

Geothermal Technologies Office: Quarterly Update

August 3, 2023



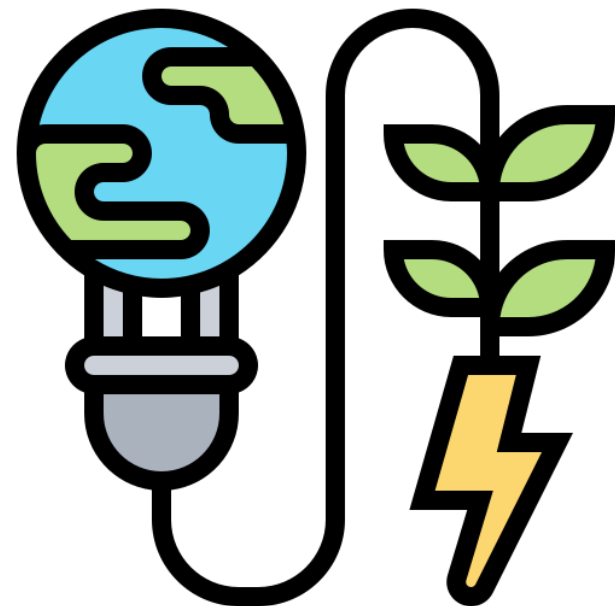


Agenda

- Department of Energy / Office of Energy Efficiency and Renewable Energy Updates
- #GeothermalEverywhere
 - Recent Events
 - In the News
- Info Resources Update
- Upcoming Events
- GTO Project Updates
 - **Spotlight: Paul Schwering, Sandia National Laboratories**
- Q&A

Enter your questions into the Q&A tab anytime during the webinar!

- **Department of Energy (DOE)**
 - [\\$72 Million for Small Business Research and Development Grants](#)
 - Includes four geothermal [projects](#) (Phase 1, Release 2)
 - [Clean Energy Jobs Grew in Every State in 2022](#)
 - [Plan to Ensure Free, Immediate, and Equitable Access to Federally Funded Research](#)
- **Office of State and Community Energy Programs**
 - [\\$150 Million for States to Train Residential Energy Efficiency Contractors](#)
 - [\\$25 Million to Expand Weatherization Assistance Program](#)
- **Grid Deployment Office**
 - [Over \\$200 Million for States and Tribal Nations to Modernize Electrical Grid](#)
- **Industrial Efficiency and Decarbonization Office**
 - [Funding Selections: Onsite Energy Technical Assistance Partnerships](#)



Jolt Newsletter

- Get the latest clean energy news by signing up for the [Weekly Jolt](#): your one-stop-shop for the latest articles, announcements, funding opportunities, and upcoming events from EERE!

Get Real-Time Updates!



- Follow DOE, Secretary Granholm, and EERE on social media
- Use #GeothermalEverywhere

U.S. Department of Energy

- Twitter: [@ENERGY](#)
- Facebook: [@energygov](#)
- LinkedIn: [@u-s--department-of-energy](#)
- Instagram: [@energy](#)

Secretary of Energy

- Twitter: [@SecGranholm](#)
- Facebook: [@SecGranholm](#)
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DOE Office of Energy Efficiency and Renewable Energy

- Twitter: [@eeregov](#)
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#GeothermalEverywhere: Recent Events

- [Enhanced Geothermal Shot™ Summit](#)
- Acting Assistant Secretary Alejandro Moreno [toured FORGE site](#)
- Deputy Secretary Turk attended [Western Governors Association \(WGA\) Annual Meeting](#); WGA released [Heat Beneath our Feet report](#)
- Lauren Boyd and DOE Special Advisor Jeff Marootian spoke at [Fervo Energy Tech Day](#)
- Arlene Anderson presented at the [International Ground Source Heat Pump Association Town Hall](#), the [Midwestern Governors Association](#) meeting, and the [International District Energy Association Conference](#)
- Lauren Boyd presented to [ARPA-e Summer Scholars](#)
- Alexis McKittrick spoke at the Southwest Research Institute's [Thermal Mechanical Chemical Energy Storage Workshop](#).





#GeothermalEverywhere: In the News

Canary Media | [Why This NYC Apartment Complex Will Use a Giant Underground Heat Pump](#) featuring GTO's Alexis McKittrick

CNBC | [Abandoned Coal Mines May Be Gold Mines for Geothermal Energy](#)

CNBC | [Fervo Energy Hits Milestone in Using Oil Drilling Technology to Tap Geothermal Energy](#)

CNN Politics | [DOE Eyes Geothermal Energy to Heat and Cool US Homes with Low Climate Impact](#) featuring GTO's Arlene Anderson

Deseret News | [Utah's FORGE Geothermal Site Proves it's More than Just Wishing Wells](#)

KOCO-ABC5 | [OU Researchers Welcome Nation's Tallest Geothermal Rig \(koco.com\)](#)

SmartCitiesDive | [To Spur Geothermal Heating and Cooling, DOE Funds 11 Community-Scale System Design Projects](#) featuring GTO's Alexis McKittrick

ThinkGeoEnergy | [Utah FORGE Starts Production Well Drilling to Further EGS Testing](#)

WMTV-NBC15 | [Green Co. CSA Farm Uses Solar, Geothermal Greenhouse to Provide Produce for Locals \(nbc15.com\)](#)

The collage features several news articles related to geothermal energy. At the top right is a SmartCitiesDive article titled "To spur geothermal heating and cooling, DOE funds 11 community-scale system design projects" by Ysabelle Kempe. Below it is a CNBC article titled "Why this NYC apartment complex will use a giant underground heat pump" with a photo of a construction site. To the right of that is a CNN Politics article titled "The Biden administration eyes a relatively untapped climate solution to revolutionize how homes are heated and cooled". Below the CNBC article is another CNBC article titled "Fervo Energy hits milestone in using oil drilling technology to tap geothermal energy". At the bottom right is a Deseret News article titled "Utah's FORGE geothermal site proves it's more than just wishing wells" by Amy Joi O'Donoghue.

Get news updates in The Drill Down! geothermal.energy.gov

Making Geothermal Info Accessible

GEOTHERMAL TECHNOLOGIES OFFICE

Geothermal Heat Pump Information for Consumers

Geothermal Technologies Office

Geothermal Technologies Office » Basics & Resources » Geothermal Heat Pump Information for Consumers

Geothermal heat pumps (GHPs) offer an efficient solution for heating and cooling. Navigating applicable tax credits or grants and finding local installers can be difficult.

GEOTHERMAL TECHNOLOGIES OFFICE

Geothermal Publications

Geothermal Technologies Office

GEOTHERMAL TECHNOLOGIES OFFICE

Permitting for Geothermal Power Development Projects

Geothermal Technologies Office

Geothermal Technologies Office » Basics & Resources » Permitting for Geothermal Power Development Projects

Geothermal project development can be subject to numerous permits,

Geothermal Technologies Office » Geothermal Publications

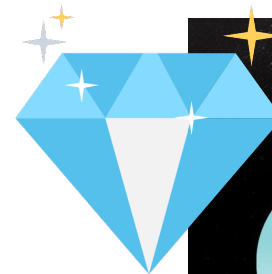
The U.S. Department of Energy's (DOE) Geothermal Technologies Office (GTO) collaborates on and supports several publications each year to inform and educate about advances in geothermal technology. Explore below for important analyses, planning documents, technical reports, and



energy.gov/eere/geothermal/

Upcoming Events

- Aug. 30 | [Geothermal Rising Webcast](#), *Investing in Opportunity: How GTO is Supporting Geothermal Everywhere*, Lauren Boyd, virtual.
- Oct. 1–4 | [Geothermal Rising Conference](#), Reno, NV. GTO is a Diamond Sponsor for 2023!
- Oct. 11 | [International Ground Source Heat Pump Association \(IGSHPA\) Town Hall](#), *Navigating the U.S. Department of Energy*, Alexis McKittrick, virtual.
- Nov. 14–15 | [Society of Petroleum Engineers/Geothermal Rising Workshop: Geothermal and Oil & Gas - Mutual Challenges and Solutions](#), Englewood, CO.





GTO Staff Updates



Federal Staff	Contractor Staff
Meisha Baylor	Jason Braden
	Pamela Daitch
	Ian Johnson
	Rick Potter
	Angie Southcott



Program Updates Enhanced Geothermal Systems

Jon Payne



Frontier Observatory for Research in Geothermal Energy (FORGE) Updates

- **Drilling updates**
 - Completed drilling of 16B production well
 - Intersects existing injection well (16A) through reservoir of hydraulically created fractures
 - Confirmed connectivity of the doublet pair
 - Continued stimulations and circulation testing planned
- **Solicitation 2 applications still in review**
- **2023 R&D Annual Workshop, Sept. 7–8 (virtual).** Registration required: utahforge.com/rd/solicitations/

Utah FORGE project confirms connectivity of EGS reservoir



Utah Forge site at sunset (source/ photo: Eric Larson, FlashPoint SLC via UtahForge)

The Salt Lake Tribune

Utah geothermal project hits a milestone, pumping water through deep granite

Utah FORGE scientists connect two deep wells that could one day generate a continuous flow of hot water to produce power.





Other EGS Updates

- **Bipartisan Infrastructure Law EGS Pilot Demonstration Projects**
 - Applications under review

- **Society of Petroleum Engineers Geothermal Datathon**
 - Currently in the judging phase
 - Winners expected in September at PIVOT 2023





Program Updates

Data, Modeling, and Analysis

Sean Porse



Geothermal Collegiate Competition

Fall 2023 competition is now open!

- Real-world geothermal experience
- Opportunities to engage with established industry professionals and local communities
- Cash prizes!

Open to teams of three or more students from any discipline.

Visit <https://bit.ly/GTOGCC> to learn how to register.



****Informational webinar August 15****



Geothermal Data Repository

Publicly available resource for data on GTO-funded reports and projects:

<https://gdr.openei.org/>



search GDR data

Search

Direct Use

EGS

FORGE

Hydrothermal

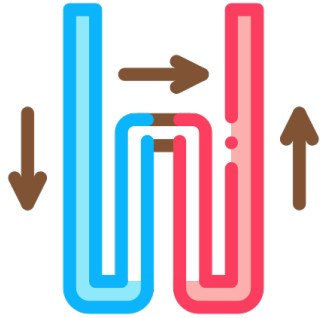
Featured Data

135 datasets
Utah FORGE Project

34 datasets
EGS Collab Project

124 datasets
Play Fairway Analysis

Machine Learning
Analytics
135 TB of Data (Big Data)
Data Lakes




Program Updates

Low-Temperature and Coproduced Resources Program

Alexis McKittrick


Department of Energy Industrial Heat Shot




ENERGY
earthshots
U.S. DEPARTMENT OF ENERGY

Industrial Heat™


Goal: The Industrial Heat Shot™ is a Department-wide initiative to develop cost-competitive industrial heat decarbonization technologies with at least 85% lower greenhouse gas emissions by 2035.



85% Reduction



2035



U.S. DEPARTMENT OF
ENERGY

energy.gov/eere/industrial-heat-shot

Department of Energy Industrial Heat Shot

DOE has identified three key methods to decarbonize industrial heat and achieve the target:



ELECTRIFICATION
of heating operations



**INTEGRATION OF
LOW-EMISSIONS HEAT
SOURCES** (such as geothermal
energy, concentrated solar power,
or nuclear energy)



INNOVATIVE
low- or no-heat process
technologies



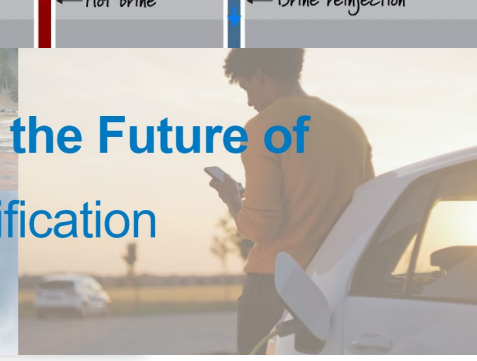
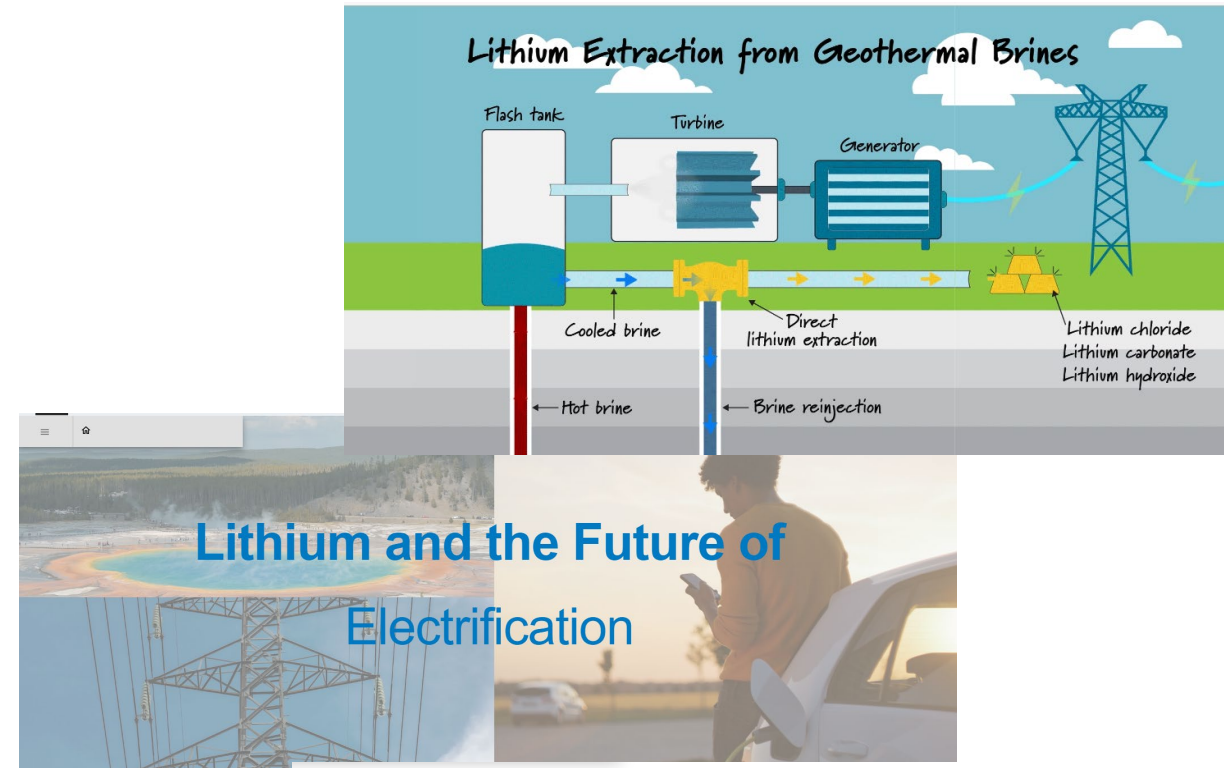
Program Updates **Hydrothermal Program**

Alexis McKittrick



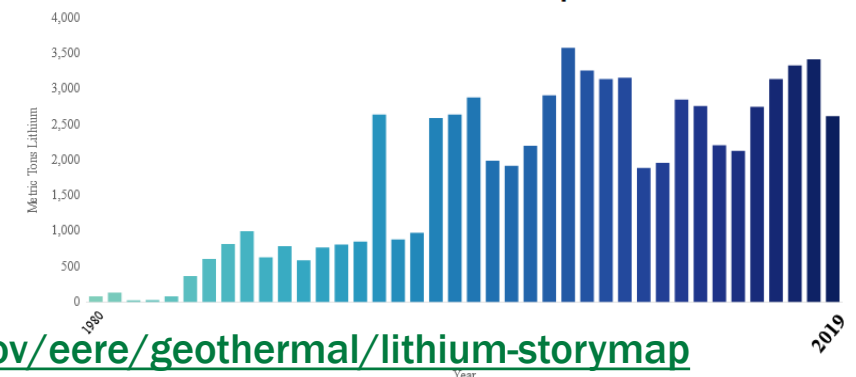
Lithium Extraction from Geothermal Brines

- Joint Funding Opportunity Announcement between GTO and DOE's Advanced Manufacturing and Materials Technology Office
- Will advance innovative technologies to extract and convert battery-grade lithium from geothermal brine sources in the United States
- \$10.9 million for 10 projects across nine states, in two topic areas:
 - Field Validation of Lithium Hydroxide Production from Geothermal Brines
 - Applied Research & Development for Direct Lithium Extraction from Geothermal Brines



Lithium and the Future of Electrification

U.S. Lithium Imports



Visit our Lithium Storymap to learn more about this critical material! energy.gov/eere/geothermal/lithium-storymap



New Hidden Systems Data!

INnovative Geothermal Exploration through Novel Investigations Of Undiscovered Systems (INGENIOUS): Aims to accelerate discoveries of new, commercially viable hidden systems across the Great Basin region and create predictive geothermal maps at regional and prospect scales. gdr.openei.org/submissions/1391 and ScienceBase.gov (USGS Data).

Collaboration w/U.S. Geological Survey:

gdr.openei.org/submissions/1501

- **Geoscience Data Acquisition in Western Nevada (GeoDAWN):** Focused on new subsurface data in western Nevada and leveraging machine learning for better understanding of geologic conditions and stress regime.
- **GeoFlight: Salton Trough:** Data on hidden geothermal systems in Imperial Valley (CA), using specially equipped, low-flying aircraft to help identify unique surface and near-surface characteristics to create more accurate geologic maps for the area.

Play Fairway Analysis (PFA) Retrospective Data Sets: Synthesis and analysis of GTO's geothermal PFA program

gdr.openei.org/submissions/1498



GeoFlight photos (Glamis Dunes) courtesy Kyle Kendall



Exceptional service in the national interest

Basin & Range Investigations for Developing Geothermal Energy (BRIDGE)

An overview of a research project in exploration methodology, conceptual modeling, the 'public data bonanza'

Presented by Paul Schwering

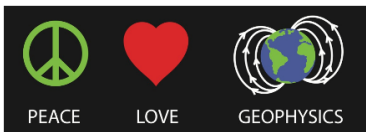
GTO Quarterly Webinar

Thursday 03 August 2023

BRIDGE = Basin & Range Investigations for Developing Geothermal Energy

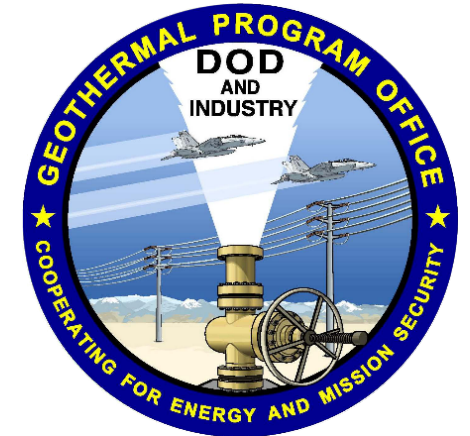
This is an update from a multi-institution collaborative study in progress of west-central Nevada, USA funded by the Geothermal Technologies Office (GTO) of the DOE.

Paul Schwering



Principal Geoscientist

Sandia National Laboratories



...and more to come!

The Applied Research Team (so far)

Christine Downs, Thomas Lowry, William Cumming, Steven Sewell, Nicholas Hinz, Kelly Blake, Andrew Sabin, Carmen Winn, Janice Lopeman, Alex Milton, Matt Folsom, Jade Zimmerman, Drew Siler, Stephanie Nale, Kurt Kraal, Adam Schultz, Paul Bedrosian

GTO: Mike Weathers, Jessica Quintanar, Alexis McKittrick



Motivation – Hidden Geothermal Systems Research

- Characteristics and background
 - No active (e.g. hot springs) or relict (e.g. sinter terrace) surface manifestations
 - Traditionally discovered ‘by accident’
 - Numerous studies suggest prolific hidden geothermal reservoirs in the western US
 - Need methods for intentional & successful discovery (mitigate uncertainty & risk)
- What are the tools for discovery?
 - Exploration geophysics & geoscience data
 - Conceptual & reservoir modelling
 - And then, yes, drilling!



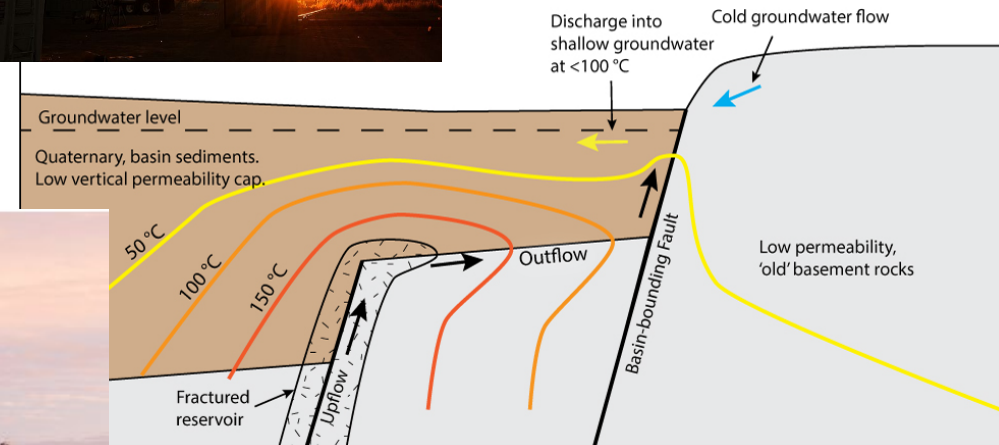
Ormat's 36 MW Don A. Campbell Geothermal Complex, Nevada, USA; a hidden system initially discovered during mineral exploration drilling



BRIDGE Purpose: reduce risk & increase success of exploration for hidden geothermal systems

Objectives of 3-year Project:

- Improved exploration technology
 - Regional prospecting
 - Statistical metrics for down-selection
- Facilitate conceptual modeling & verification
 - Data-driven resource visualization
 - Confirmation drilling of wells
- Mitigate non-technical barriers
 - Dept of Defense (DOD) & Bureau of Land Mgmt (BLM) territories
 - High-visibility exploration & data

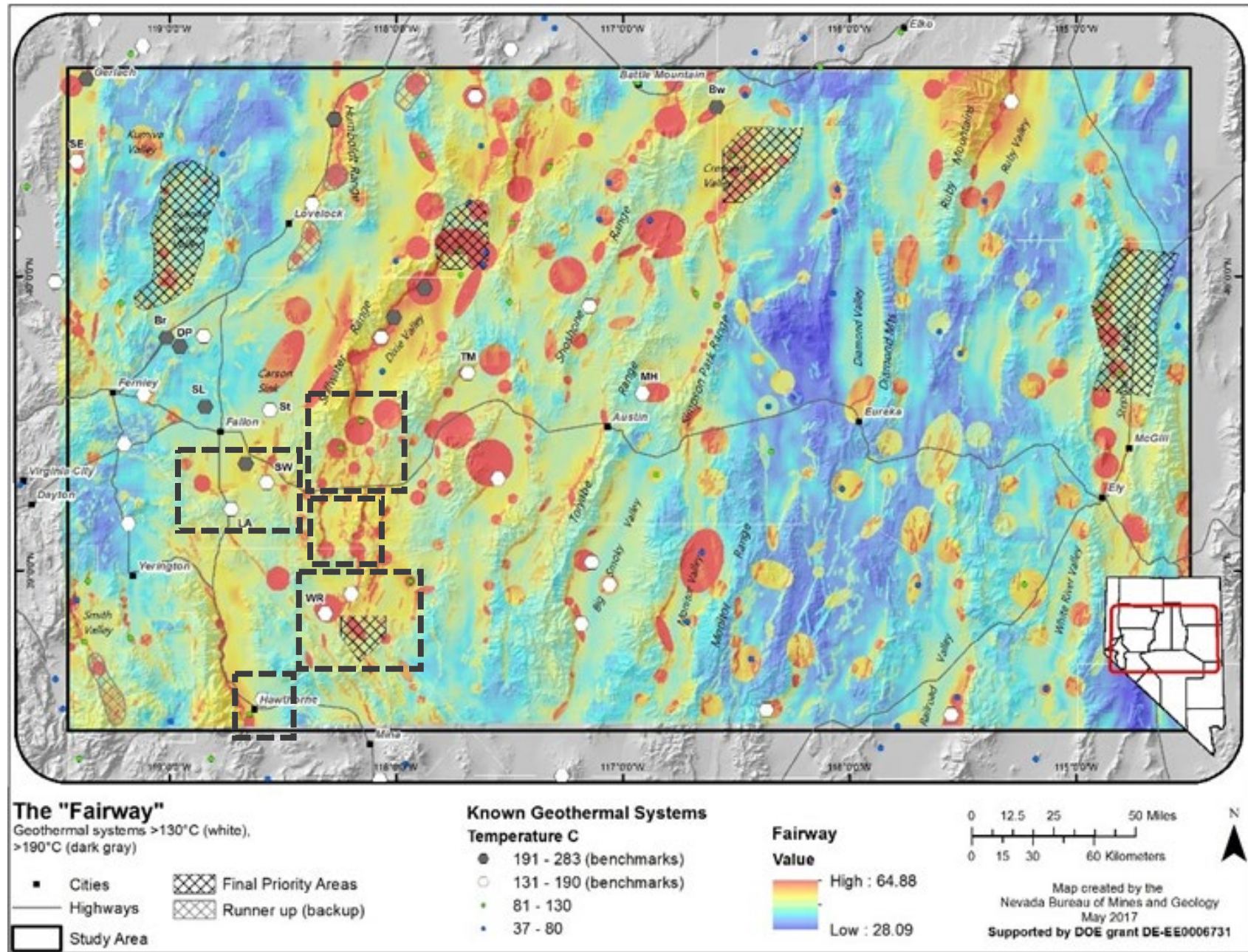




Study Area

West-Central Nevada

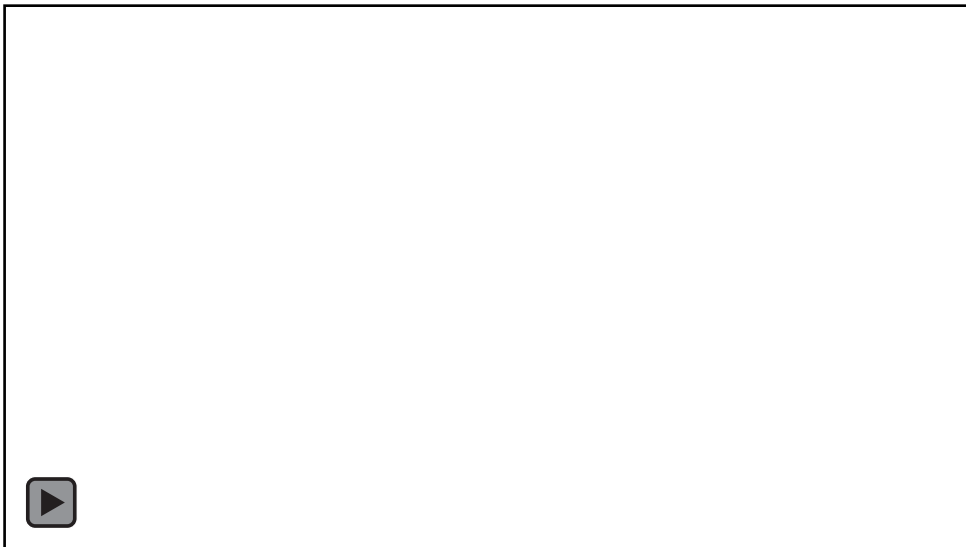
- Investigating southwest portions of Nevada Play Fairway Analysis (Faulds et al., 2015)
- Region of both actively producing geothermal energy fields, nearly unexplored territory, and all points in-between
- *We have a lot of existing data to work with!!*



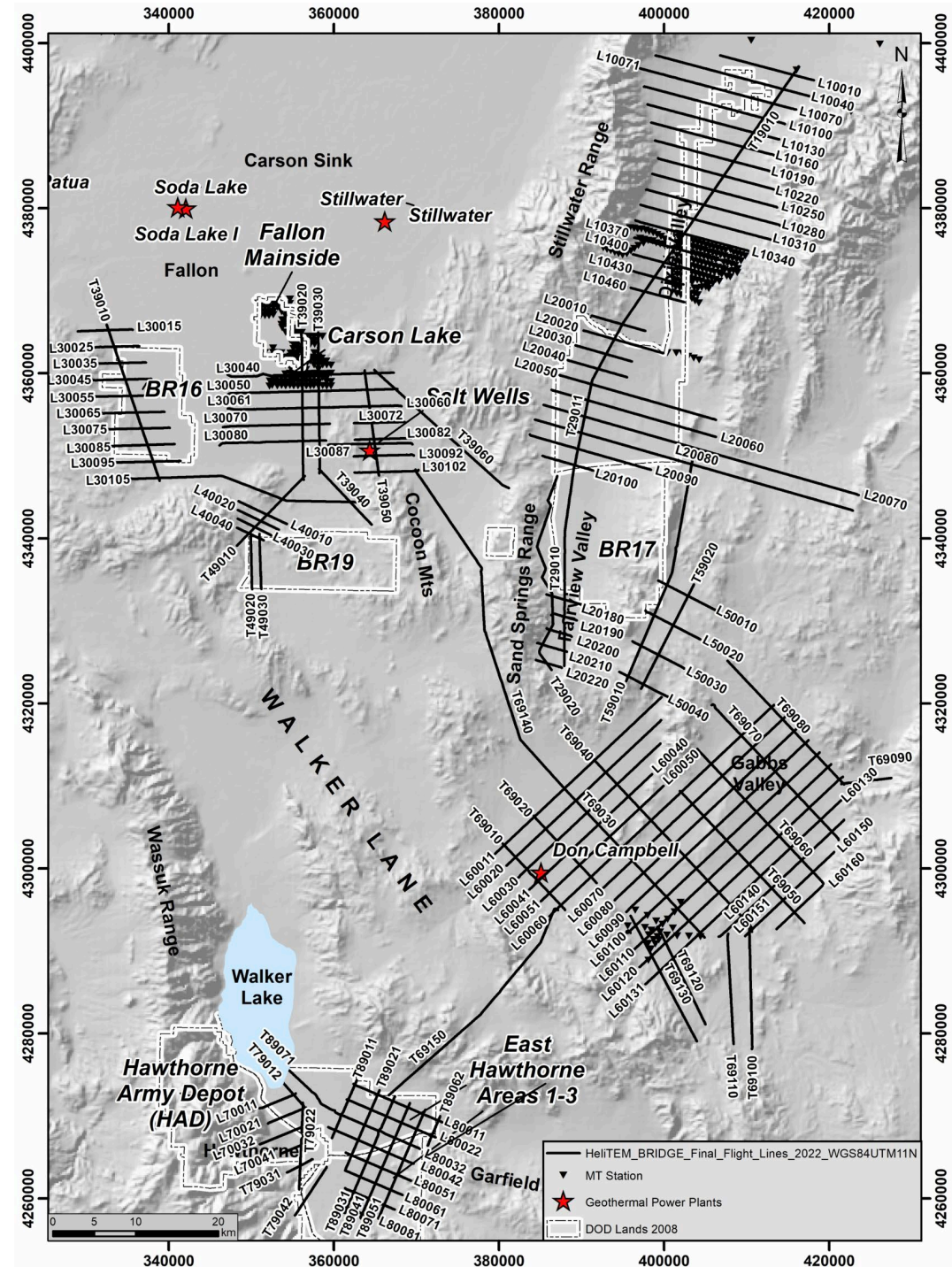


Airborne Electromagnetic (AEM) Survey

- Helicopter system covered approximately 3,000 km² (1,877 line-km) in Spring of 2022
- Square wave EM system tuned to maximum 7.5 Hz base frequency for resistivity depth of investigation tuned for approx. 30 to 300 meters below ground surface



Xcalibur's HeliTEM™ system lift-off





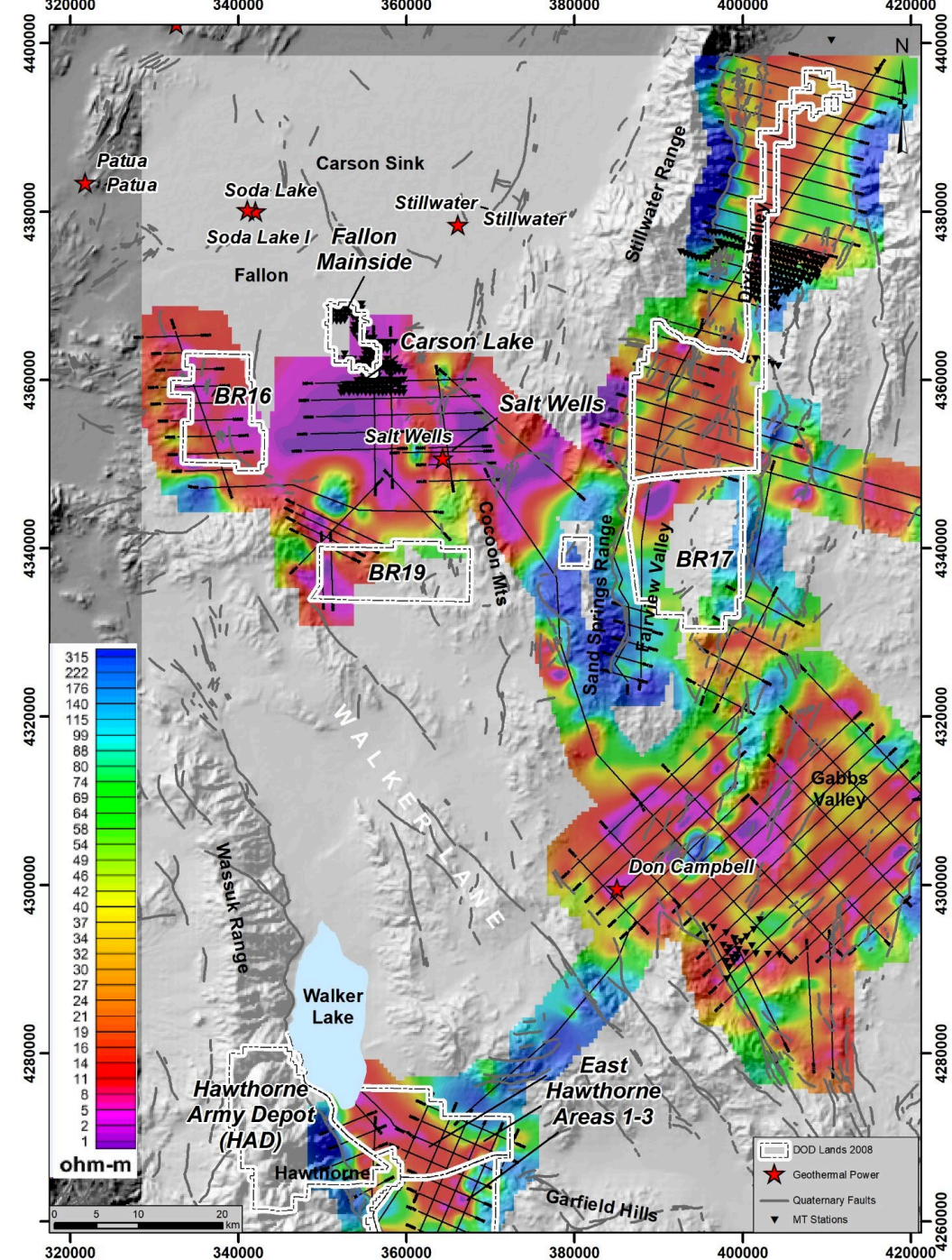
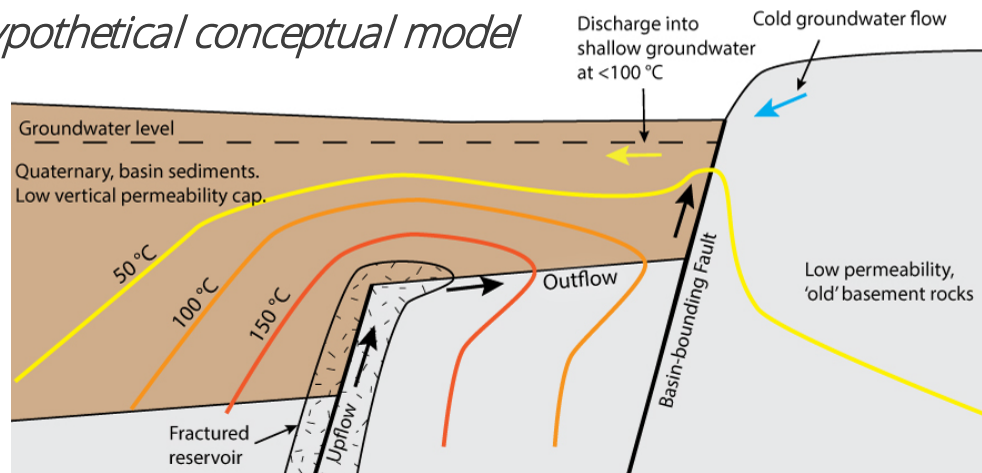
AEM Exploration

Detecting attributes of hidden geothermal systems:

1. Low-resistivity clay zones capping (seal) buoyant up-dip flow of hot formation-hosted aquifers (resource)
2. Meteoric aquifers that render standard shallow (i.e., 150 meter) temperature gradient methods ineffective
3. Low-resistivity zones associated with hydrothermal alteration (often complicated in Nevada by widespread, very low-resistivity evaporitic formations)

Eastern portion of Hawthorne Army Depot (HAD) emerged as an attractive hidden system prospect!

Hypothetical conceptual model

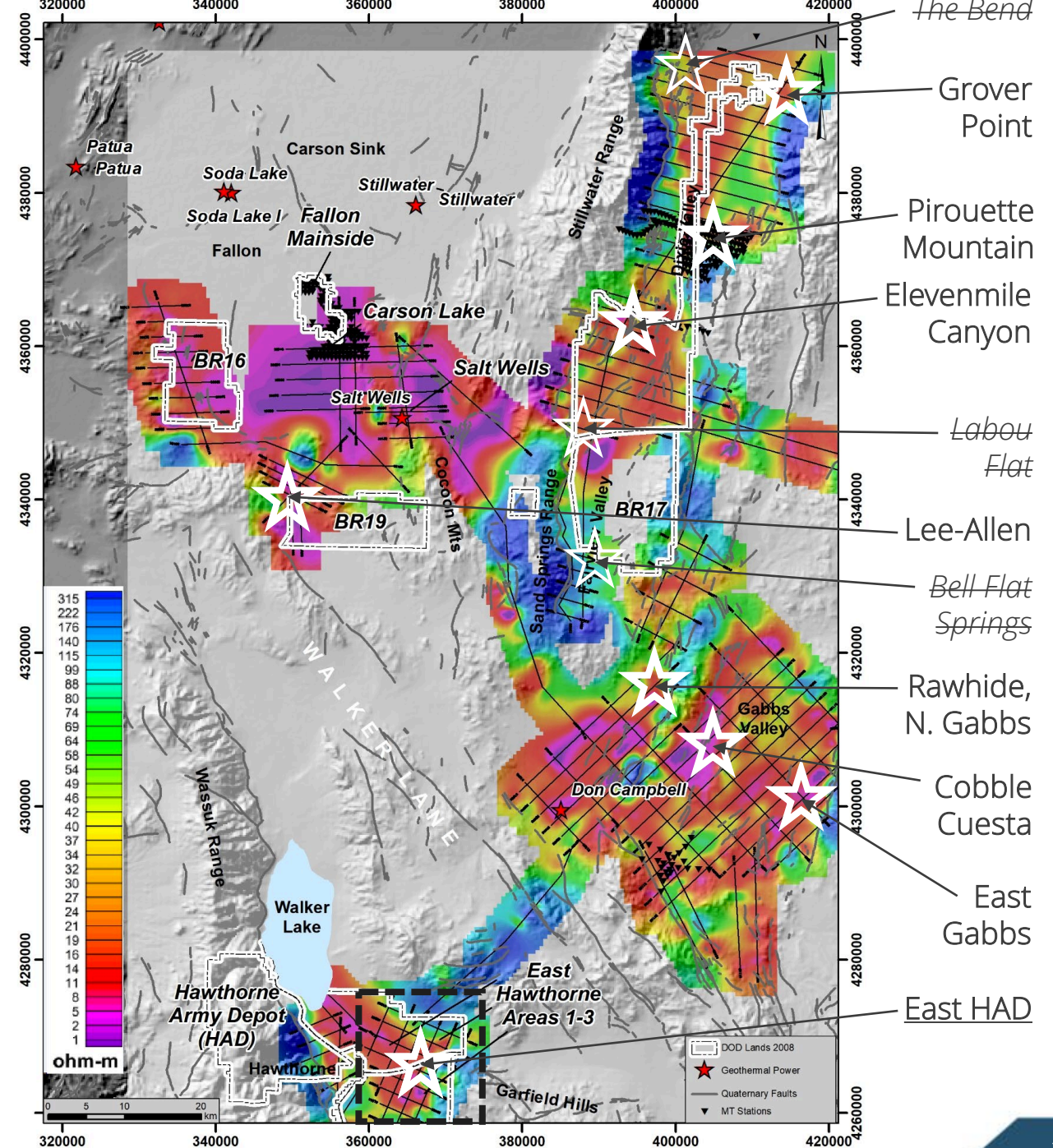


AEM Exploration



Upon review of AEM and existing geoscience data, we identified 28 individual hidden system prospects within the BRIDGE study area! We have since down-selected and continue to prioritize and update our prospect portfolio.

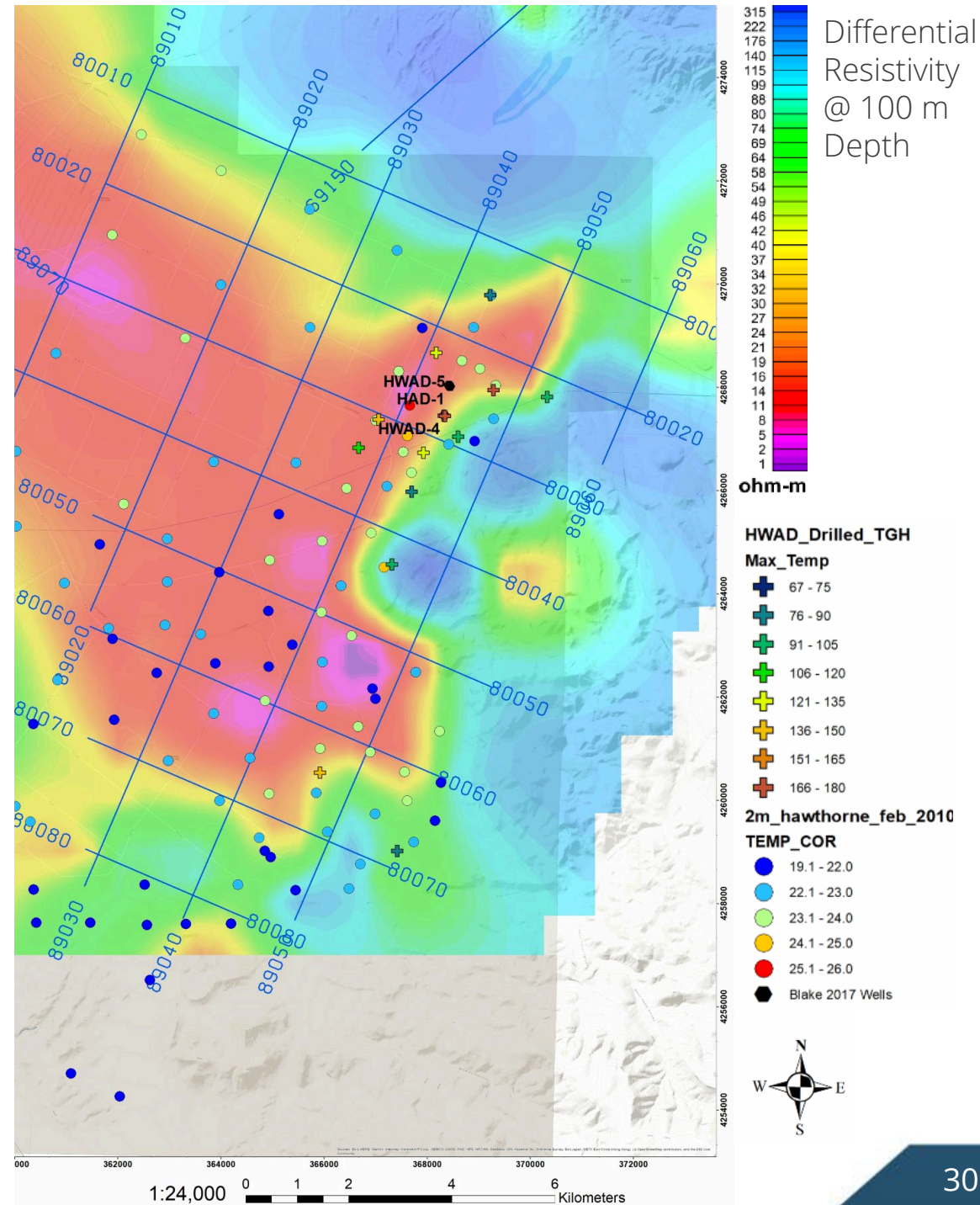
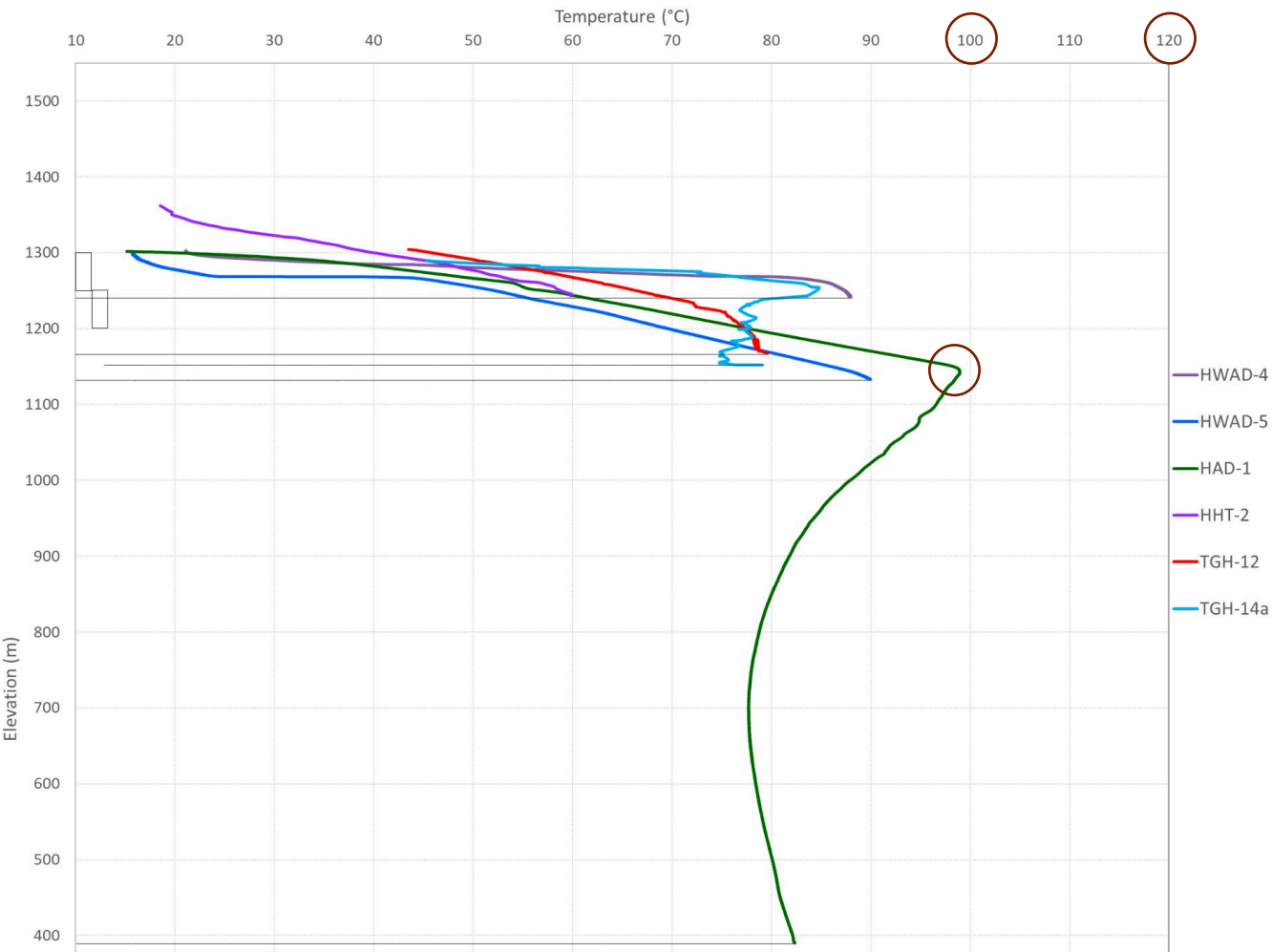
Let's "zoom in" on the east Hawthorne Army Depot (HAD) area of interest, as a working example among our geothermal prospects.





Eastern Hawthorne Army Depot (HAD)

Previous studies, preliminary AEM data, and a field work opportunity (crew ready to deploy and site access authorized!) all conspired to pursue a magnetotelluric (MT) survey for deeper resistivity imaging



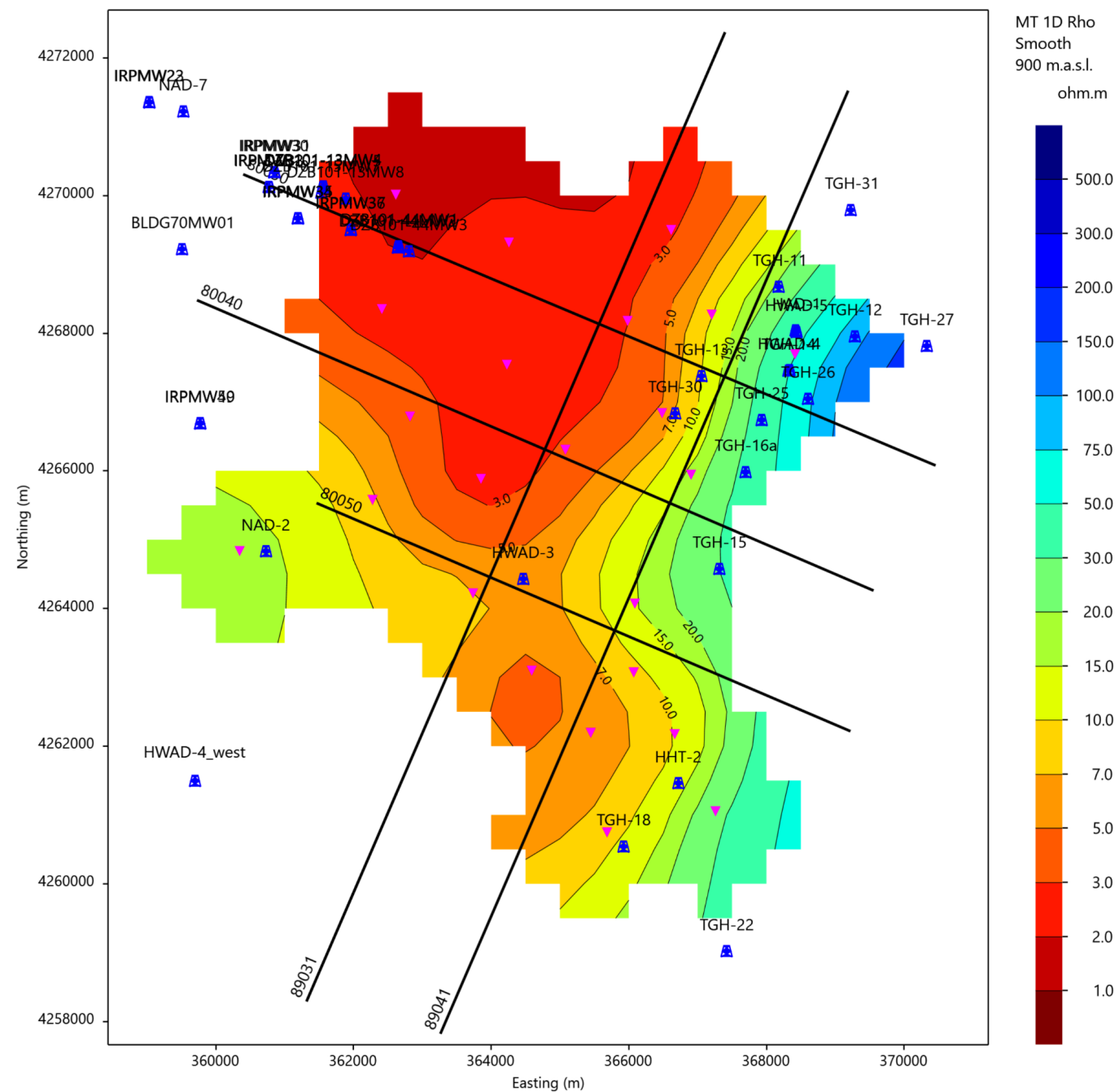


Geophysical Blitz!

Fall of 2022:

- USGS performed laterally-constrained 1D deterministic inversions of the AEM profiles
- Enthalpion conducted a 26-station full tensor wideband MT survey (pink triangles at right)
- Navy GPO also conducted a supplementary 2-meter temperature survey

Applied R&D works just like exploration; always wish we could work in series (one step informs the next), but consistently have to work in-parallel to keep budgets, timelines, and priorities on-track!

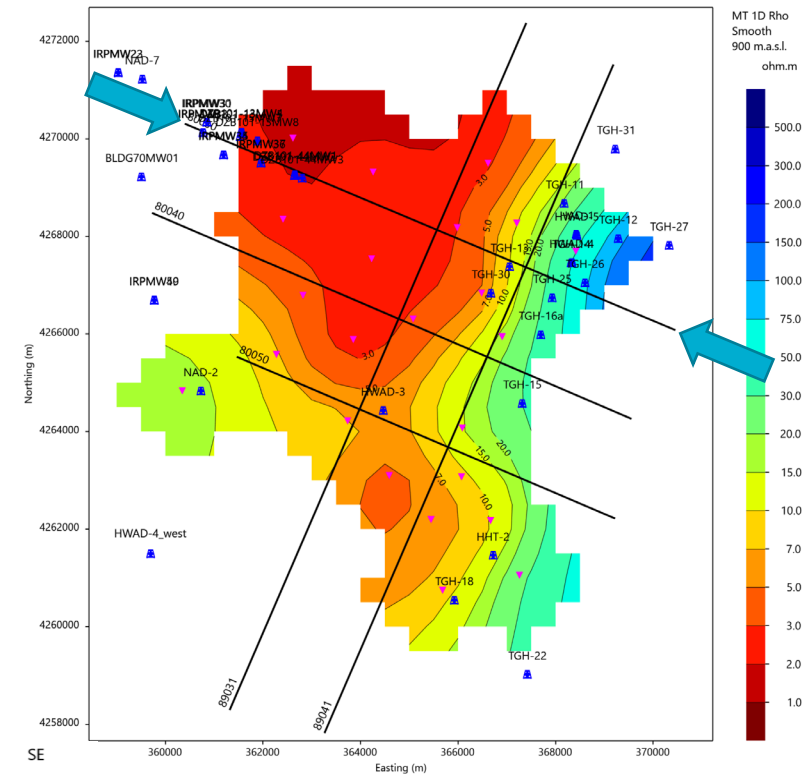


Preliminary MT elevation slice, approx. 500 m below ground surface (1D invariant smooth model resistivity)

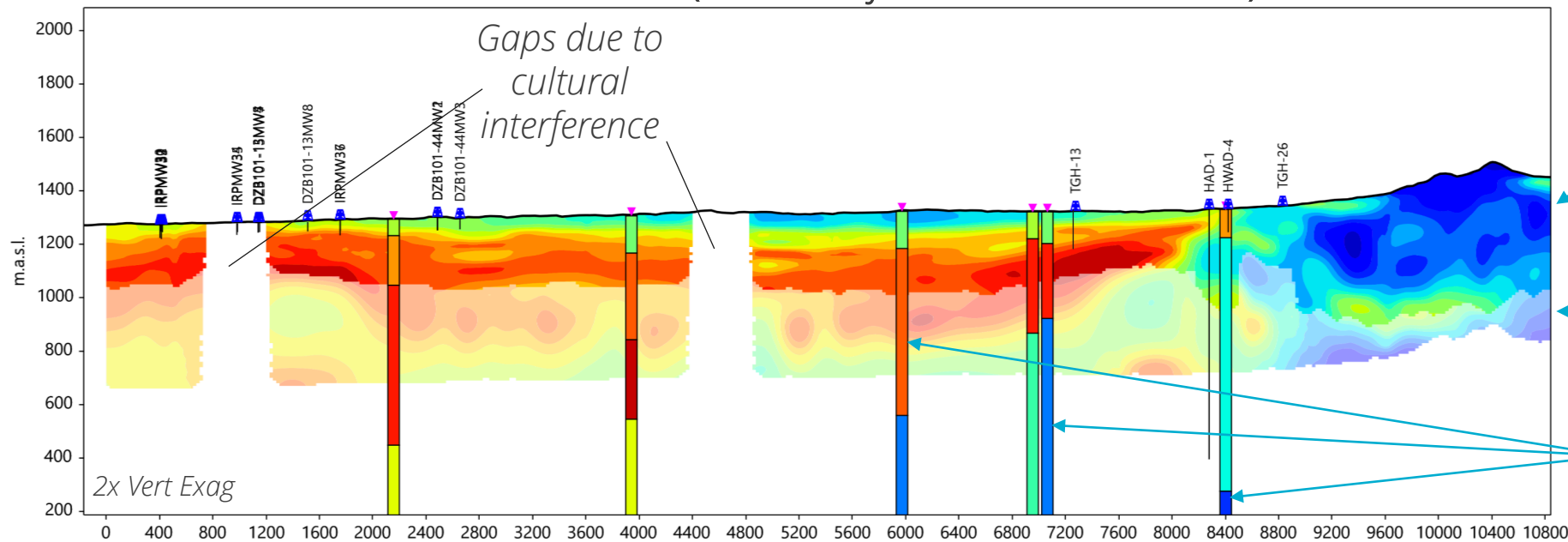


AEM/MT Preliminary Inversion Results

- AEM images shallow resistivity structure in high resolution and nominally excellent lateral continuity
- MT coverage is more sparse, but data quality with depth at this site is very good overall
- Comparison/overlay of the AEM and MT show generally consistent 1D inversion resistivity results



NW
AEM Profile 80030 (1D laterally-constrained inversion)



AEM within conservative depth of investigation estimate

AEM below conservative depth of investigation (transparent)

MT 1D invariant layer inversion (per station)

AEM/MT Preliminary Interpretation

- Top of basement follows basin-bounding contact mapped at the surface and through HAD-1 well
- Relatively resistive meteoric zone imaged across basin by AEM & MT, may be up to 200 meters thick!
- ***AEM & temp/geo profile of HAD-1 indicate shallow, clay-capped outflow at basin margin***
- ***MT suggests deeper resource in basin! >120°C?***

HAD-1 Clay Mineralogy

Weight Percent of Sample

Depth (feet)

Temperature (Celsius)

Smectite, Illite, Interlayered illite/smectite, Chlorite, Temperature

1/5/11

Clay cap

Top of basement

Shallow thermal outflow (max temp just below 100°C)

AEM Profile 80030 (1D laterally-constrained inversion)

NW SE

m.a.s.l.

2x Vert Exag

Capped hydrothermal outflow?

Meteoric zone

Capped hydrothermal outflow

Hydrothermal upwelling?

Top of basement

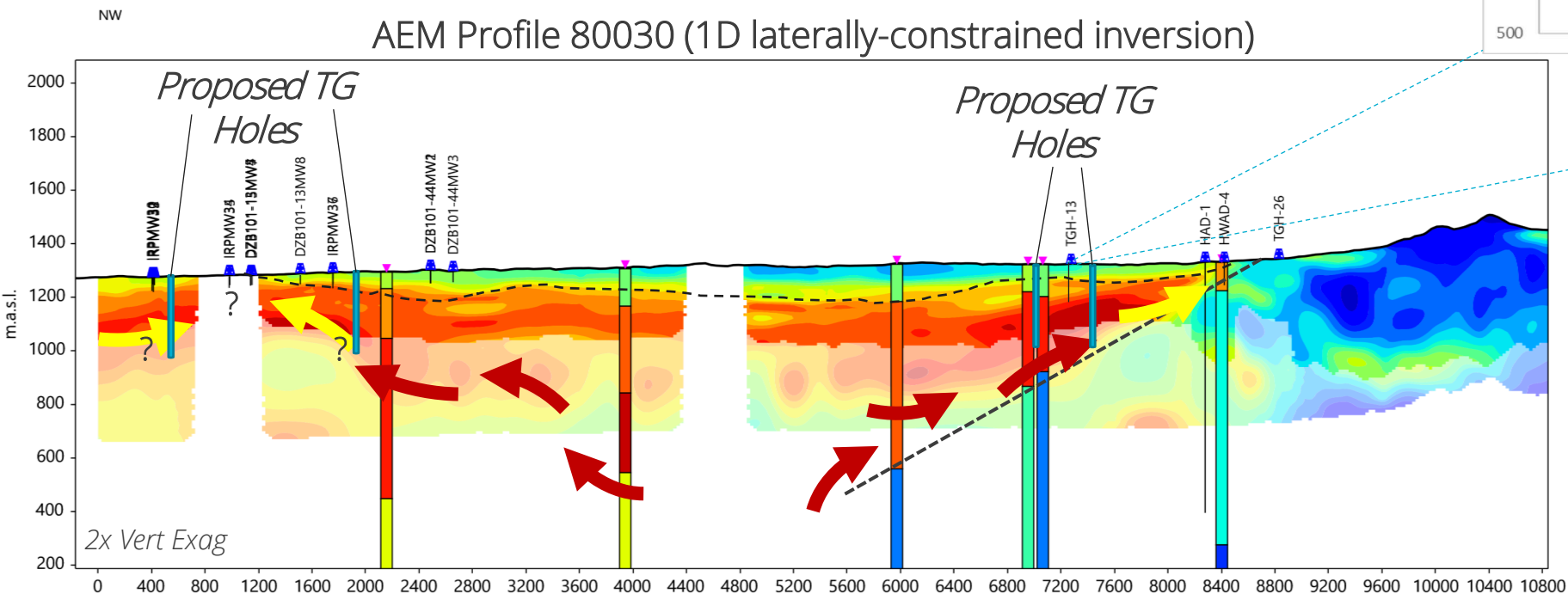
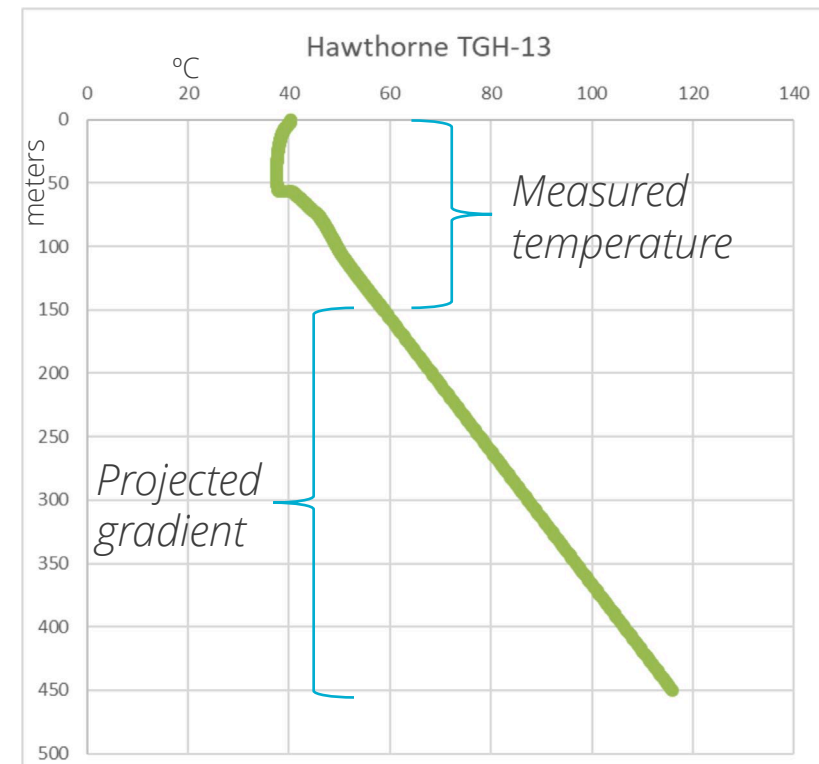
IRPMW30, IRPMW35, DZB101-13MW8, DZB101-13MW3, IRPMW36, DZB101-44MW2, DZB101-44MW3, TGH-13, HAD-1, HWAD-4, TGH-26

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Next Step: Temperature Confirmation

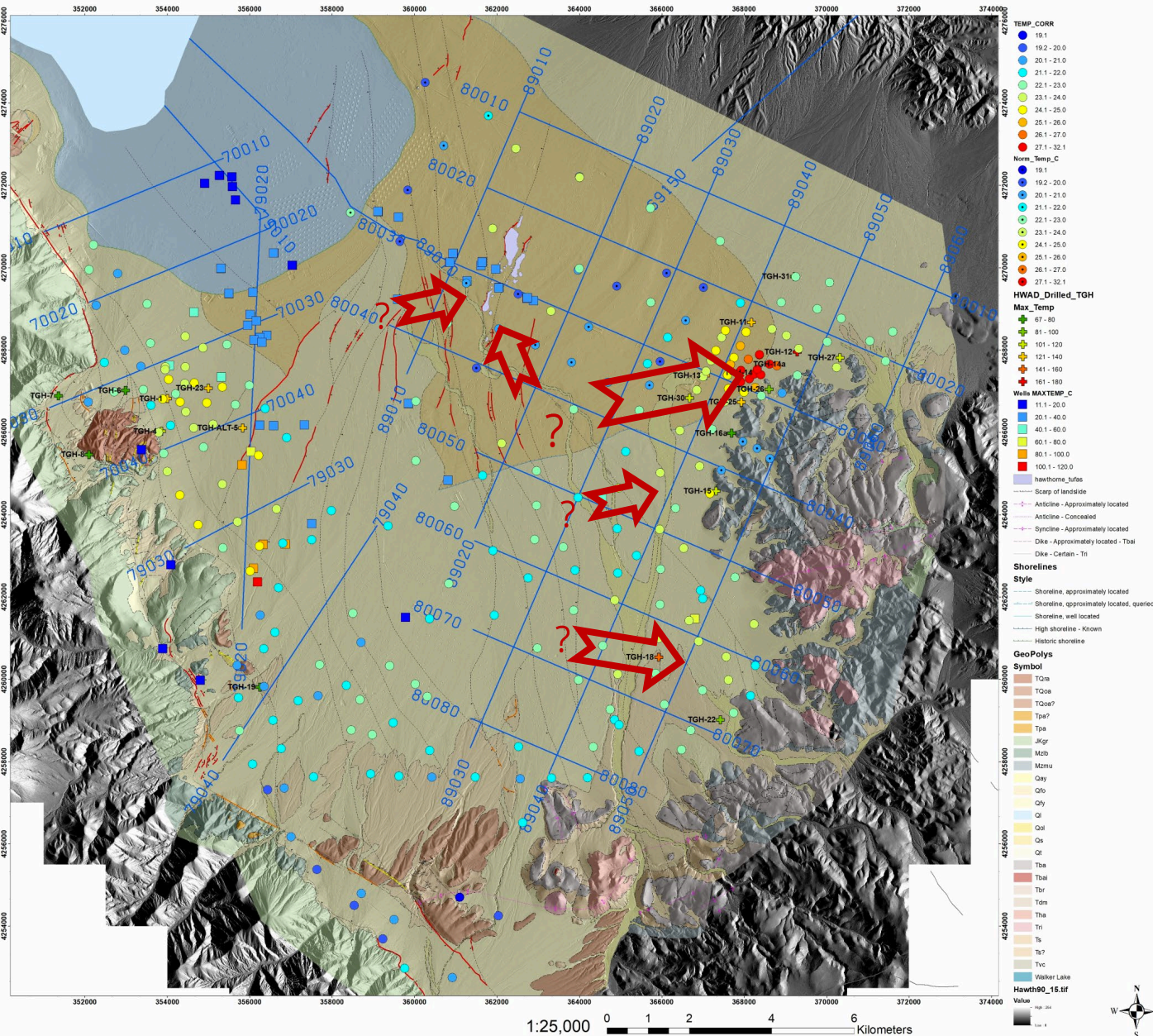
- Drilling temperature-gradient (TG) holes is a cost-effective way to interrogate/confirm thermal resources
- Typical 150 m holes, however, are insufficient here
- Need to explore in the deeper margins of the basin
- Targeting 300 m deep TG holes, exact locations and number of holes to be drilled currently under review



Risk/uncertainty is higher on the NW side of the prospect where we have considerably less thermal data and few well constraints

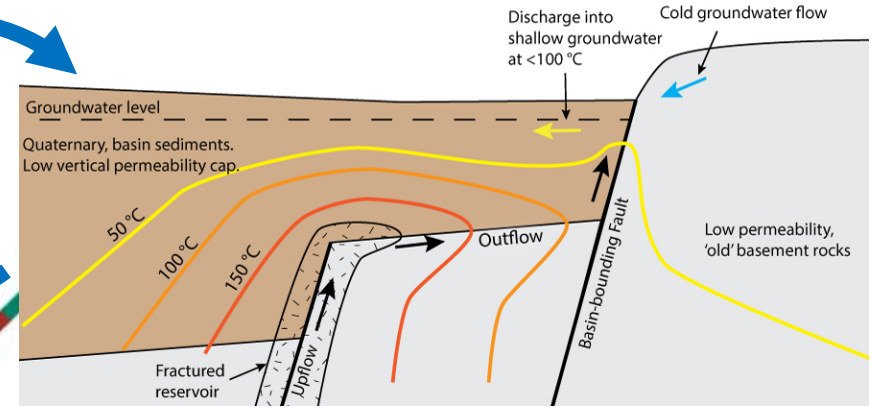
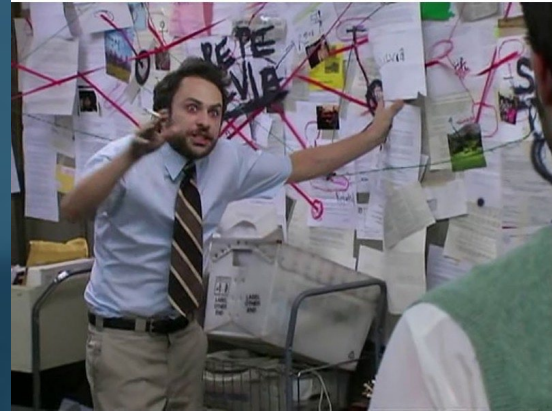
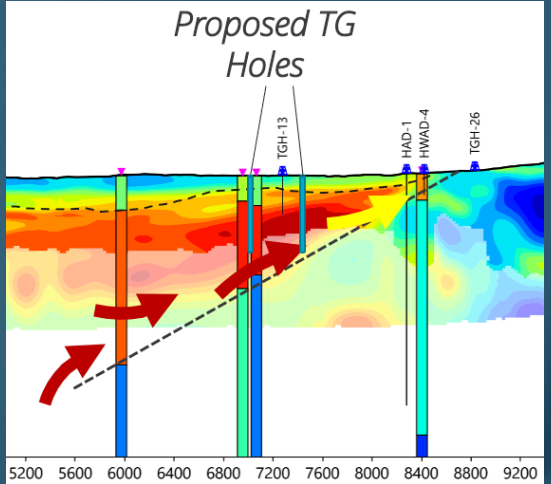


Synthesizing Information and Exploring in 3D



- Seeing evidence of outflow that may be indicative of hydrothermal resource(s!) from a few possible directions, likely will spread out TGH holes.
- Integrating geologic and structural mapping (USGS GeoDAWN project released 1-m resolution LiDAR this year!) w/ 2-meter temperature data.

What can we expect for HAD as a geothermal prospect?



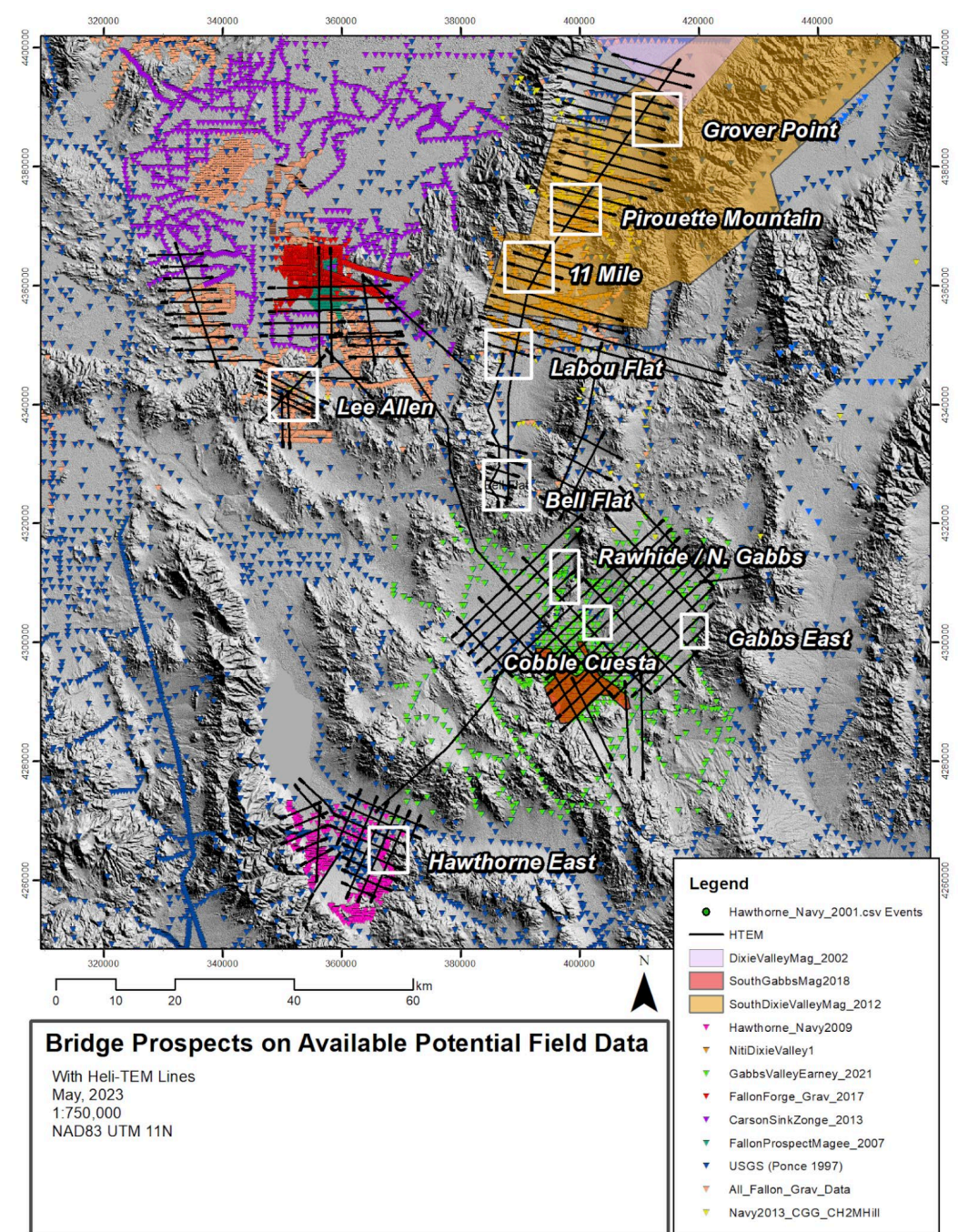
- ❑ Use improved temperature data & geologic structure context to develop a conceptual model
- ❑ Best case: conceptual modeling & probability of success analysis indicates a viable temperature resource, in which case we target and drill a slim hole to test reservoir heat & permeability parameters
- ❑ Otherwise, at some juncture, we walk away in favor of pursuing other DoD/BLM priorities
- ❑ It's an iterative, multi-disciplinary process with many decision points along the way!



Zooming Out – More Geophysics Data & Opportunities

Gravity & magnetism inform structural and hydrothermal system interpretations!

- Hawthorne, Lee Allen and Pirouette Mountain have adequate gravity data for exploration-scale analysis.
- Dixie Valley projects have excellent magnetic data coverage.
- Next objective is to re-process/ re-grid available data over each prospect.
- Then we can identify the best AOI's for gravity in-fill by BRIDGE project.





BRIDGE Project – Expected Outcomes

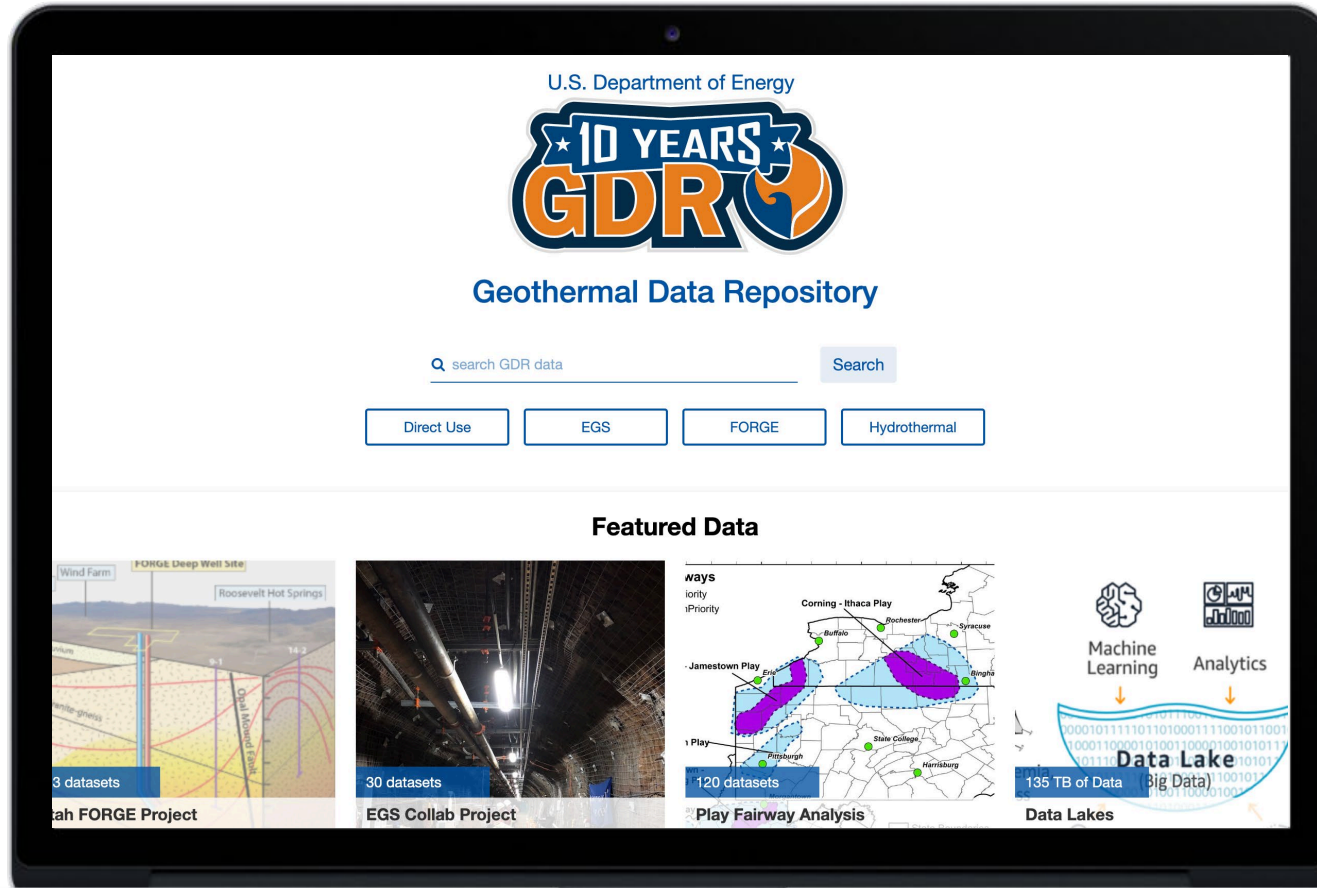


- ❑ Demonstrate utility of airborne and surface methods to identify hidden geothermal prospects
- ❑ Develop and demonstrate exploration methodology for identifying and characterizing hidden systems
- ❑ Develop and demonstrate system for ranking hidden geothermal systems
- ❑ Assessment & demonstration of tech to reduce slim hole drilling cost (if feasible)
- ❑ Development and application of joint inversion (HTEM/MT)
- ❑ Drill verification and testing of resource
- ❑ Development of a hidden geothermal prospect portfolio within the study area
- ❑ Final conceptual models and resource capacity estimates (MWe potential) for a hidden system, including recommended next steps in exploration
- ❑ Integration with contemporary studies (e.g., Earth MRI, INGENIOUS) & stakeholders (e.g., power plants, DoD)
- ❑ Delivery of a hidden systems playbook entry and contribute data to the Geothermal Data Repository
- ❑ ***Reduced risk, increased success for hidden geothermal system exploration and development***





BRIDGE data will also be made publicly available!



<https://gdr.openei.org/>





Acknowledgements & References

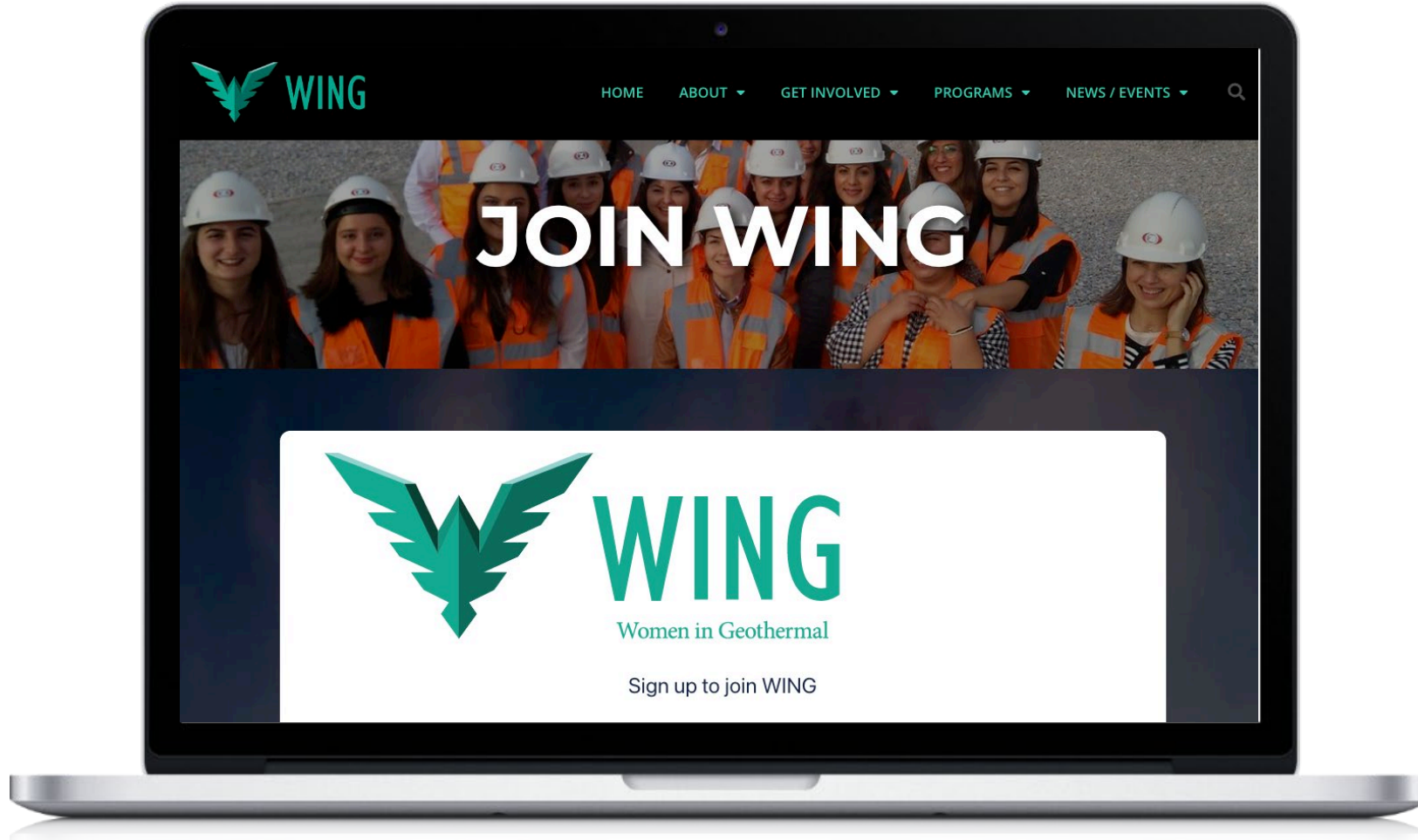
Acknowledgements Access to Public Lands is authorized in coordination with representatives of the United States Bureau of Land Management. Access to DOD Lands and Airspace is authorized in coordination with representatives of the Navy GPO, NAS Fallon, and HAD – BRIDGE appreciates the support and cooperation of Brandon Sorensen (NAS Fallon), Gregory Jacobs (HAD), and their teams to execute this work. The authors are also grateful to the Xcalibur, Heli Carrier, and Entharpion crews for coordinating and conducting the HTEM and MT surveys safely and effectively.

References Available upon request – pcschwe@sandia.gov. More info and references on the project may be found in the Geothermal Rising Conference Transactions, Vol. 46, 2022: [The BRIDGE Project – Hidden Systems Reconnaissance in Western Nevada](#) by Schwering et al.



Quick Plug: It's time to join Women In Geothermal (WING)!

<https://womeningeothermal.org/>



Thank you for your attention!

Questions & discussion welcome

#thegeothermalgoodlife



Join
WING!

"10,000 foot view" BRIDGE
study area



GDR!

Thank You!



Get the hottest geothermal news from *The Drill Down*, GTO's monthly newsletter!

Sign up today:

geothermal.energy.gov

Interested in serving as a **merit reviewer** for GTO RD&D projects?

Send us your resume or CV:

doe.geothermal@ee.doe.gov

Questions?

The **Geothermal Technologies Office (GTO)** works to reduce the cost and risk associated with geothermal development by supporting innovative technologies that address key exploration and operational challenges.

Visit our * **UPDATED** * website at: energy.gov/eere/geothermal or by scanning the QR code.

