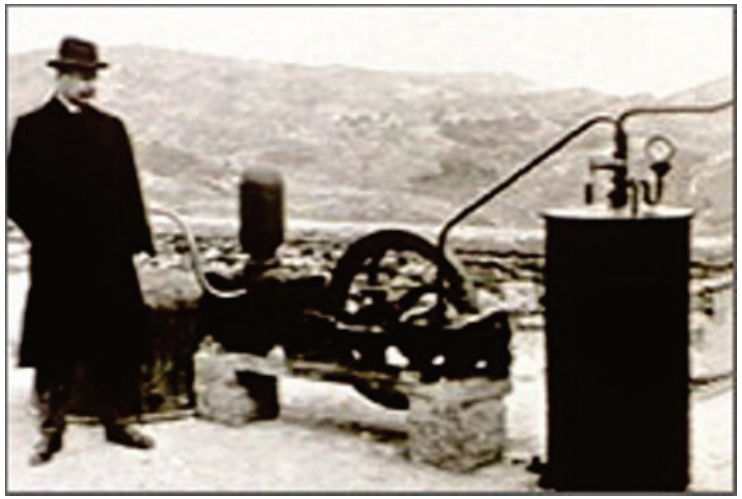
NAVOPACHE ELECTRIC COOPERATIVE

Developing An EGS Resource In East-Central Arizona



Geothermal Resources Council Webinar

December 9, 2009

Dennis W. Hughes

Chief Operating Officer – Navopache Electric Cooperative

PAN AMERICAN ENERGY CORPORATION

Los Alamos, New Mexico

50 MW ELECTRICAL GENERATING FACILITY
FUELED FROM HOT DRY ROCK GEOTHERMAL HEAT
IN APACHE COUNTY, ARIZONA

Post Office Box 1118
Los Alamos NM 87544

1

APPLICATION FOR GRANT

HAND DELIVERED TO
U. S. DEPT. OF ENERGY
OAKLAND, CA.

AUGUST 4, 1986

R F P NO: DE - RP03 - 86SF16385

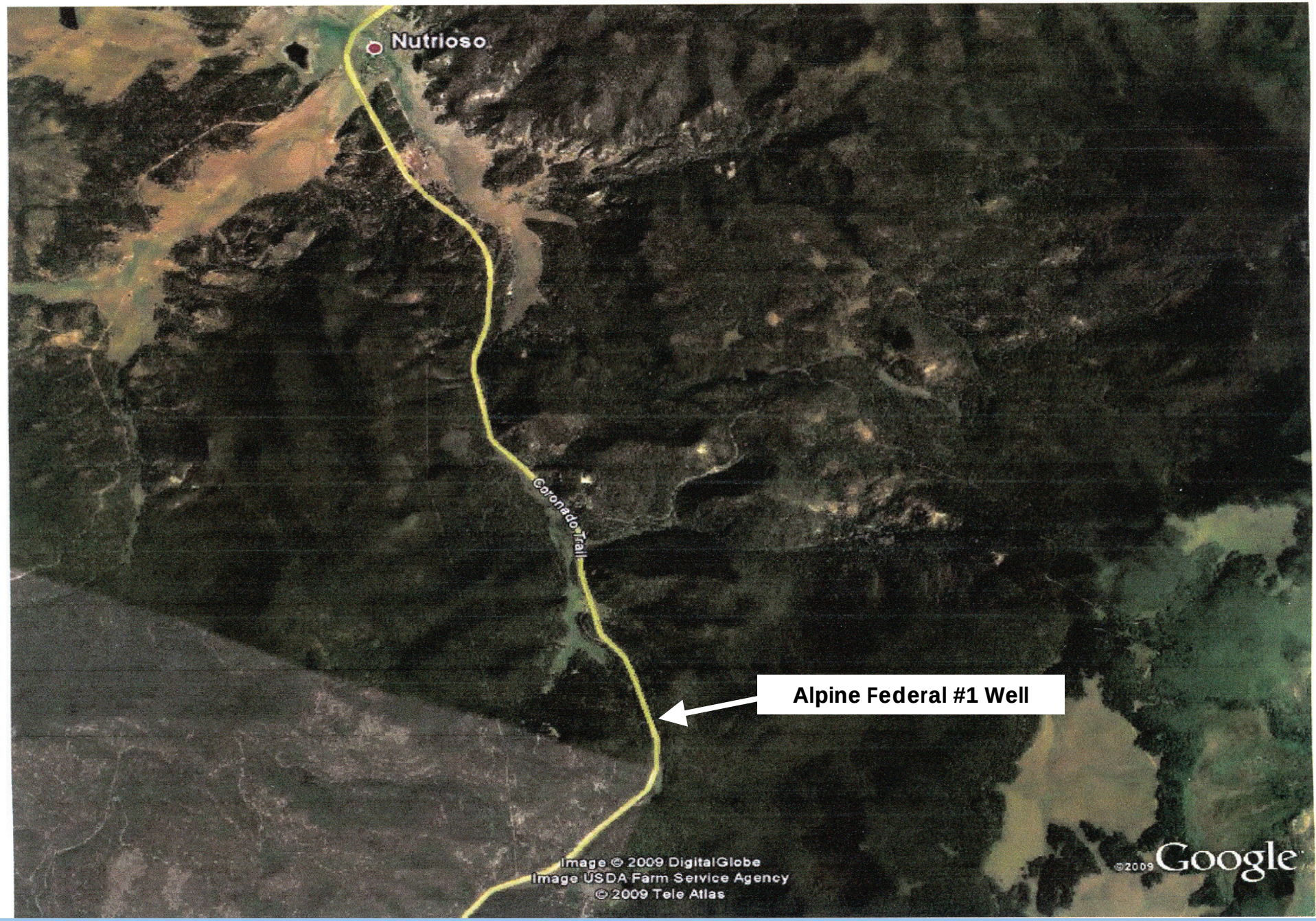
Four Sections

VOLUME 1 - OFFER AND OTHER DOCUMENTS
VOLUME 11 - TECHNICAL PROPOSAL
VOLUME 111- COST PROPOSAL
VOLUME IV - BUSINESS MANAGEMENT

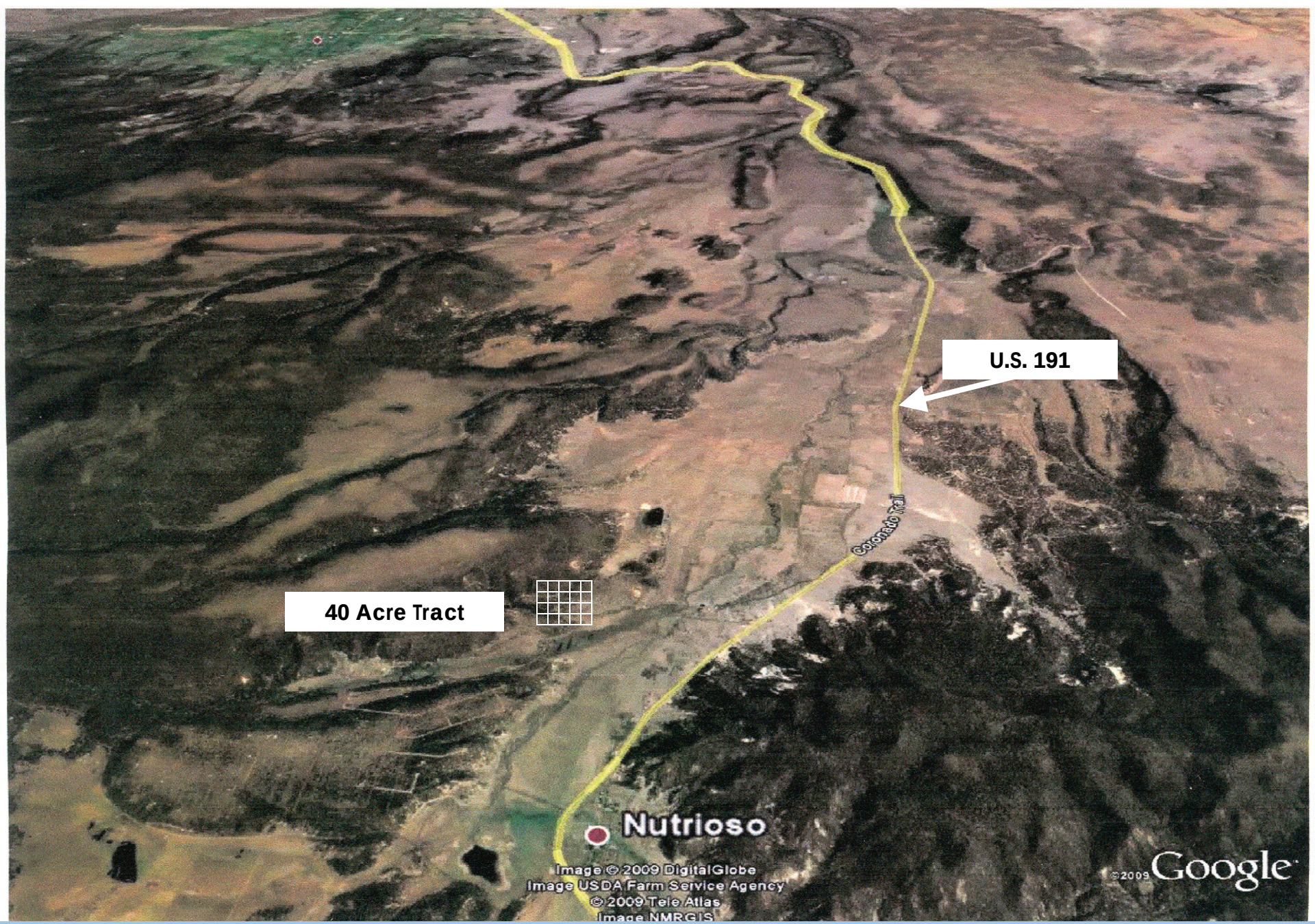
2

The NEC Project Began Over 20 Years Ago

Project Location



Project Location



Project Location

NEC has both a 69kv transmission line and a distribution line traversing the property where the project will be located.

The project will not be visible to the general public from any road in the area.

Project area in general – the Nutrioso Valley – Apache County, Arizona

Residents trying to halt geothermo construction

By JOE ZUKOWSKI
Independent Staff

NUTRIOSO — Seventy-eight residents from here have signed a petition to halt the proposed construction of a geothermo power plant near Nutrioso on grounds that such a plant would "spoil the beauty" of the area as well as adversely affect land values and the environment.

A recently formed 10n-member committee, of which town residents Glenn and Jeanne Goodwin and Ken and Linda Martin are a part, have circulated the petition and anticipate more of the town's 133 total registered voters will sign the document.

Their effort is aimed at preventing the construction start, scheduled for December, of a 50-megawatt power plant by a Los Alamos, N.M. firm.

"Part of the problem is that we don't know what the impact of this plant will be," said Glenn Goodwin, a retired National Aeronautics and Space Administration (NASA) engineer. He said he was concerned about noise, possible pollution, and extensive water use by the plant, as outlined in the petition.

It reads: "We, the undersigned, are landowners and-or residents of Nutrioso and the surrounding area, and we hereby protest the proposed geothermo project in our area.

"This is a ranching and residential area and we feel the impact of any such project would not only spoil the beauty of, but also adversely affect land values, the water supply, and the air we breathe, in this beautiful valley.

"Many of us have chosen this area for our retirement years and we are fearful of the consequences that would inevitably follow this proposed project."

Although no figures on size for the proposed Nutrioso plant have been released, a "hot dry rock" (HDR) facility at Fenton Hill, in the Jemez Mountains of northern New Mexico, covers an area of 20 acres.

Nutrioso's will be an HDR plant.

This type system does not utilize steam or hot salt water (the fuel of traditional geothermal plants) but instead uses water heated by 400-degree F granite to heat iso-butane. Pressurized butane gas then goes through a turbine-generator to produce electricity.

"There will be large quantities of butane in the area," said Goodwin. "If something ruptures and there's a fire up there, it'll burn the forest up."

Kaufman and Associates, the Los Alamos firm behind the project, will oversee the drilling of a 3,200-foot well on a bluff west of U.S. Highway 180, less than two miles north of Nutrioso.

Scheduled for December, the hole will be drilled in hopes of discovering granite with a temperature range of 400 degrees Fahrenheit.

If that happens, experts will then detonate an explosive charge to shatter the granite at the bottom of the hole to create an underground "hydraulic fracture."

Water would be forced down into the fracture, would heat up and would return to the surface through a second hole drilled down into the shattered region.

It would then be piped through a chamber called a heat exchanger, containing iso-butane. Hot water pipes in the chamber would heat the butane to a temperature equal that of the water, sending hot liquid butane to a flasher.

See GEOTHERMO, Page 12

GEOTHERMO

From Page 1

Vaporized and under strong pressure, the butane would then pass through piping to a generator-linked turbine, to produce electricity.

As the hot water reentered the ground, and the heat-extraction loop, the iso-butane vapor would cool in a "dry cooling tower" before going back to the heat exchanger.

Six holes drilled into the ground will accommodate the Nutrioso plant.

Interest in the area is keen due to a certain type of geothermal gradient existing around Nutrioso that is similar to that of the Fenton Hill area of New Mexico. A geothermal gradient is the rate at which temperature increases with depth.

And, according to officials of Navopache Electric Co-Operative Inc., who will share involvement in the plant with Kaufman and Associates, the Nutrioso project will be the world's first geothermo plant.

In effect, the 50-million watt Nutrioso plant, if constructed, will succeed Fenton Hill, largely an experimental, pioneering hot dry rock site, the highest output of which has been 35 million watts.

In a 1982 article printed in Mini-Review, a publication of the Los Alamos National Laboratory, where 15 years of geothermal research have been conducted, Morton C. Smith wrote: "Additional large-scale experiments are needed in a variety of locations and geologies before the widespread usefulness of HDR energy systems will have been convincingly demonstrated."

He also wrote in the same article, that "if these experiments are successful, they will make available..." an "energy supply that is environmentally benign...."

However, in a publication entitled "Environmental Analysis of the Fenton Hill Hot Dry Rock Geothermal Test Site," published in 1979 and compiled and edited by E. L. Kaufman, one paragaph stated: "the geothermal site (in New Mexico) is situated near major drainages...that...contribute water supplies to several small towns and villges. Any effects on these surface waters must be documented and potential relationship to the project's operation examined. In addition to the surface water problems, the potential exists for pollution to aquifers because of the nature of the experiments."

If constructed, the Nutrioso plant, which will be financed by a consortium of foreign investors, is expected to be on line in four years. Also, if the Nutrioso plant is successful, a second plant may be in the offing.

Both Glenn Goodwin and Ken Martin planned to take their protest against the proposed plant to Rep. Jim Kolbe, R-Ariz., at the congressman's town hall meeting in Alpine on Monday.

Both admit they can't tie studies or reports on other geothermo facilities to a proposed Nutrioso plant. But, with December only four months away, and with information such as an environmental impact statement unavailable to them (both said they have written letters and made phone calls requesting such information), they are obtaining and perusing information on other plants to learn something about what may be a $125 million facility near Nutrioso.

"Until such time as they publish something for this area, on this project, it means that we don't have any concrete evidence to support (our cause)," said Martin.

"We're using studies of other plants to raise questions about the proposed plant," said Goodwin, once an engineer at California's Ames Research Center and energy consultant to three Arizona governors.

At a recent meeting in Nutrioso to discuss the communities' small television system, for which only a handful of residents usually show up, between 40 and 50 people from Nutrioso gathered, said Linda Martin.

"Everyone knew we were going to talk about the plant," she said, adding that it was at the meeting that several people signed the petition.

She said that most people she's asked have already signed it.

"Of those that didn't, two people said they would like to find out more about it."

Community Impact

Alpine Federal # 1 Well - 1993

Form 3260-5
(formerly 9-1958)
(June 1988)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

GEOTHERMAL SUNDRY NOTICE

FORM APPROVED
OMB NO. 1004-0132
Expires: September 30, 1990

The Bureau of Land Management (BLM) requests this form or other BLM-approved forms to be prepared and filed in **triplicate** with requisite attachments with the authorized officer. The authorized officer must approve this permit prior to any lease operations.

1a. Well Type: ☐ Production ☐ Injection ☐ Heat Exchange ☒ Observation ☐ Other

1b. Well Status: Completion as a temporary observation well

2. Name of Lessee/Operator
Tonto Drilling Services, Inc.

3. Address of Lessee/Operator
2200 South 4000 West, Salt Lake City, UT 84120

4. Location of Well or Facility 35-23 surface 35-23 TD
Ground Elevation 8555.6
T6N, R30E, SEC 23 1153 WL 2122SL

6. Lease Serial No.
N/A

7. Surface Manager: ☐ BLM ☒ FS ☐ Other

8. Unit Agreement Name
N/A

9. Well No.
Alpine #1

10. Permit No.
N/A

11. Field or Area
Alpine

12. Sec., T., R., B. & M.
Sec 23, T6N, R30E

13. County
Apache

14. State
Arizona

5. Type of Work
☒ Change Plans
☐ Site and Road Construction
☐ Construct New Production Facilities
☐ Alter Existing Production Facilities
☐ Convert to Injection
☐ Fracture Test
☐ Shoot or Acidize
☐ Repair Well
☐ Pull or Alter Casing
☐ Multiple Complete
☐ Abandon
☐ Other

15. Describe Proposed Operations *(Use this space for well activities only. See instructions for current well conditions on reverse)*

(1) At 3,369 feet the HQ rods were differentially stuck (Attachment A, B)
(2) The HQ rods were cemented from 2500 to 3369 feet (Attachment B)
(3) From 3369 feet to total depth (4505 feet) the borehole is NQ size (see Attachment B)
(4) HQ rods from surface to 2500 feet were retrieved (see Attachment B)
(5) A bottom-capped NQ string was inserted into the borehole from the surface to 4505 feet (T.D.) as a temporary observation completion (see Attachment B)
(6) Install a secure temporary well head for geophysical logging.

Attachment A - monthly drilling reports for July and August
Attachment B - diagram of temporary observation well completion

16. Describe Proposed Operations *(Use this space for all activities other than well work)*

N/A

17. I hereby certify that the foregoing is true and correct

Signed _____ Title VICE PRESIDENT & GENERAL MANAGER Date 4/17/93

(This space for Federal use)

Approved by _____ Title _____ Date _____
Conditions of Approval, if any:

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

(Instructions on reverse)

BOTTOM-HOLE TEMPERATURE

Depth (feet)	Temperature (F)
2996	128
3077	136
3114	124
3166	137
3207	131
3276	132
3326	134
3459	128
3515	125
3555	125
3605	130
3655	137
3705	136
3755	124
3805	134
3855	134
3905	149
3955	153
4005	155
4055	158
4105	159
4145	152
4205	155
4255	158
4304	160
4355	163
4405	163
4445	166
4505	164

RETURN MUD TEMPERATURE AT SURFACE

Depth (feet)	Temperature (F)
3209	80
3338	74
3348	81
3392	72
3565	66
3655	65
3845	65
4055	69
4185	67
4474	62
4505	58

Original Drilling Log from the Alpine Federal #1 Well

Navopache and Mohave Electric Cooperatives

Enhanced Geothermal Systems (EGS) Evaluation

FINAL REPORT
B&V Project Number 161412.0010

April 2009

JOINTLY PERFORMED BY:

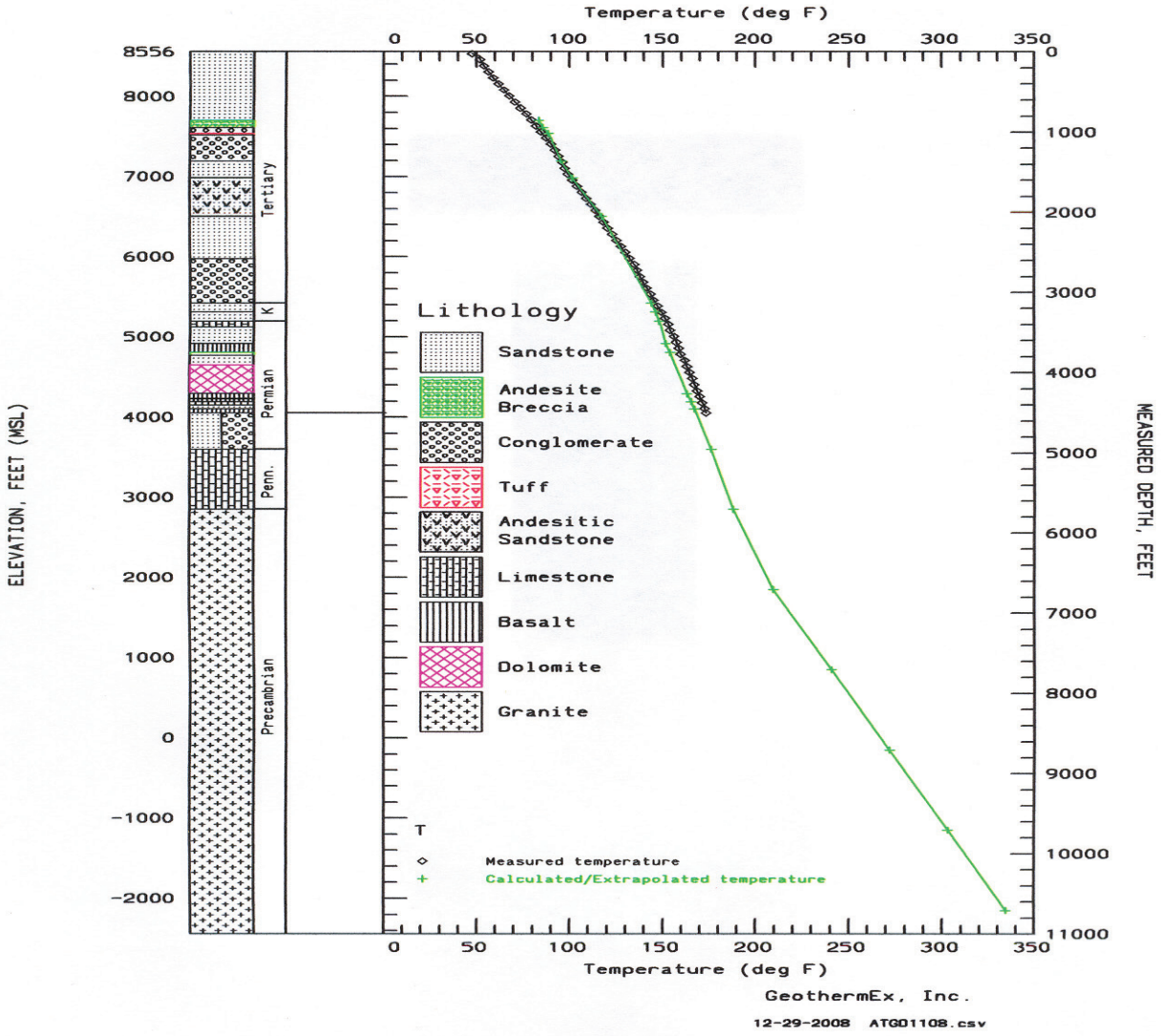
BLACK & VEATCH
Building a world of difference.

Black & Veatch Corporation
2999 Oak Road, #490
Walnut Creek, CA 94529
Tel: (913) 458-2000 www.bv.com

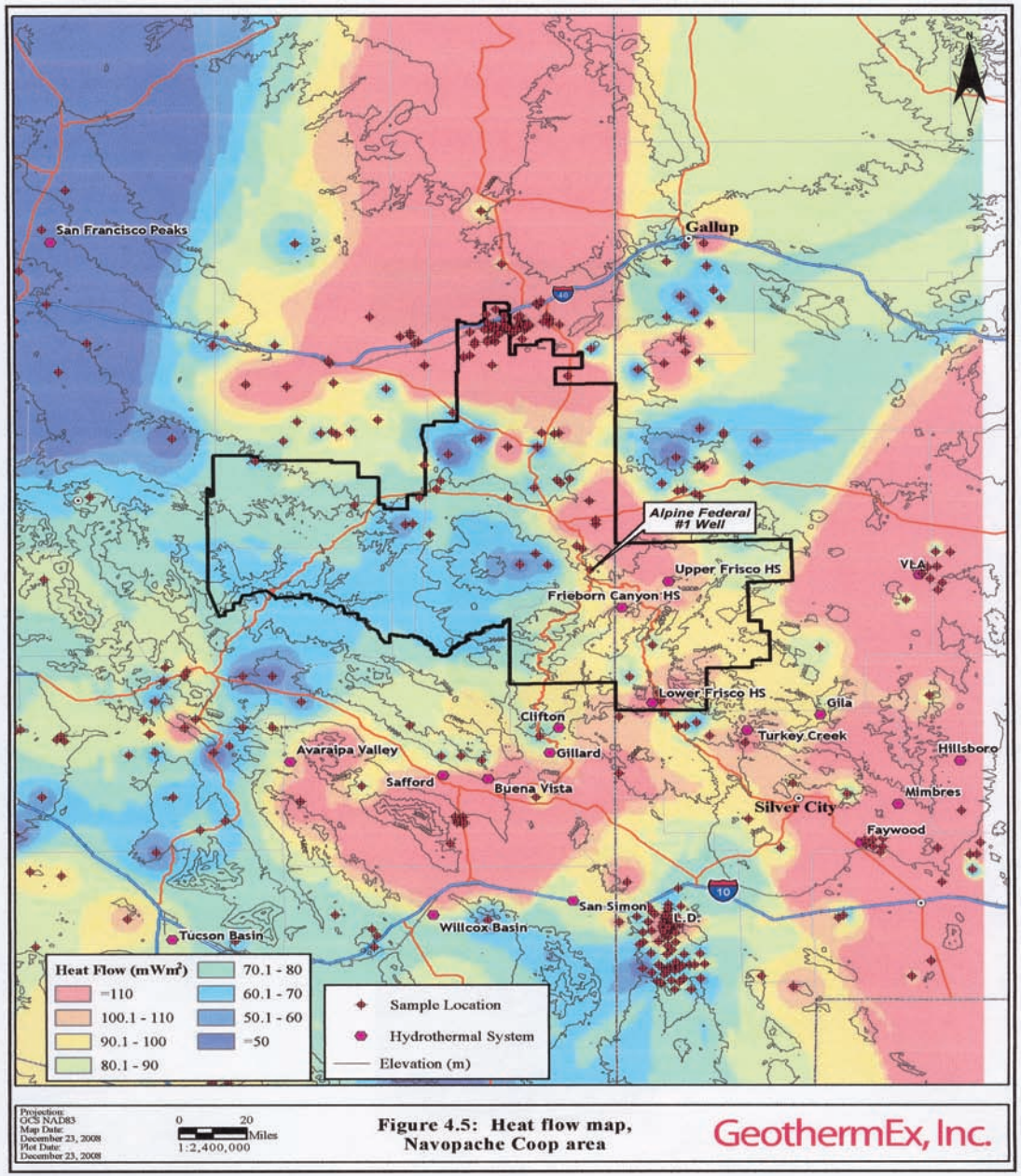
GeothermEx, Inc.
3260 BLUME DRIVE, SUITE 220
RICHMOND, CALIFORNIA 94806

NEC Engaged Black & Veatch to perform a Feasibility Study before moving forward to consider a Project

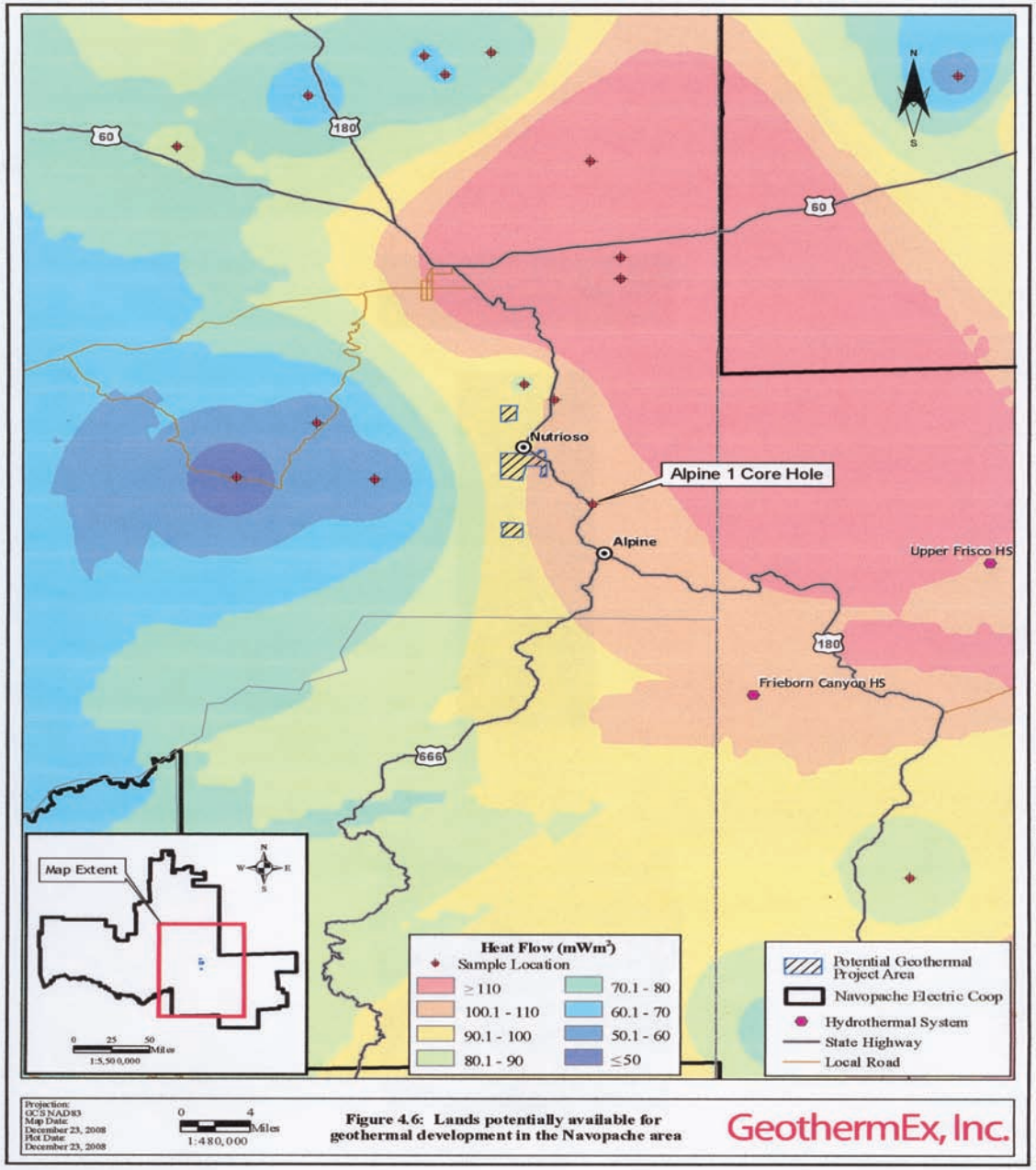
Figure 4.7: Measured and extrapolated temperature data
Alpine 1 core hole



The Feasibility Study extrapolated temperature data from the original Alpine 1 Core Hole to indicate a temperature of 350 Degrees Fahrenheit likely at a depth of +10,000 feet.



GeothermEx developed a heat flow map of the NEC Service Territory, based on their research and the existing historical data available.



Zooming in on the Alpine Federal #1 Core Hole location, Nutrioso is situated in the same heat zone and affords the opportunity to site the project on private property.

Table 6.2: Estimated Budget and Time Requirements for Small (~5 MW) EGS Development

Exploration

Activity	Estimated Cost (K $)	Time Required (months)	Comments
Literature Search	20	2	Undertaken concurrently
Compliation of temperature data	20	2	
Evaluation of geologic and stress data	80	2	
Deep Temperature Gradient Drilling	1,200	6	Assumes 2-3 holes at $300 - $500K each; deeper than gradient holes for conventional geothermal projects; may not be needed if sufficient data are available from other sources
Feasibility Assessment	100	4	
Totals:	1,420	12	

Development (Wellfield Only)

Activity	Estimated Cost (K $)	Time Required (months)	Comments
Permitting / Planning	200	6	
Drill, core and log first well and undertake pre-stimulation injection test	7,000	3	Assumes well depth of 10,000 - 12,000 feet
Determine mechanical properties of cores, evaluate logs and plan stimulation of first well	150	3	Concurrent with next task
Set up seismic monitoring network	300	3	Concurrent with previous task
Stimulate first well and undertake post-stimulation injection test	1,000	1	After moving rig off
Evaluate stimulation and seismic monitoring data; site second well	250	2	Go / No-Go decision point (if Go, then begin power plant design)

GeothermEx, Inc. 2008

Project cost estimates from the feasibility study.

Activity	Estimated Cost (K$)	Time Required (months)	Comments
Drill, core and log second well and undertake injection test	7,000	3	
Evaluate logs and plan stimulation of second well (if needed)	100	1	
Stimulate second well (if needed) and undertake post-stimulation injection test	500	1	
Undertake circulation and tracer test between the two wells	400	2	
Evaluate stimulation, testing and seismic monitoring data; site third well	150	1	Go / No-Go decision point (if Go, then begin power plant construction)
Drill, core and log third well and undertake injection test	7,000	3	
Evaluate logs and plan stimulation of third well (if needed)	100	1	
Stimulate third well (if needed) and undertake post-stimulation injection test	500	1	
Undertake circulation and tracer test between the three wells	400	2	
Evaluation and modeling	300	3	
Totals:	**25,350**	**33**	

Optional task

GeothermEx, Inc. 2008

Project cost estimates from the feasibility study.

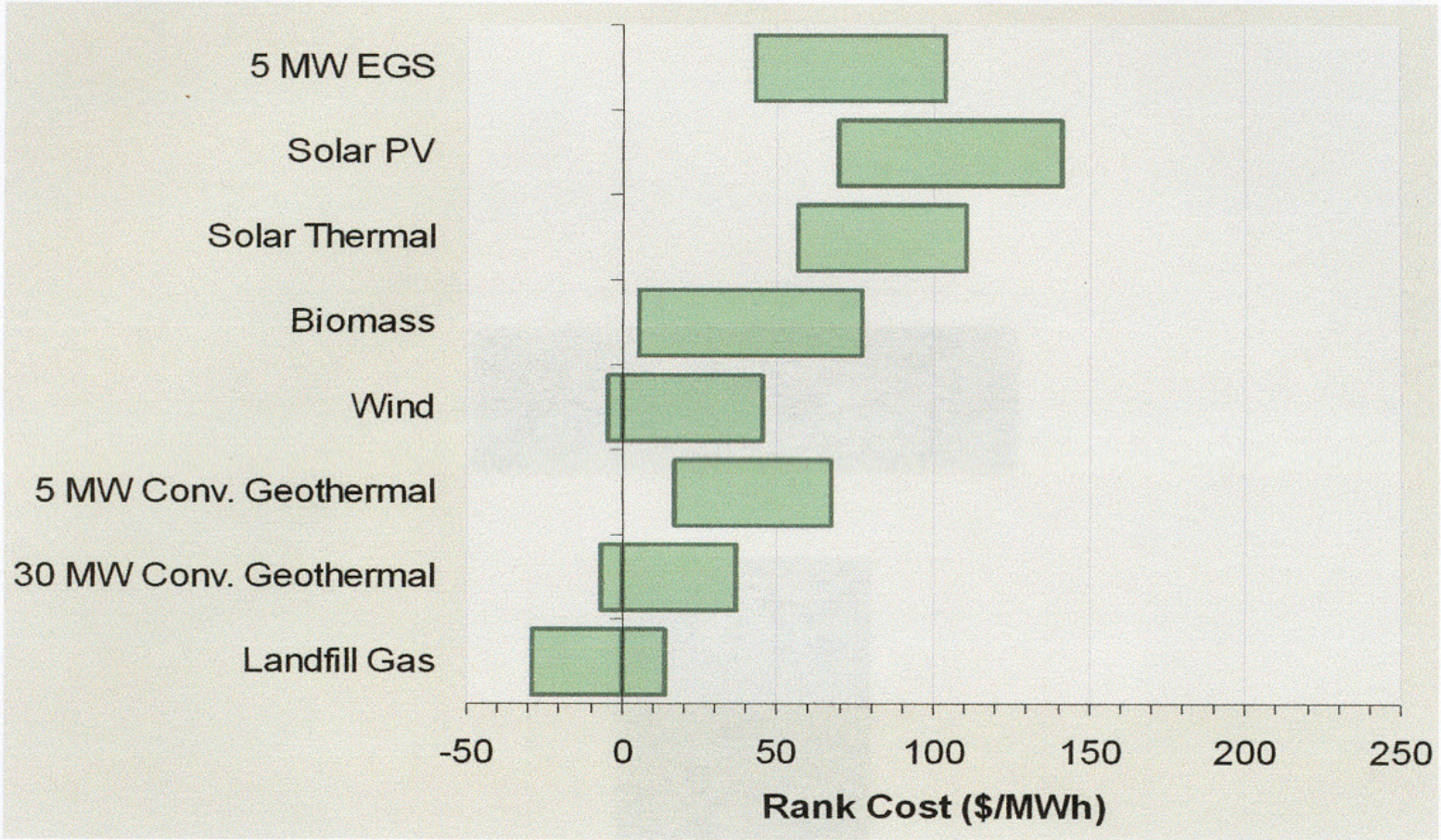


Figure 8-3. Arizona Renewable Net Cost Projection

EGS as a renewable energy option.

EGS has some potential advantages over other technologies which makes its consideration promising. It is much less location constrained than conventional geothermal since the primary requirement for EGS is the presence of a useful temperature. Unlike conventional geothermal, EGS is broadly applicable to many areas in the United States and could become a prominent renewable energy technology once developed and proven on a large scale. There will likely be Department of Energy (DOE) funding opportunities at the exploration stage to further EGS development and share risk. Finally, the resource is base load and can more reliably meet the demand needs of the utility.

8.4 Conclusions and Recommendations

The conclusion of this study by Black & Veatch and GeothermEx is that EGS is a viable option within the Navopache and Mohave service territories on a technical and economic basis. Both service territories contain moderate to good geothermal resource with heat flow rates that are similar to other successful EGS pilot projects. The technical feasibility of an EGS facility at these temperatures has recently been demonstrated in a recent project in Germany. Although EGS is not the lowest cost renewable energy technology, it may be one of the better long-term options due to its potentially competitive cost at a small scale, base load generation profile and siting flexibility.

If the decision is made to pursue an EGS or a conventional geothermal project, the recommended next steps are to further evaluate specific sites for factors such as land availability, water availability, environmental and cultural issues, and technical potential. It would then be recommended that Navopache and Mohave partner with a small to medium size geothermal developer and jointly fund the higher risk exploration stage of a project. The partnership should engage the DOE to play a role in risk mitigation by providing funding assistance at this exploration stage.

"The conclusion of this study by Black & Veatch and GeothermEx is that EGS is a viable option within the Navopache and Mohave service territories on a technical and economic basis."

Conclusions & Recommendations from the feasibility study.

Thank You for the opportunity and for your attention.

C. MacEddy – NEC General Manager 1976-1989