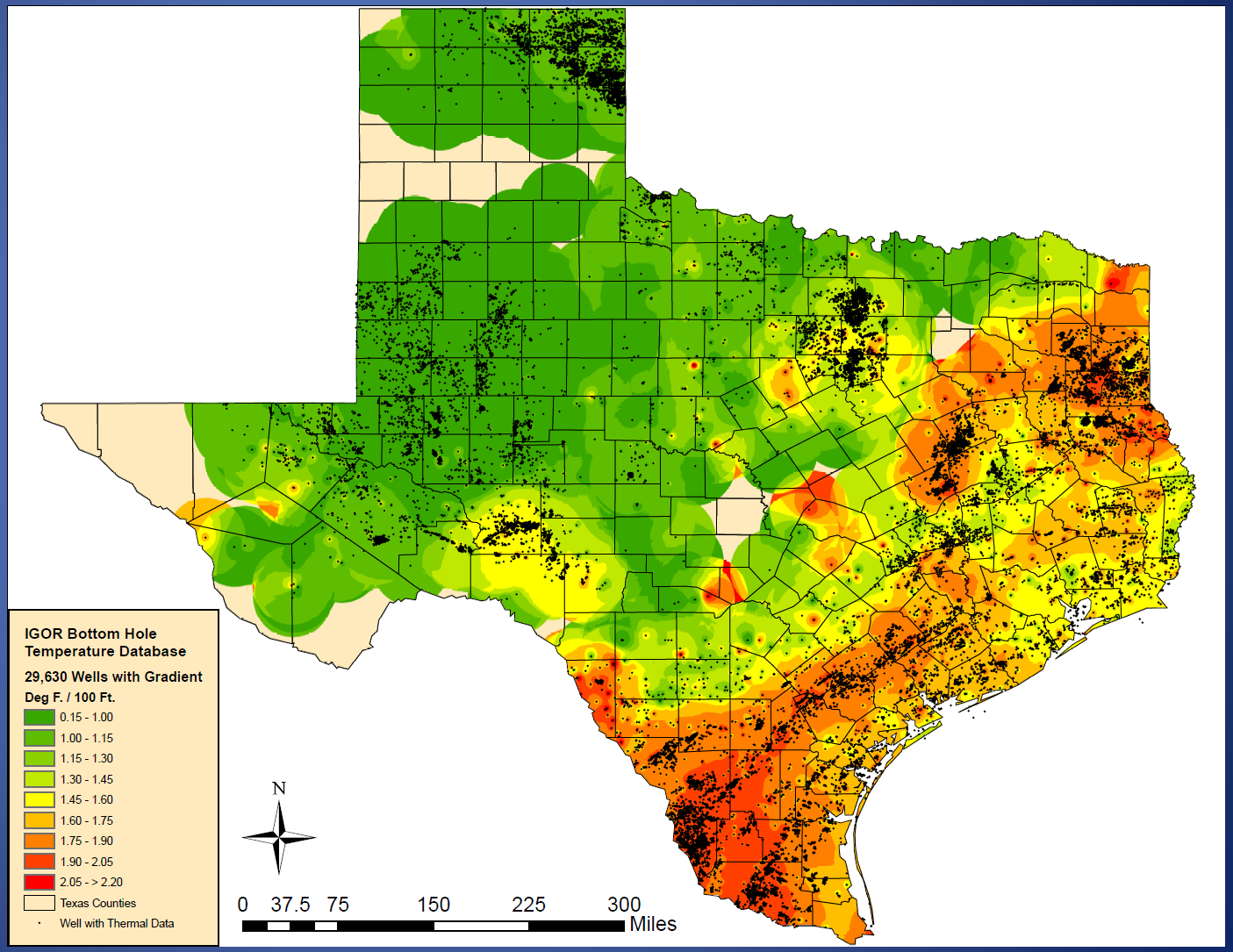
Geothermal Assessment of Texas

Increased temperature database from 3,000 to nearly 30,000 wells.

Data coverage across the state of Texas.

Better understanding of Texas' geothermal resources.

New and improved insight into where greatest geothermal potential is within state.



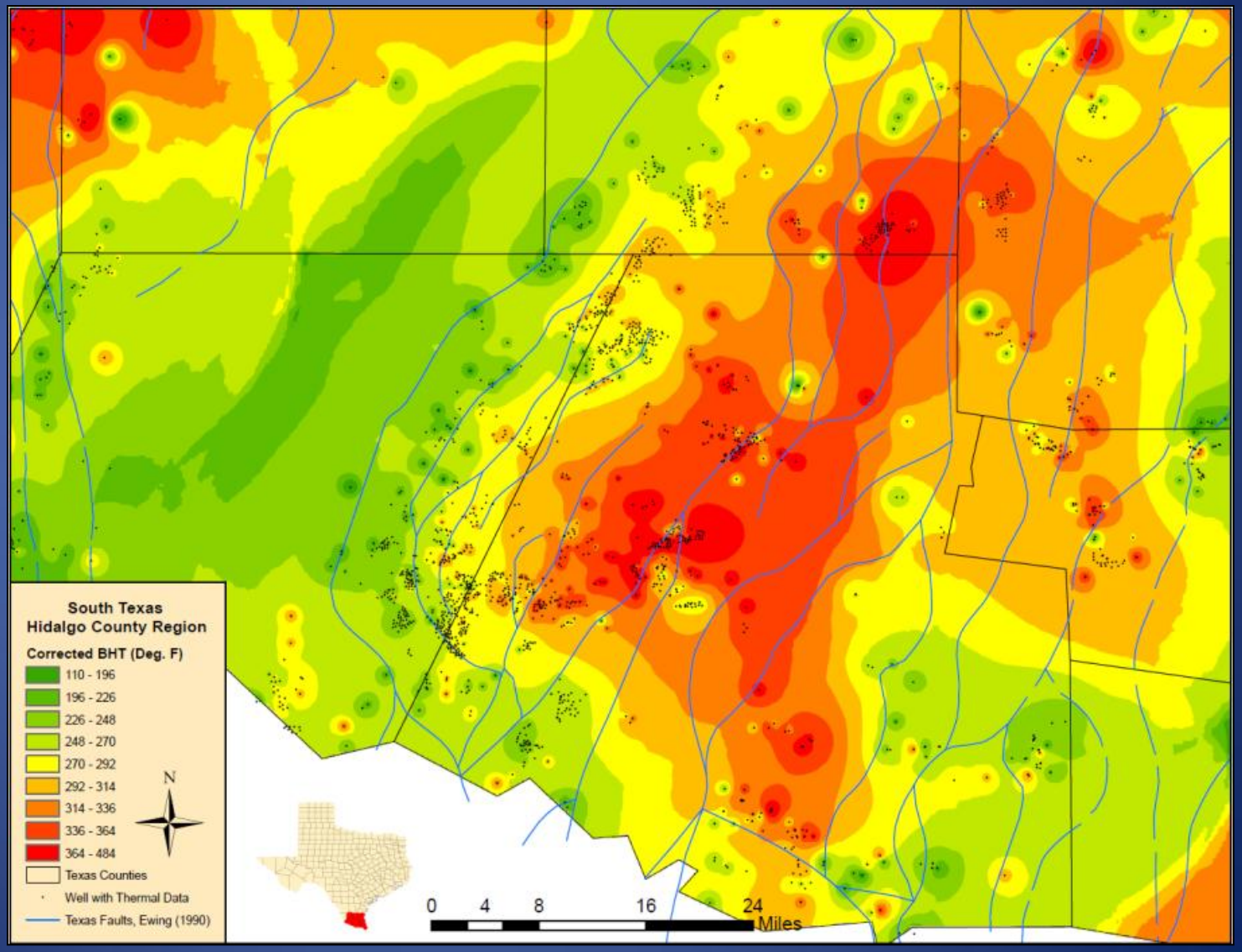
Applying the BEG database

- This new dataset will provide information for comprehensive geothermal exploration in the state of Texas.
- Critical reservoir parameters have been gathered and analyzed for geothermal resource assessments.
- Here we will present the effectiveness of this dataset, which will soon be available through the NGDS website, by doing a case study of southern Hidalgo county, south Texas.

Corrected Bottom Hole Temperature

Map of corrected bottom hole temperatures (BHT) from well log headers using the SMU-Harrison correction (Blackwell et al., 2010).

Based on well density and temperature, we can identify targeted areas for further investigation.



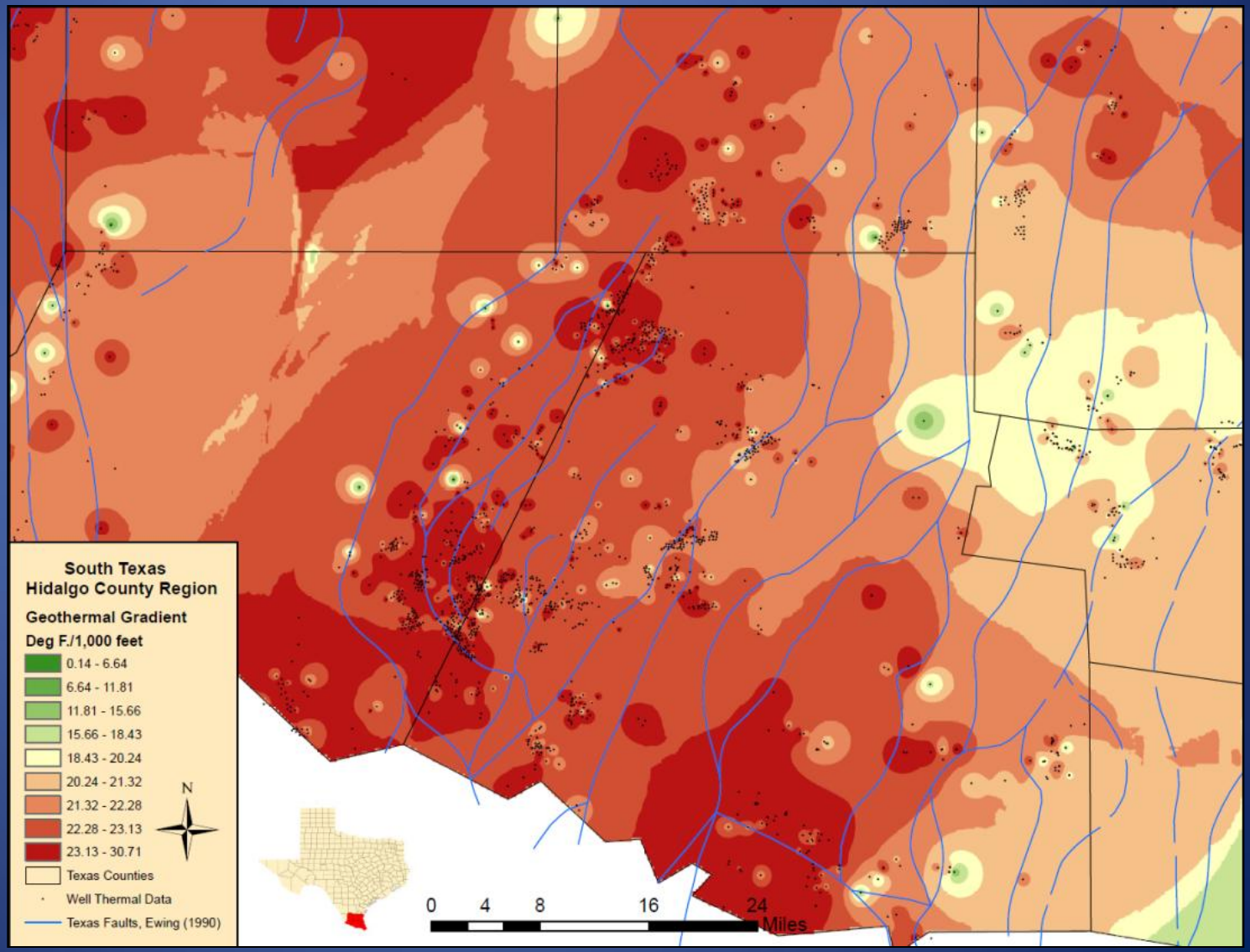
Geothermal Gradient

Geothermal gradient is calculated and mapped to help better identify target areas for more in depth analysis.

The average ambient surface temperature for Texas, reported by NOAA, is 70 deg. F and is used in our gradient calculations

Gradient Equation

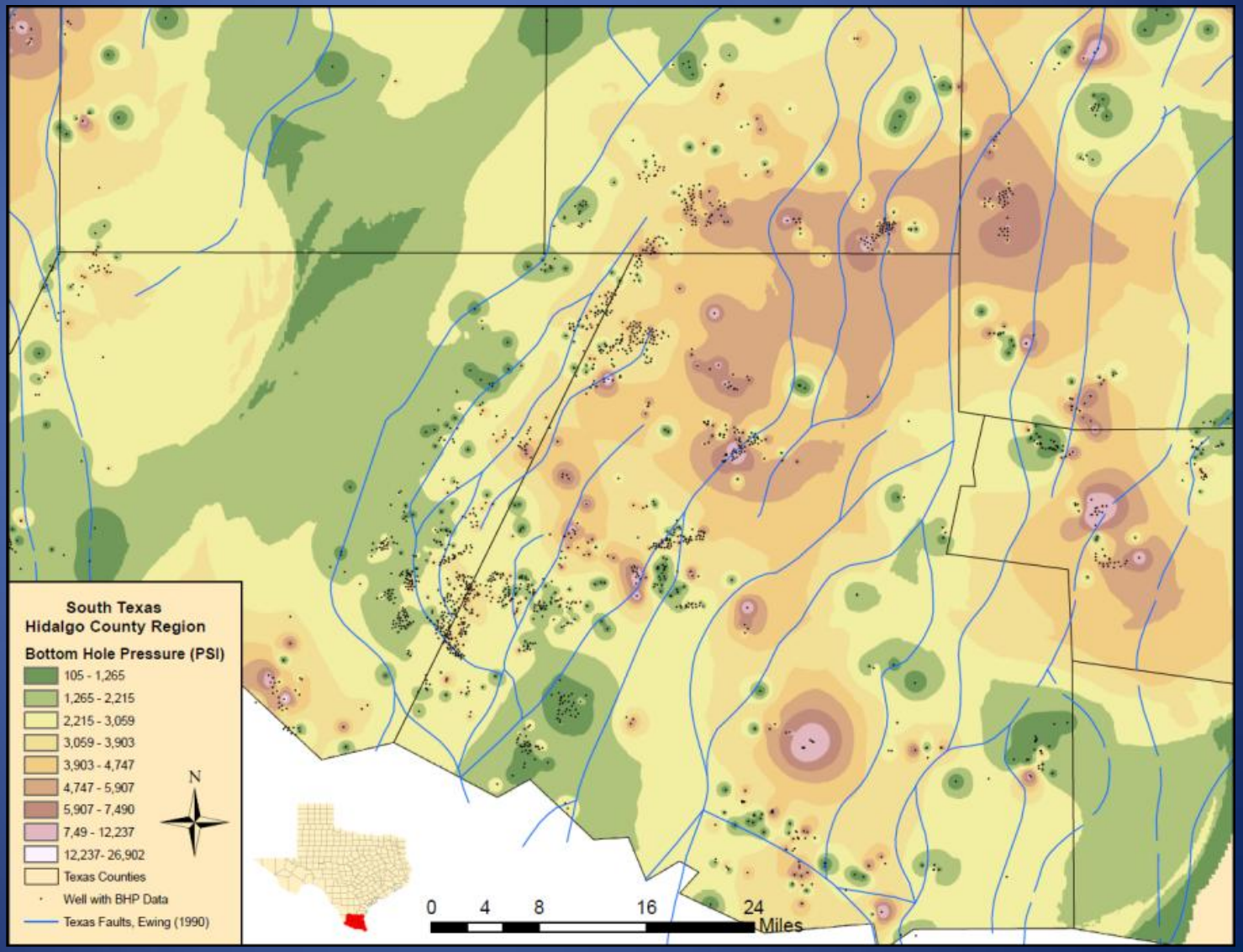
$$Deg\ F/_{Kft} = \frac{(BHT - 70)}{Depth} * 1{,}000$$



Bottom Hole Pressure

Bottom hole pressure (BHP) is used to better understand the initial reservoir properties of a potential geothermal reservoir.

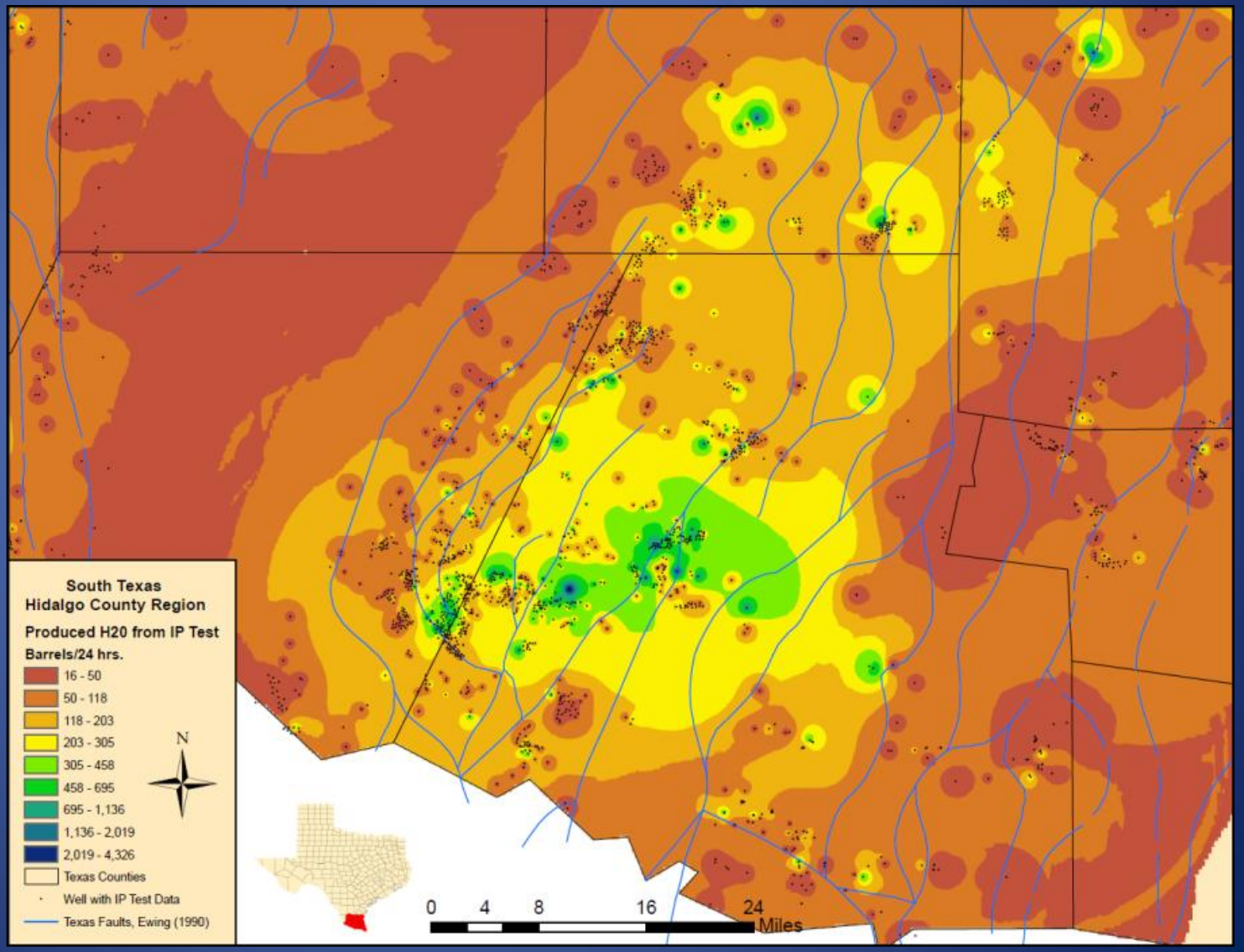
This information is vital for reservoir modeling purposes and understanding how the reservoir will perform over time.



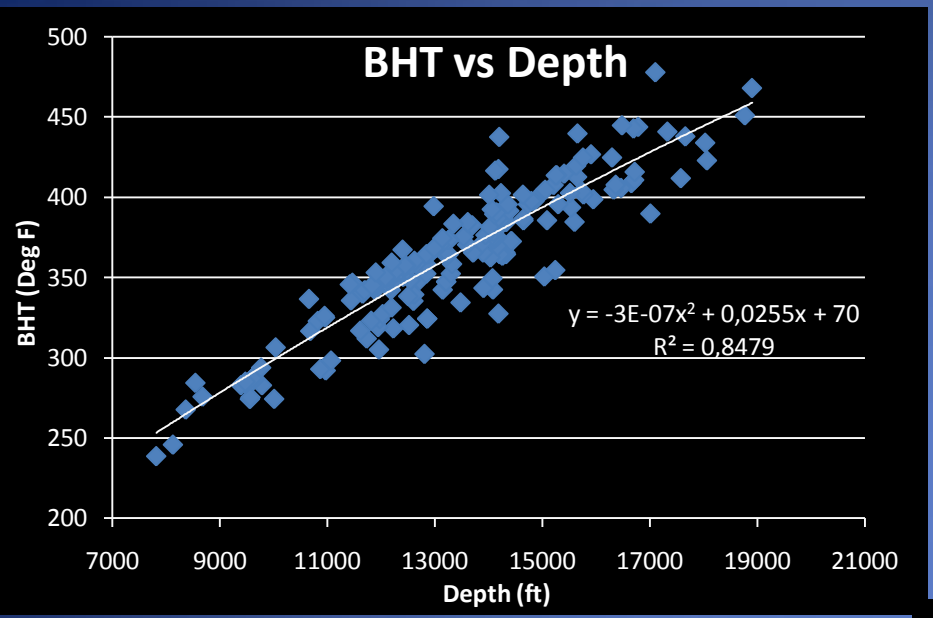
Water Production

Water production from initial production (IP) tests provides important information about how much water has been recorded flowing from a well over a 24-hour period.

This information is critical in understanding whether this is a viable geothermal resource.



Gradient Tiling



Identify area of interest based on BHT, BHP, gradient, water flow and well density.

Correct BHT using SMU-Harrison correction.

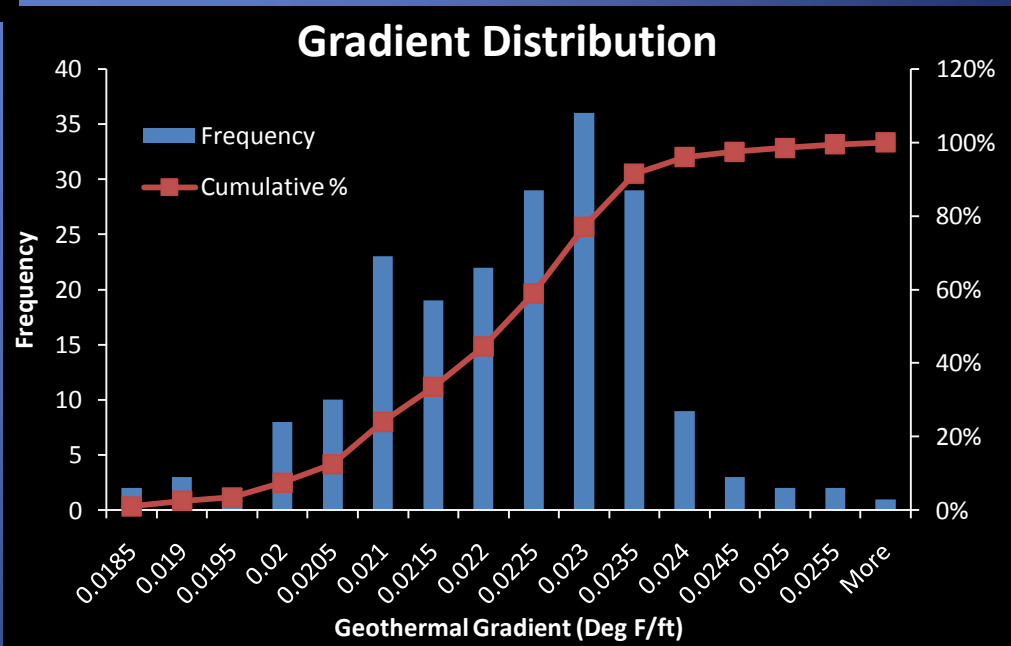
Plot BHT vs Depth to identify outliers and general thermal regime of the target area.

Best fit line, typically linear or polynomial with intercept at 70 (mean surface temp. reported by NOAA), and R^2 help determine thermal trends.

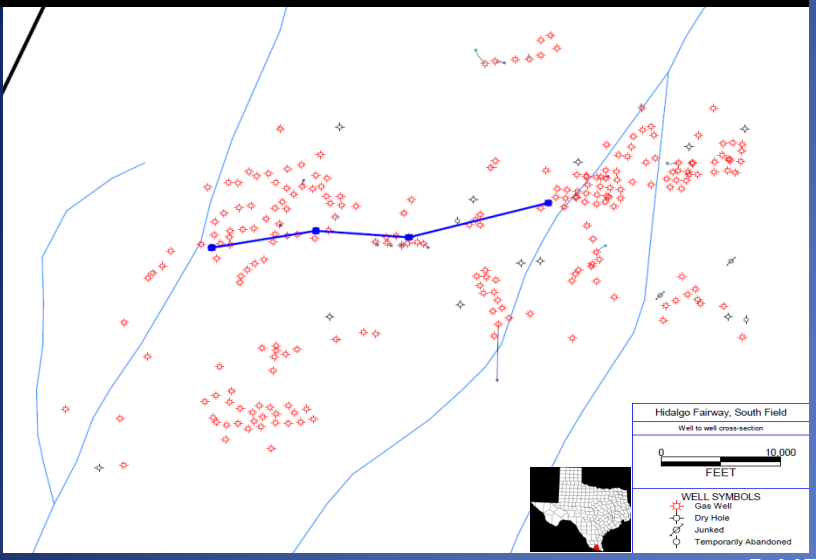
Create histogram of geothermal gradients for target area and analyze distribution.

Assumption that BHTs are minimum temperature measurements and if the distribution has a rapid drop in frequency then we can claim data are approaching "true" geothermal gradient of target area.

Identify a representative regional gradient and generate isothermal surfaces for well log analysis.



Well to well cross section



Based on the gradient tiling assessment, 200˚, 250˚, 300˚, and 350˚ Fahrenheit isotherms are imported into Petra.

Sections of low Gamma Ray and SP are used to define sand sections.

The sand intervals are then summed to create a sand thickness map between isotherms.

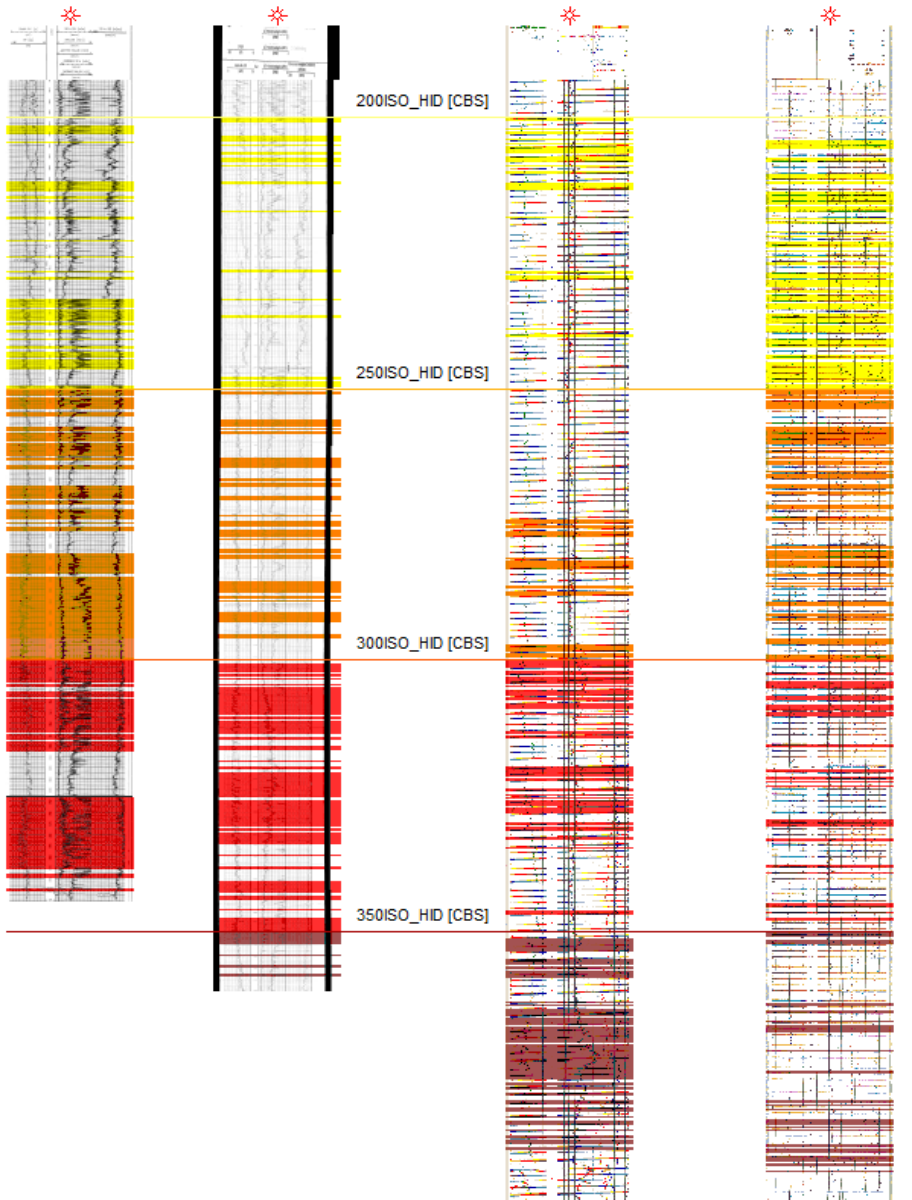
5,447 ft.
200 Degree Surface

7,769 ft.
250 Degree Surface

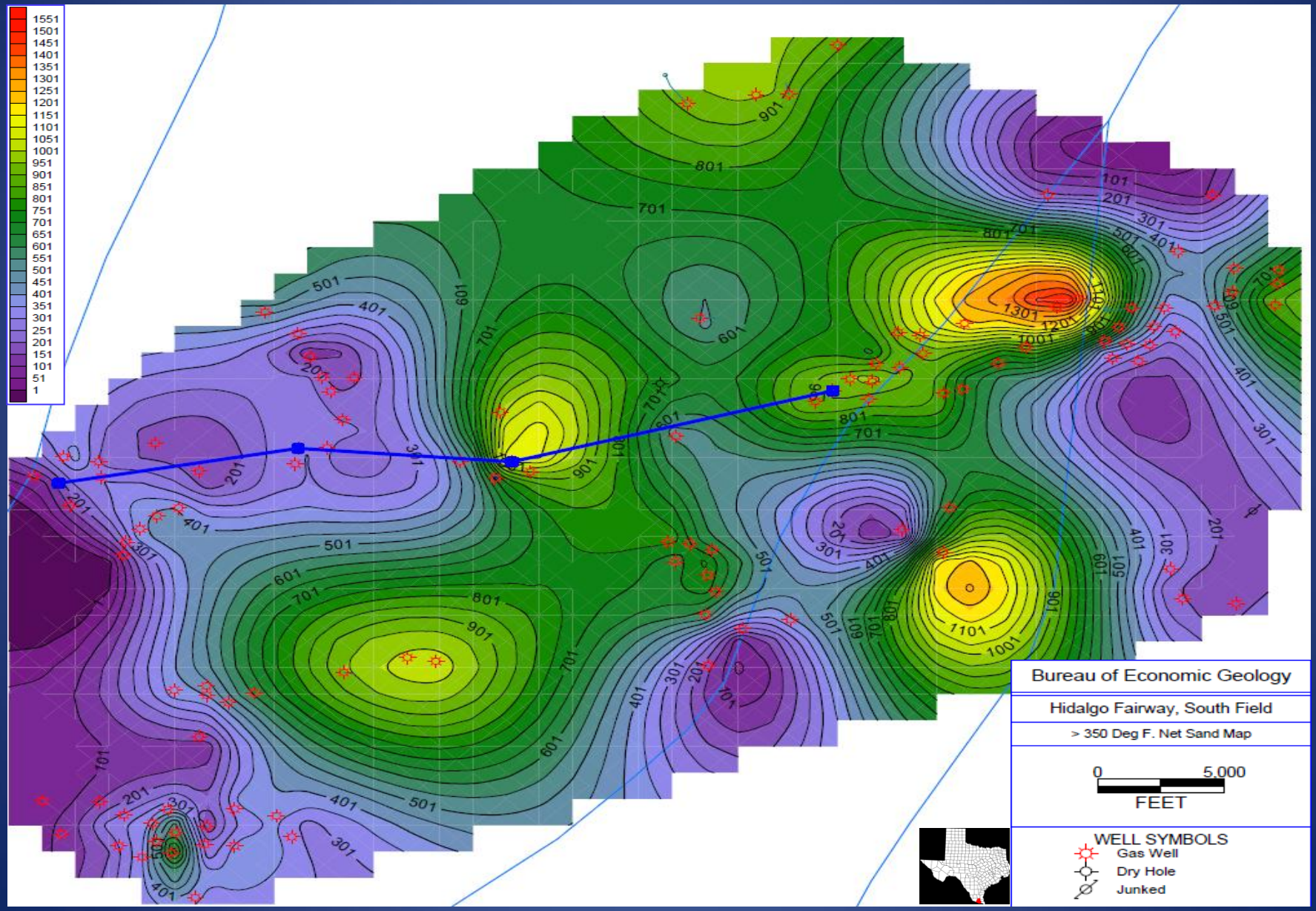
10,257 ft.
300 Degree Surface

12,955 ft.
350 Degree Surface

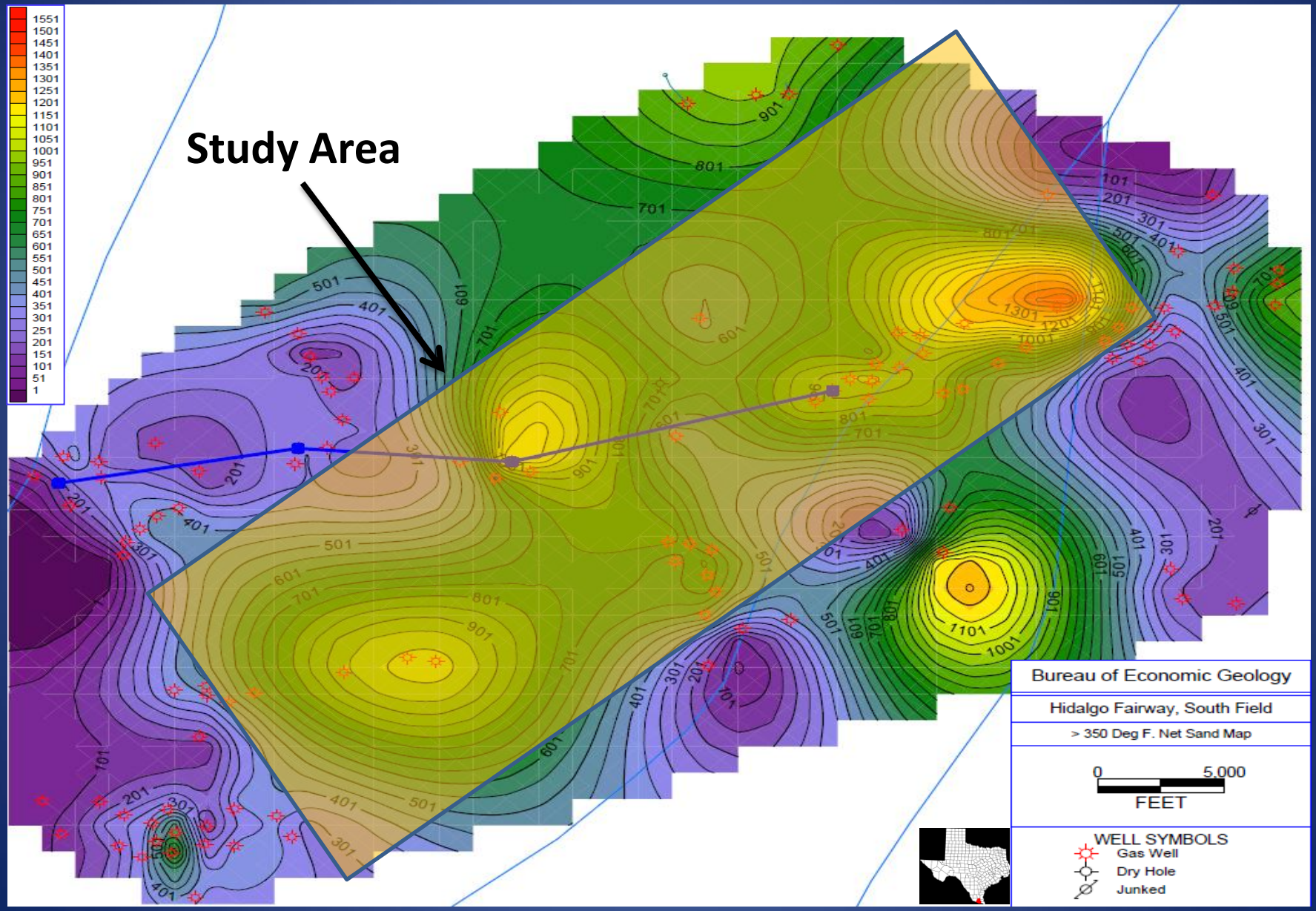
Well Log Interpretation



Hidalgo South
>350 Deg F Net Sand Map

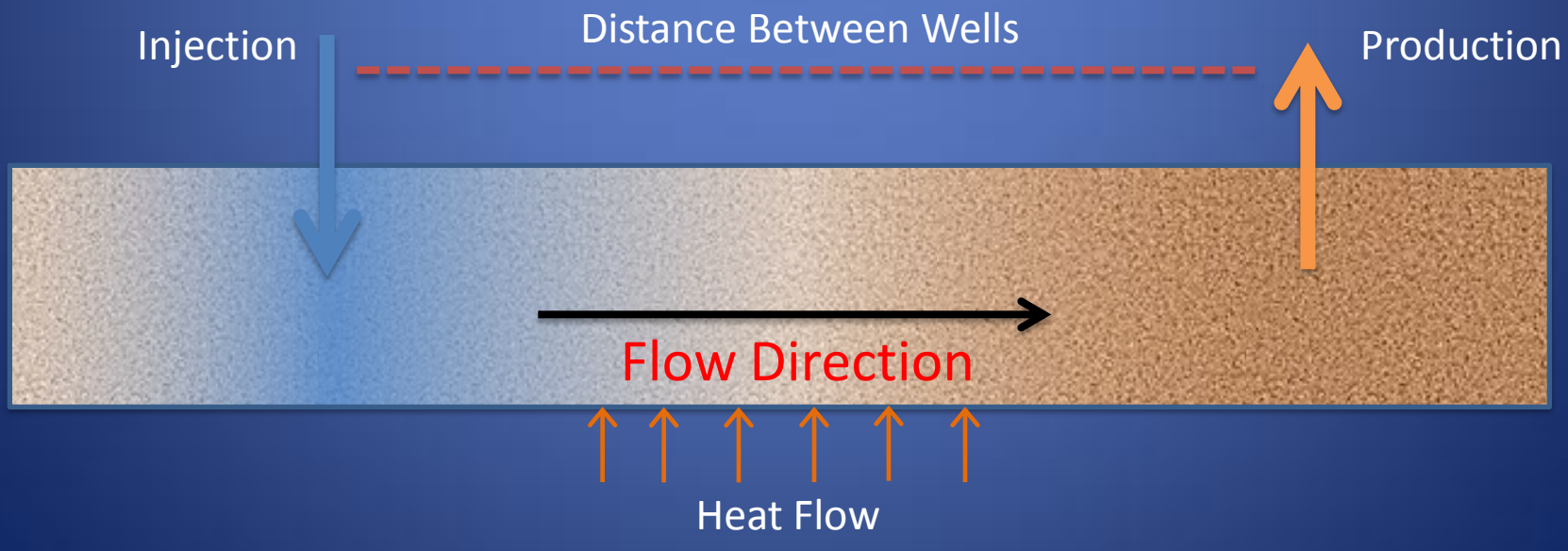


Hidalgo South
>350 Deg F Net Sand Map



Lumped Parameter Estimator

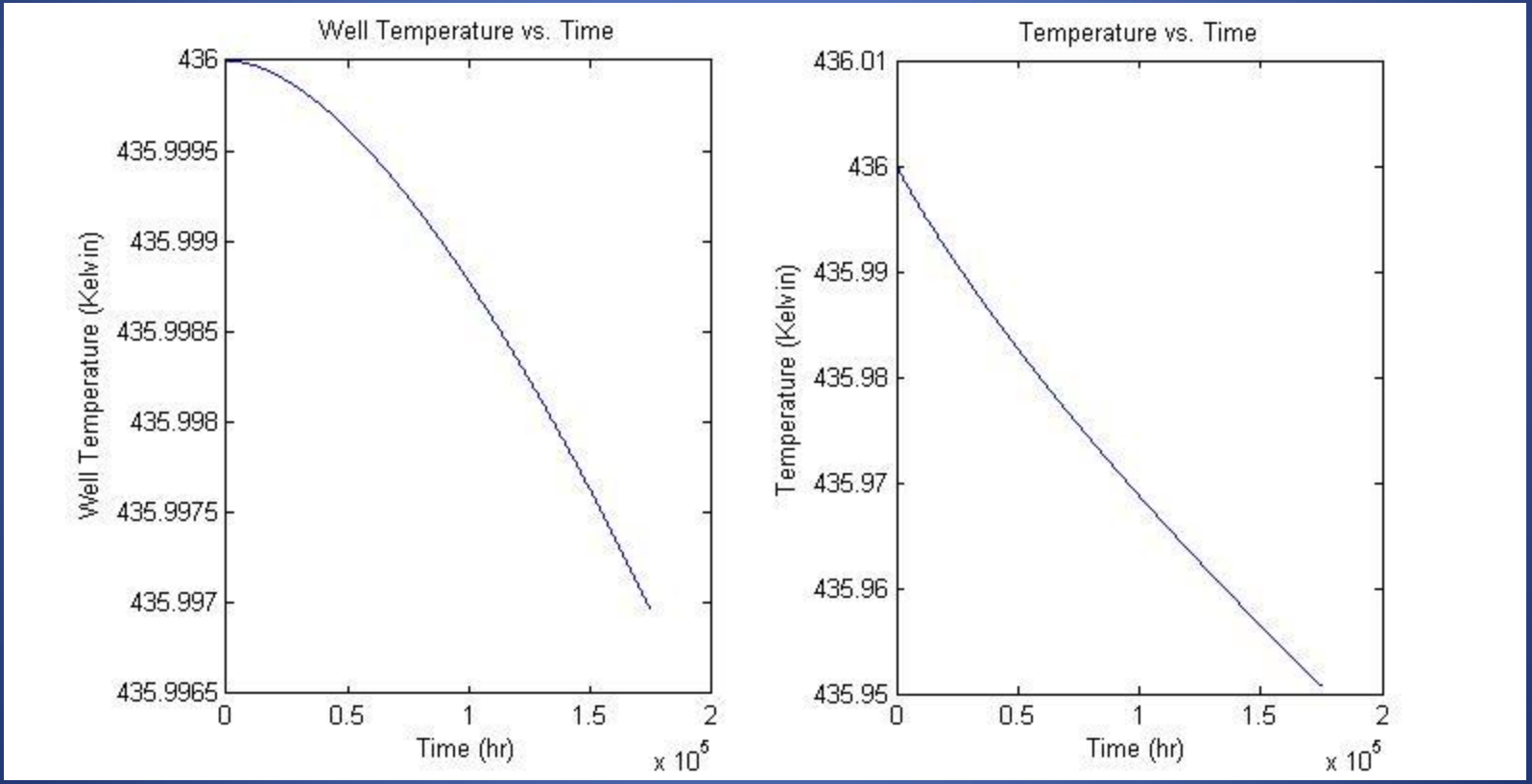
Intial Inputs Used in Matlab	Values	Units
Decision Variables		
permeability	0.0005	Darcies
Production	100000	kg/hr
Time	20	Years
Dt	1	discrete time interval
Deltatemp	0.8	percent temperature change of fluid
inj_prod_ratio	1	ratio of produced fluids to injected fluids
production_constraint	0.01	% difference pressure between well and avg
		reservoir pressure
D	5000	distance between wells in meters



Results – Sustainable Development

Production = 100,000 kg/hr

Distance Between wells= 5000 meters

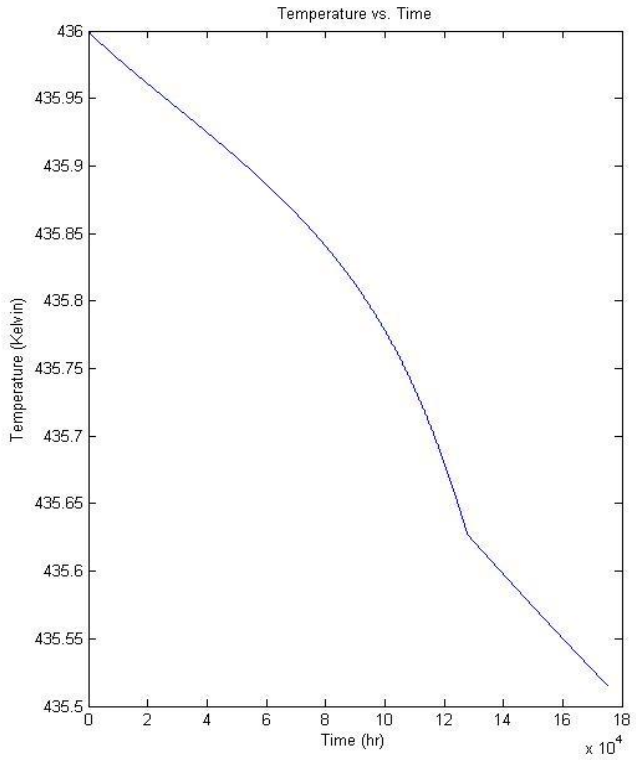


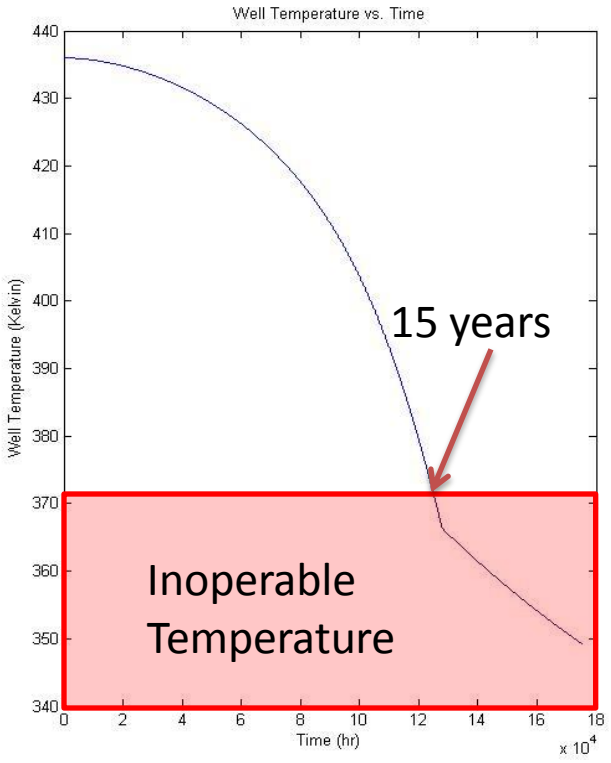
6 wells needed to produce specified production rate

Results – Unsustainable Development

Production = 500,000 kg/hr

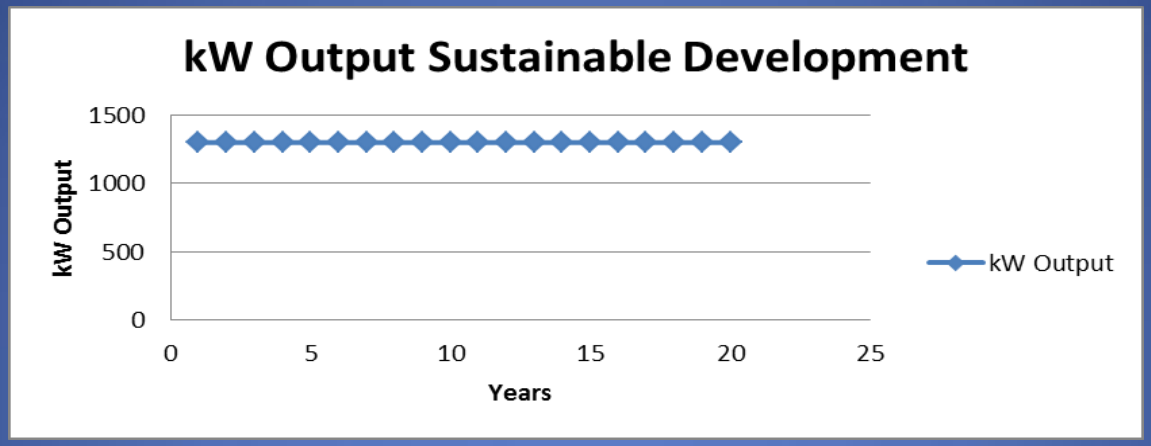
Distance Between wells= 1000 meters

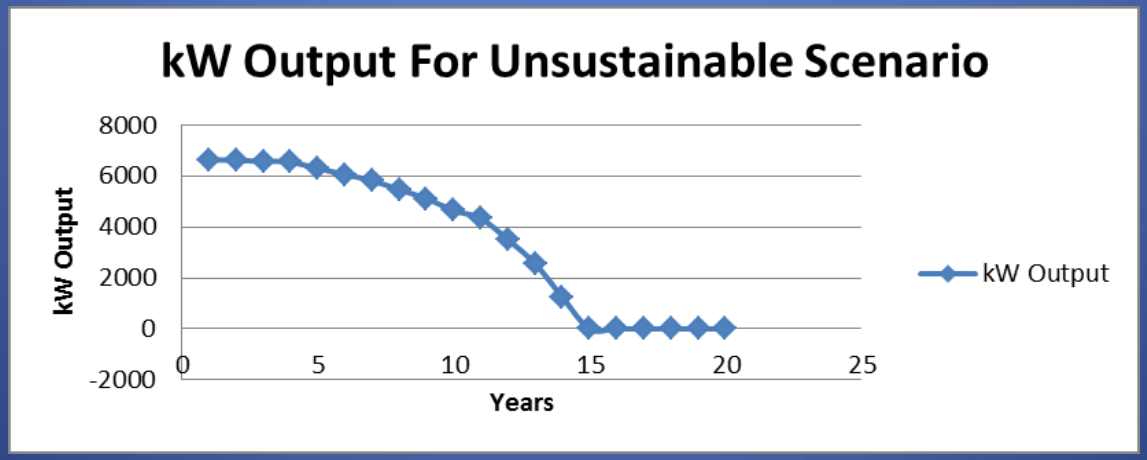




22 wells needed to produce specified production rate

Relative Output





Conclusion

Using the reservoir database created for the NGDS project in conjunction with the lumped parameter estimator, designed in this study, allows for a thorough screening of geothermal resources within Texas.