CALPINE®
NYSE CPN

A GENERATION AHEAD, *today*

Calpine Corporation

NW Geysers
Enhanced Geothermal System
Demonstration Project

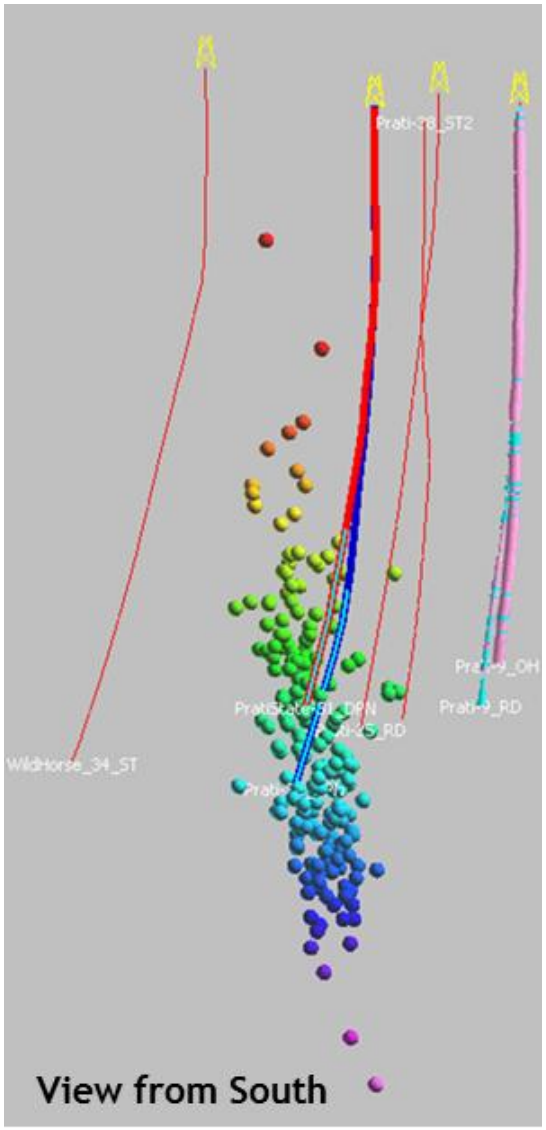
November 2, 2012

Community Update
Calpine Geysers Visitor Center
Middletown, CA

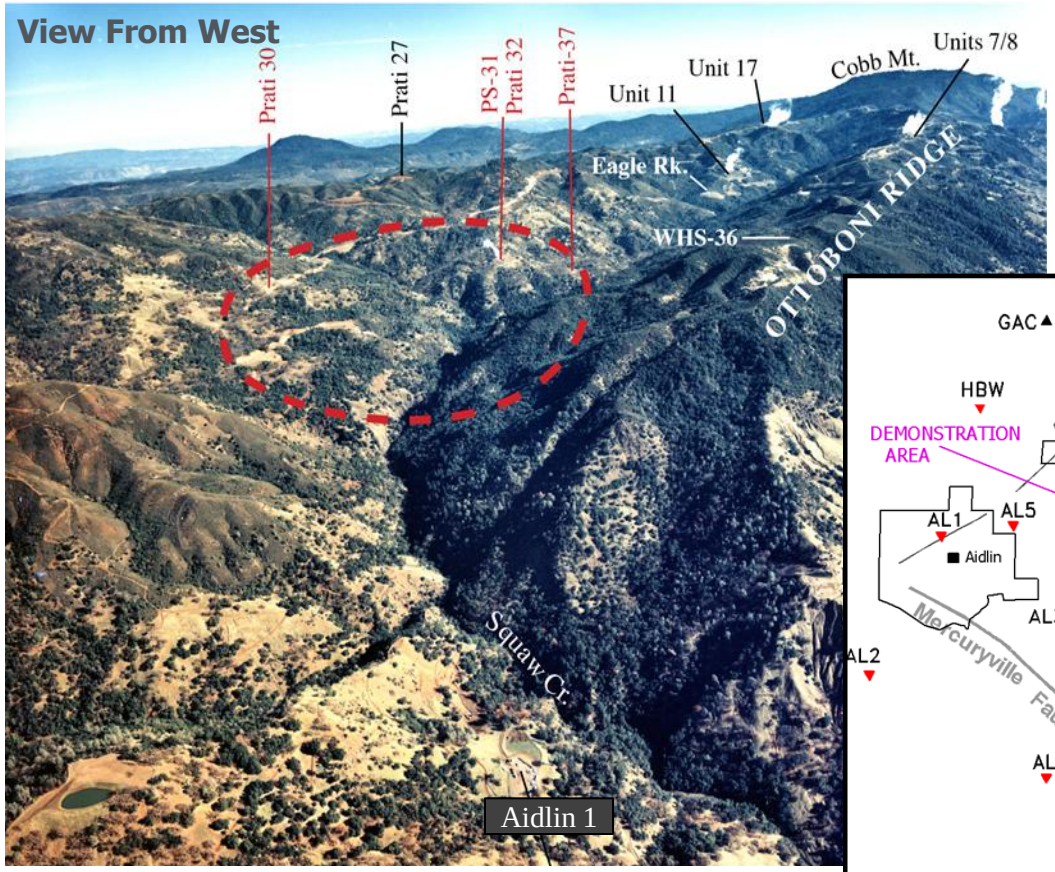
CLEAN MODERN EFFICIENT FLEXIBLE POWER GENERATION

Accomplishments, Results and Progress

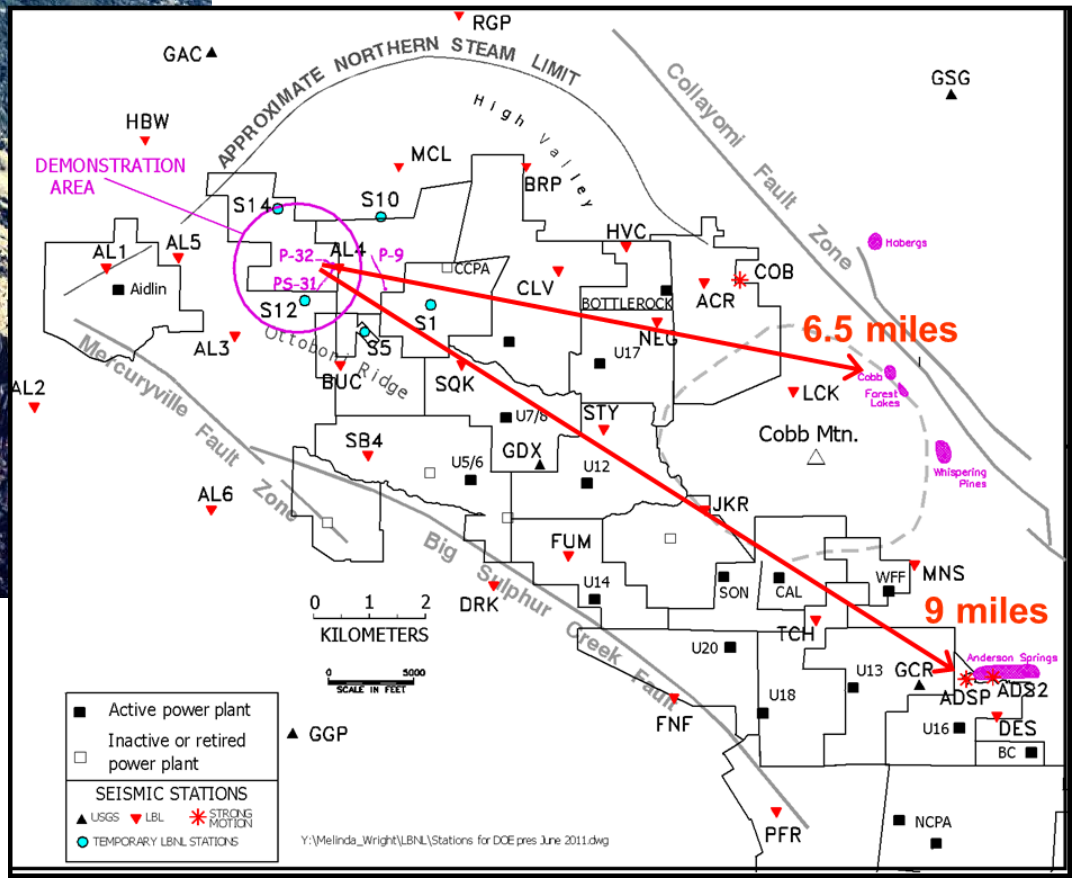
- Prati State 31 and Prati 32 were recompleted as a production-injection well pair in September 2011 (respectively).
- Injection into Prati 32 began on October 6, 2011 and has been continuously monitored.
- Continuous injection of water at rates of 400, 700 and 1000 gallons per minute into 750°F rock at a depth of 11,000 feet.
- A microseismicity "cloud" began to form almost immediately with the Prati 32 water injection.
- An Enhanced Geothermal System has been created in hot dry rock. The evidence for this comes from the analysis of:
  - Microseismicity data
  - Isotope data
  - Temperature data
  - Pressure data
  - Prati State 31 flow response
- A connection has been established between the deep, hot-dry rock reservoir and the overlying normal temperature reservoir.



Future Directions - Additional EGS Development Area

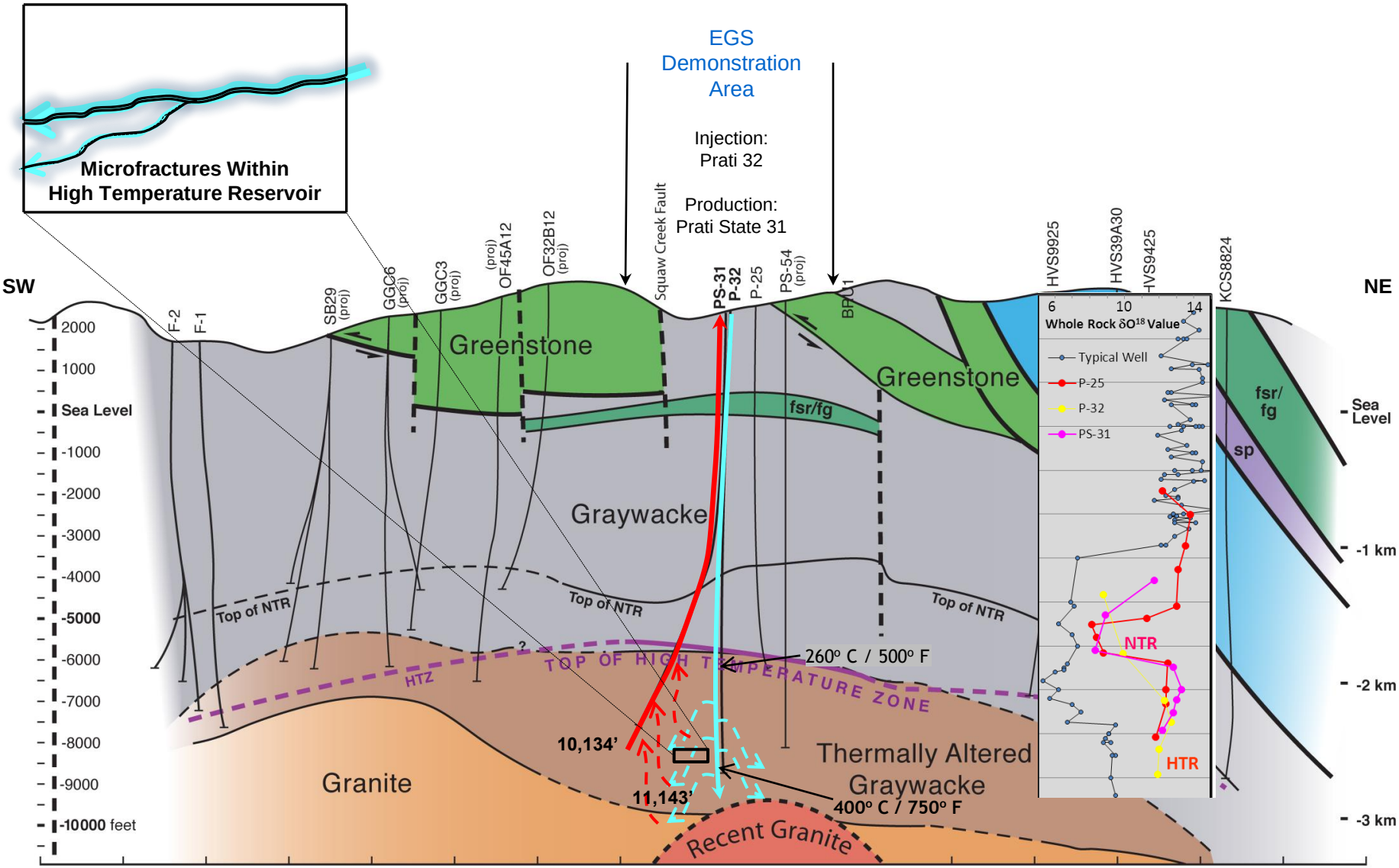


The undeveloped EGS Demonstration Area is 7 to 9 miles from the nearest sensitive communities.



There are approximately 1100 undeveloped acres in the vicinity of the EGS Demonstration Area which are underlain by a high-temperature, hot dry rock reservoir.

Scientific/Technical Approach



Prati 32 Deepening

Final Bit from Prati 32 (11,134’) after 100’ of drilling where Temperatures are 750 ^{o}F

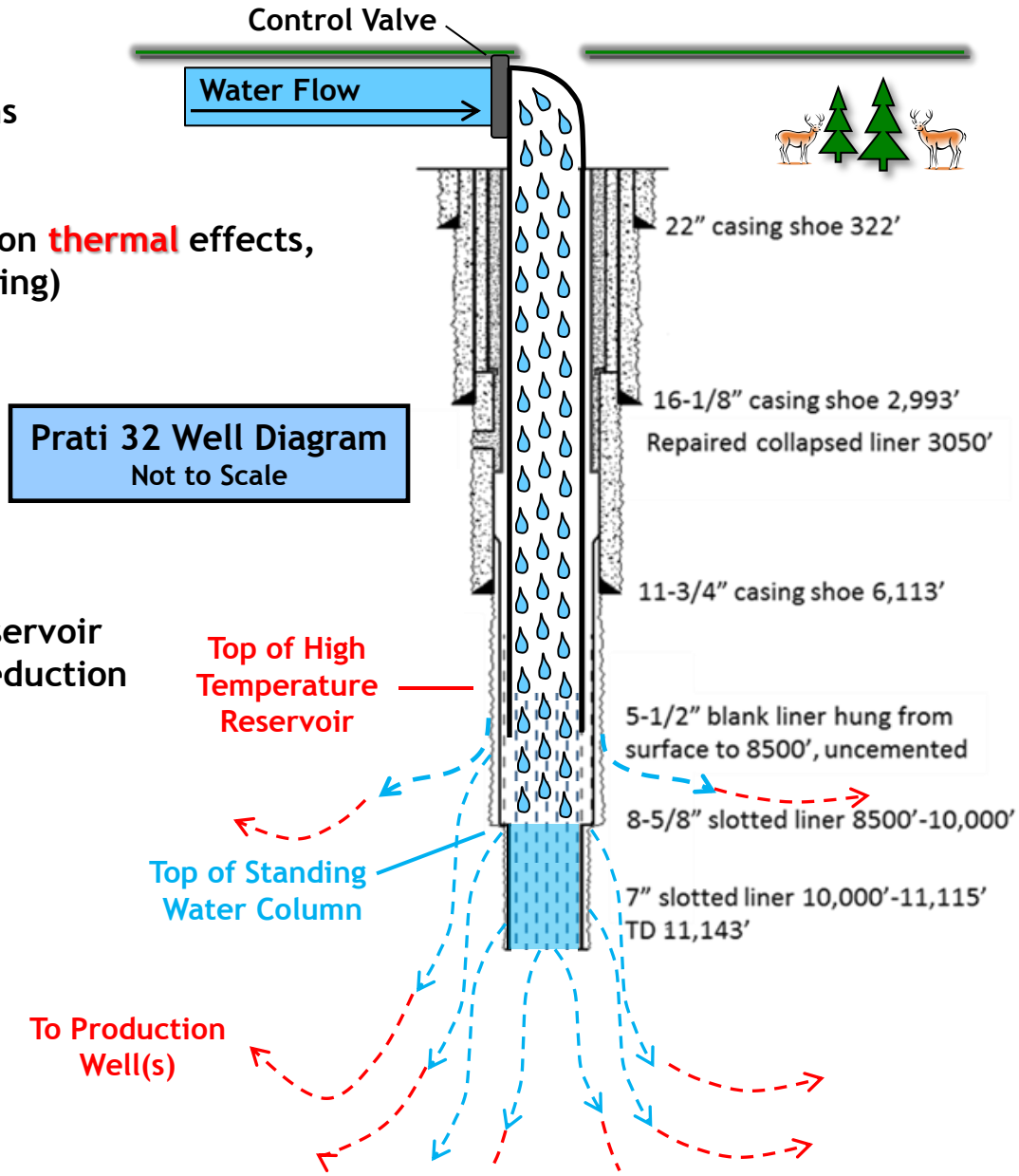
Average Bit Condition after 300’ of drilling at the Geysers where temperatures are 450 ^{o}F

Calpine
Northwest Geysers Enhanced Geothermal System Demonstration

Water "Injection" Under Vacuum

The NW Geysers EGS Demonstration Project is "injecting" water under vacuum conditions (as with all water injection at The Geysers)

Micro-fracture development relies primarily on **thermal** effects, not pressure effects (as used in hydrofracturing)

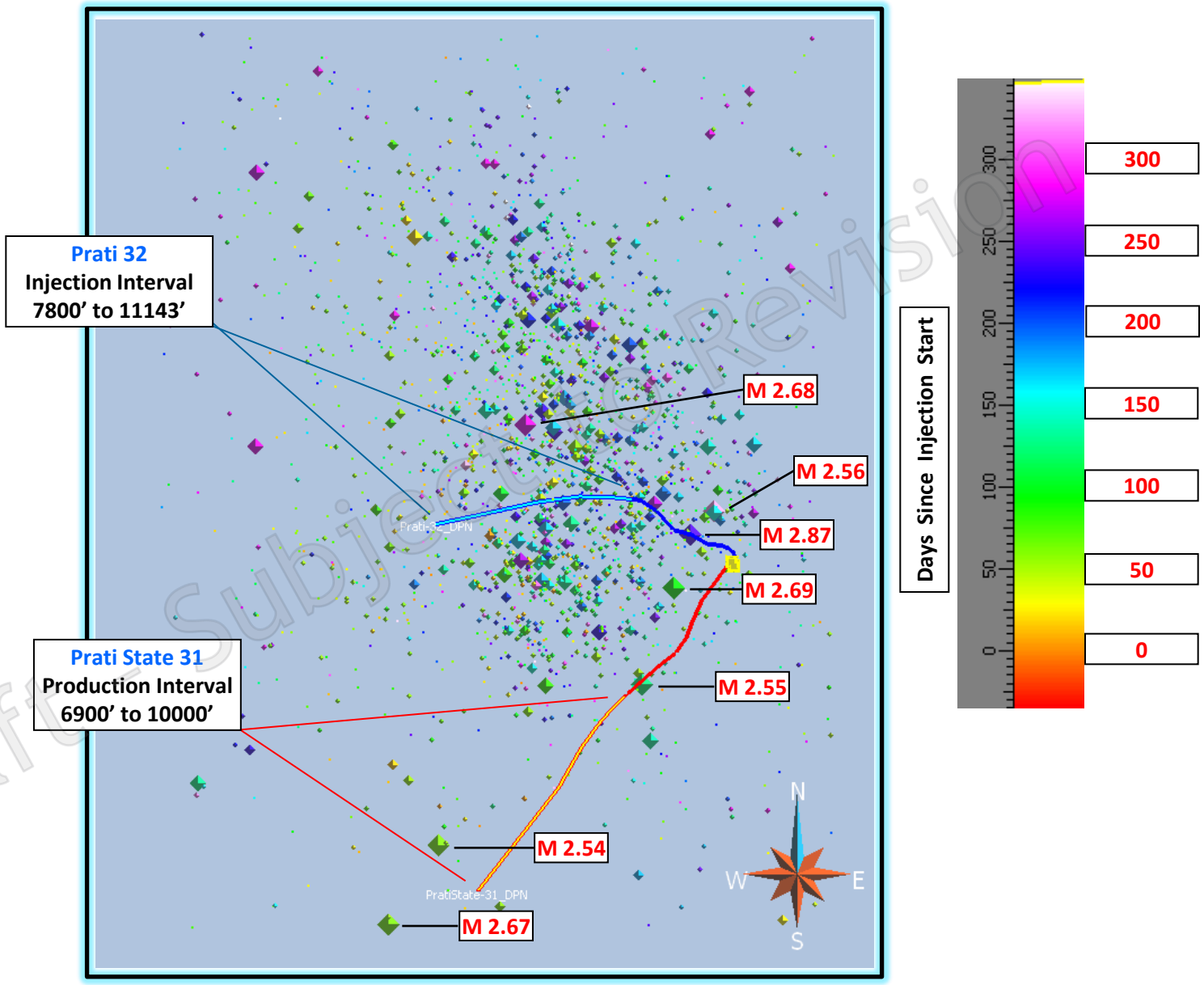


Why Vacuum Conditions?

Injection of cool water into the hot steam reservoir
Steam condenses with a significant volume reduction
Results in vacuum conditions
Injected water "drawn" into reservoir

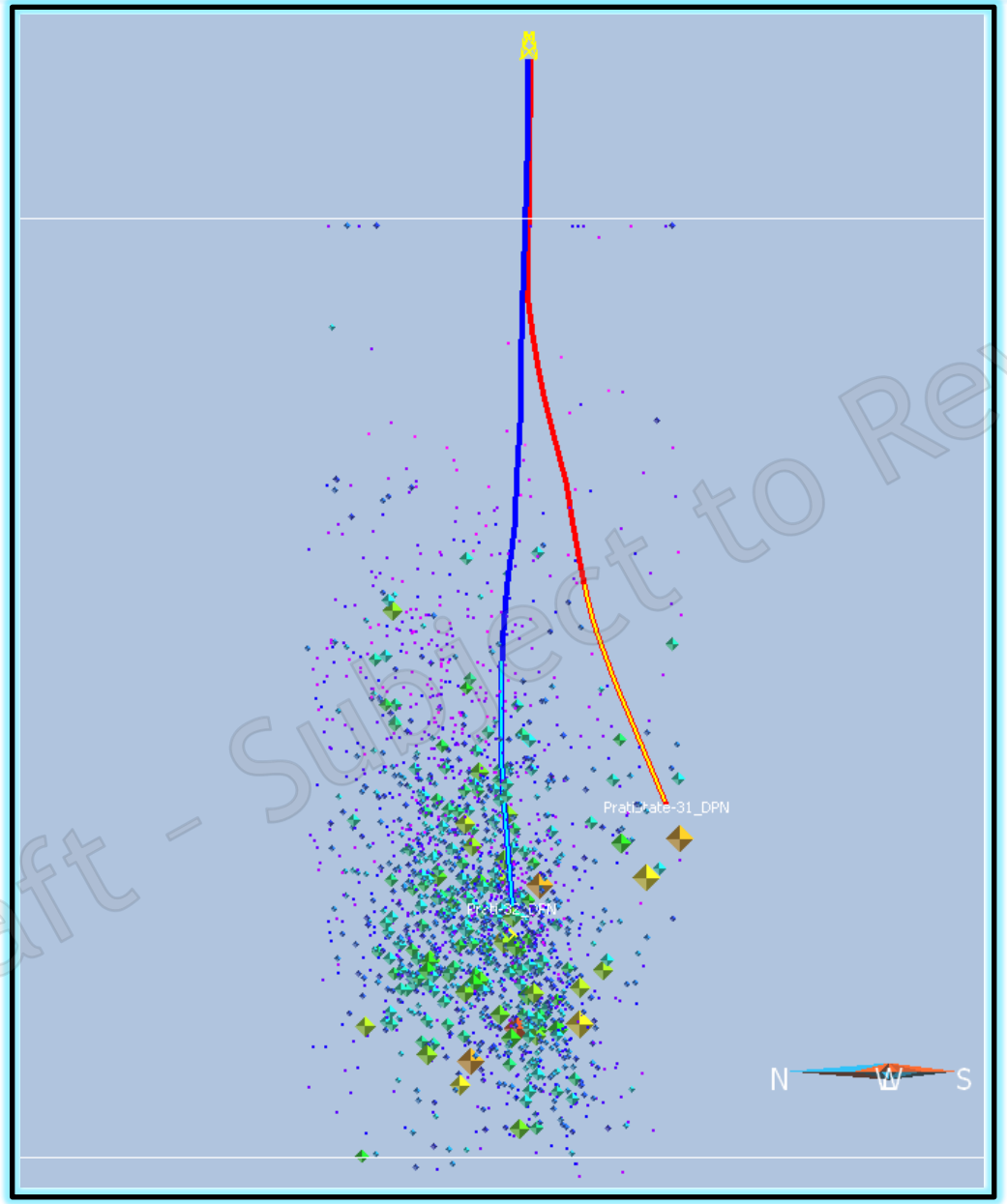
Calpine NW Geysers EGS Demonstration
Seismicity Analysis: 01 September 2011 to 19 September 2012

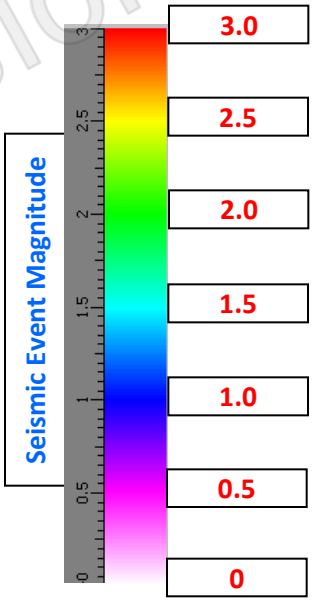
LBNL database events with ErH (horizontal error) and ErZ (vertical error) less than 1 km



Calpine NW Geysers EGS Demonstration
Seismicity Analysis: 01 September 2011 to 19 September 2012

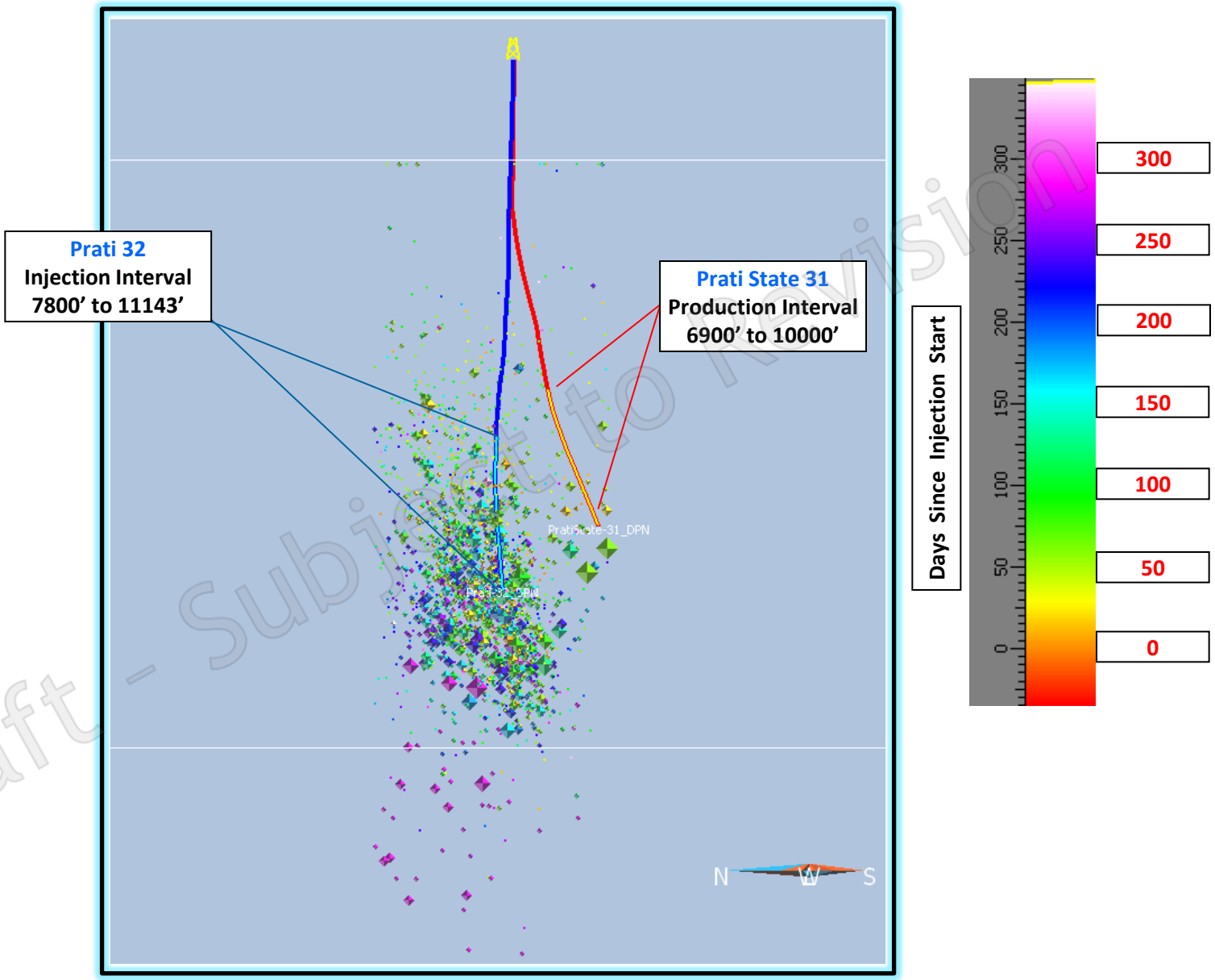
LBNL database events with ErH (horizontal error) and ErZ (vertical error) less than 1 km





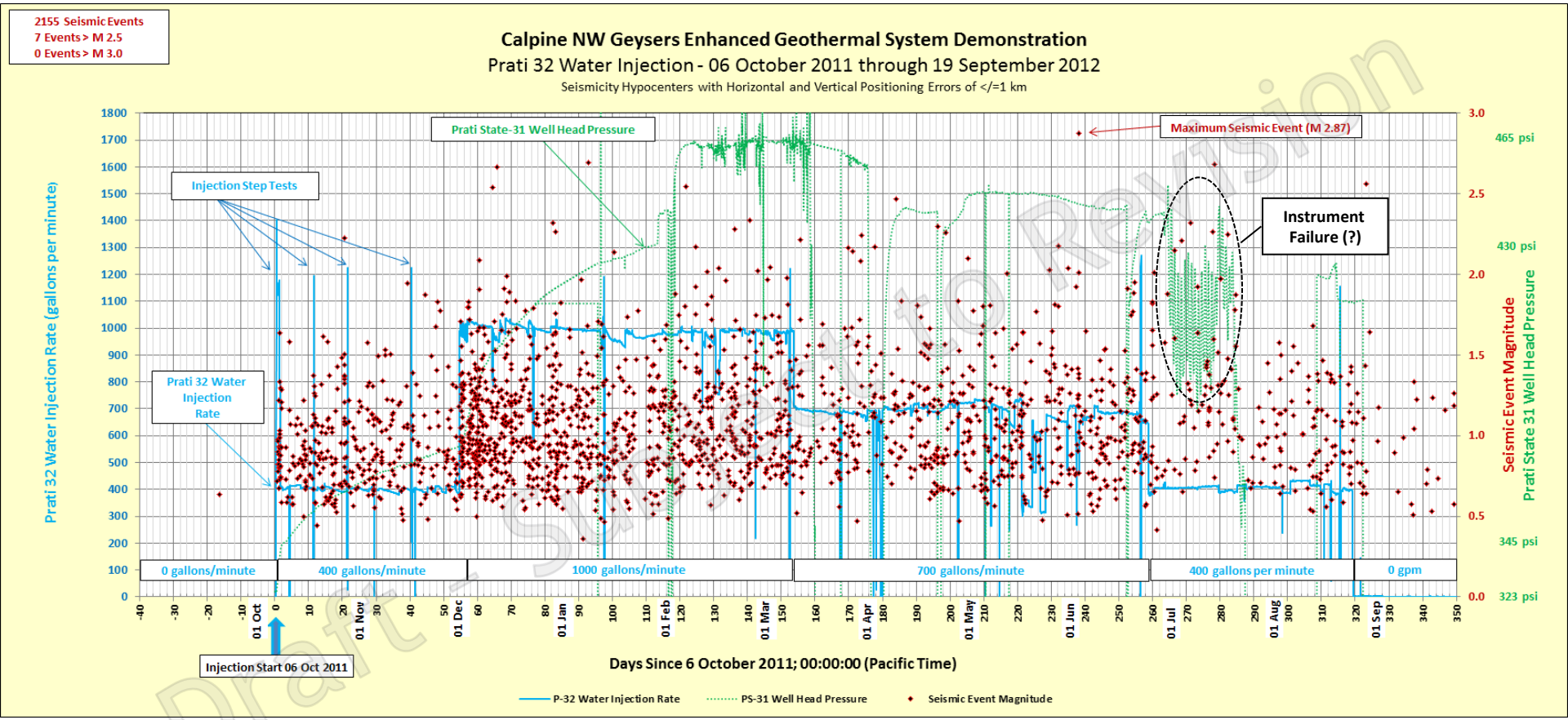
Calpine NW Geysers EGS Demonstration
Seismicity Analysis: 01 September 2011 to 19 September 2012

LBNL database events with ErH (horizontal error) and ErZ (vertical error) less than 1 km



Calpine NW Geysers EGS Demonstration
Seismicity Analysis: 01 September 2011 to 19 September 2012

LBNL database events with ErH (horizontal error) and ErZ (vertical error) less than 1 km



Calpine NW Geysers EGS Demonstration
Seismicity Analysis: 01 September 2011 to 19 September 2012

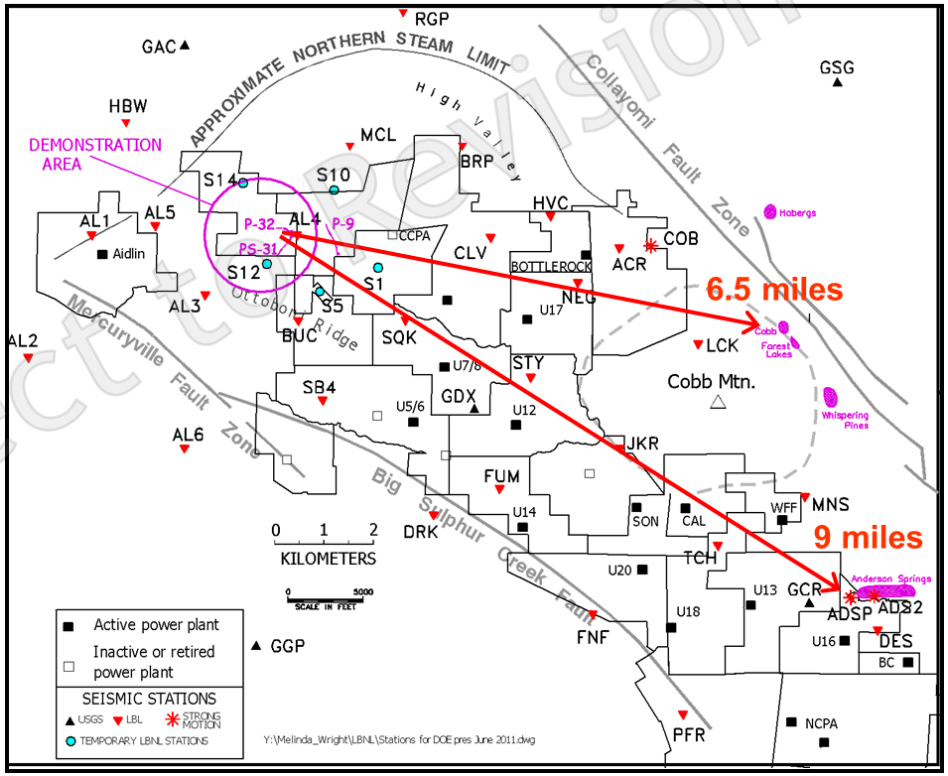
CALPINE

Negligible Strong Motion Instrument Responses at Anderson Springs and Cobb From Maximum Seismic Event (M 2.87)

20120531_053126_COB-03432_EF081 COB 05/31/2012/ 05:31:26.000
HNE 1.484894 0.019180 0.590780 0.054566 0.008896 HNN 1.281621 0.021821 1.063913 0.045667 0.008398 HNZ 0.818167 0.010188 0.395494 0.036799 0.004547

20120531_053129_ADSP-03433_FF1239 ADSP 05/31/2012/ 05:31:26.000
HNE 1.718394 0.022286 0.600226 0.034296 0.008010 HNN 1.366358 0.019826 0.484243 0.029602 0.010503 HNZ 0.998494 0.011479 0.185820 0.014799 0.004931

Magnitude 2.87 Event
31 May 2012, 05:31:26 UTC



Anderson Springs:
Geometric Mean (Horizontal Components):
1.53 cm/sec^2 = 0.16% of gravitational acceleration
Modified Mercalli Intensity: I
Not Felt; No Potential Damage

Cobb:
Geometric Mean (Horizontal Components):
1.38 cm/sec^2 = 0.14% of gravitational acceleration
Modified Mercalli Intensity: I
Not Felt; No Potential Damage

Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Potential Damage	None	None	None	Very Light	Light	Moderate	Mod/Heavy	Heavy	Very Heavy
Peak Acceleration (% of g)	< 0.17	0.17 - 1.4	1.4 - 3.9	3.9 - 9.2	9.2 - 18.0	18.0 - 34.0	34.0 - 65.0	65.0 - 124.0	> 124.0
Peak Velocity (cm/sec)	< 0.10	0.1 - 1.1	1.1 - 3.4	3.4 - 8.1	8.1 - 16.0	16.0 - 31.0	31.0 - 60.0	60.0 - 116.0	> 116.0
Modified Mercalli Intensity	I	II-III	IV	V	VI	VII	VIII	IX	X

CALPINE NYSE CPN

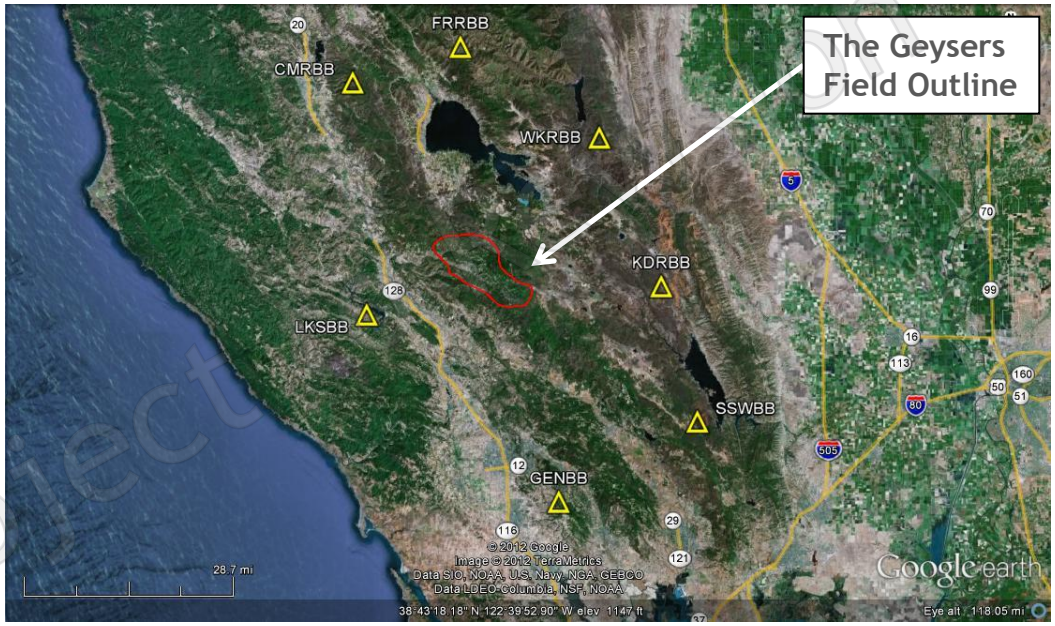
Research Collaboration with European GEISER Project

Coordinated with Dr. Roland Gritto; Array Information Technology

At The Geysers:

- 32 stations installed in early 2012:
- 25 within field boundary
- 7 beyond field boundary

- Continuous monitoring
- Broadband
- Within and beyond geothermal field



Most are co-located:

LBNL Stations (24)
USGS Stations (4)
Strong Motion Stations (1)

Improve understanding of:

structural features
seismic energy attenuation
seismic velocities (Vp and Vs)
velocity change with reservoir fluid variations

GEISER
Geothermal Engineering Integrating Mitigation of Induced Seismicity in Reservoirs

This seismic monitoring network contributes to worldwide GEISER consortium goals

Additional Seismic Monitoring and Research

CALPINE NYSE CPN

Research Collaboration with European GEISER Project*
Coordinated through GFZ Potsdam (Germany)

GEISER — Geothermal Engineering Integrating Mitigation of Induced Seismicity in Reservoirs

Goal:

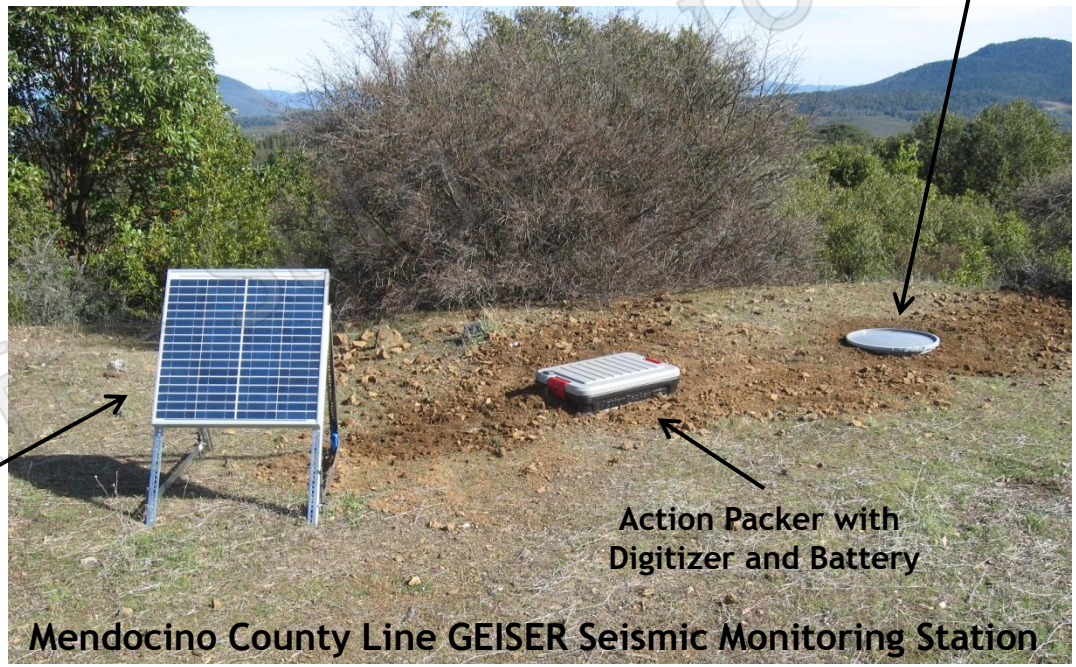
Address challenges to geothermal energy

Main topics:

1. *World-wide acquisition and analysis of induced seismicity data*
2. *Understanding induced seismicity the geomechanics and processes*
3. *Consequences of induced seismicity*
4. *Strategies for the mitigation of induced seismicity*

Triaxial Broadband Seismometer in Sealed Container

GÜRALP: 60 second to 50Hz
or
Trillium: 120 second to 100 Hz



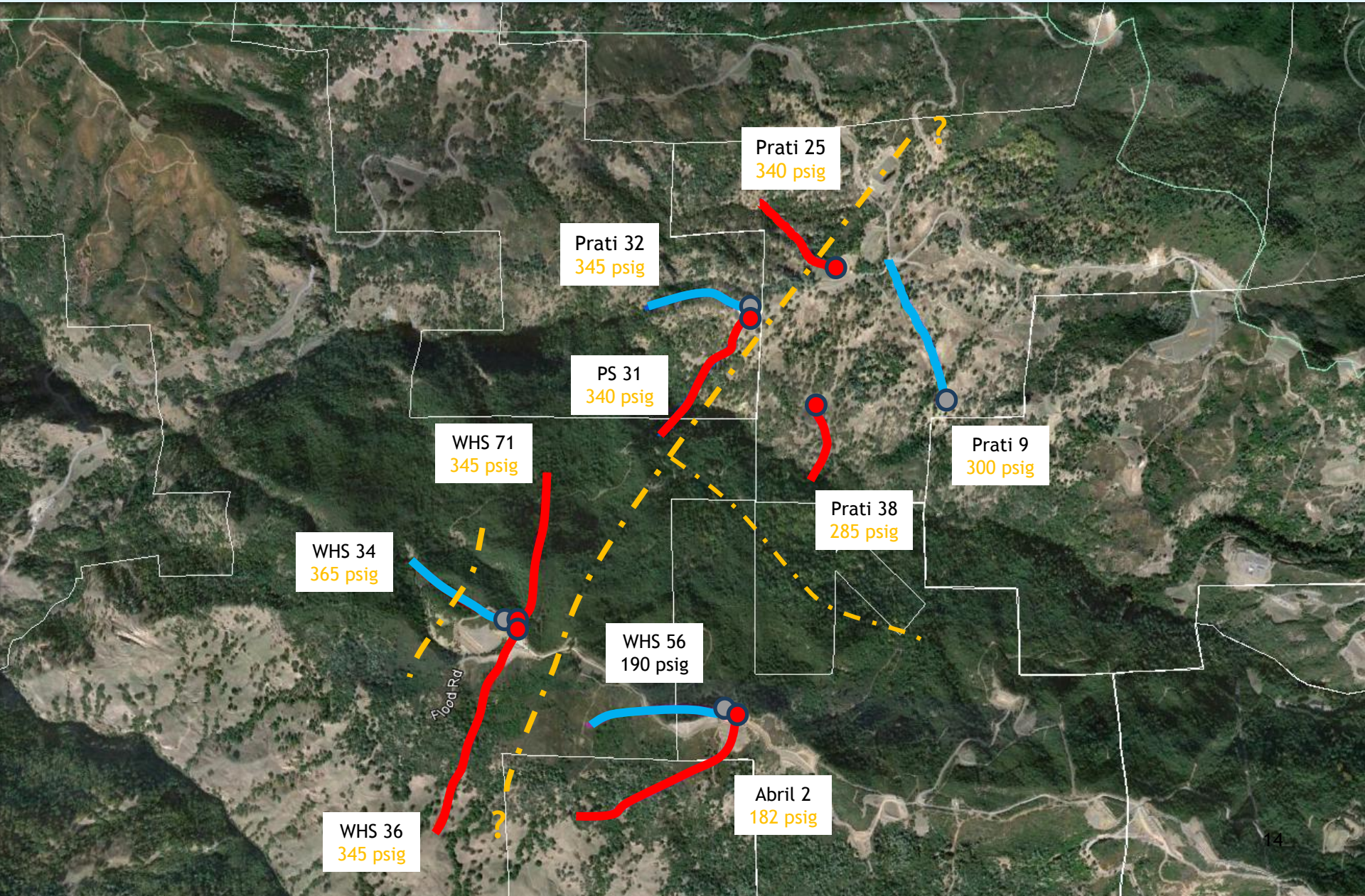
Mendocino County Line GEISER Seismic Monitoring Station

Trillium triaxial seismometer

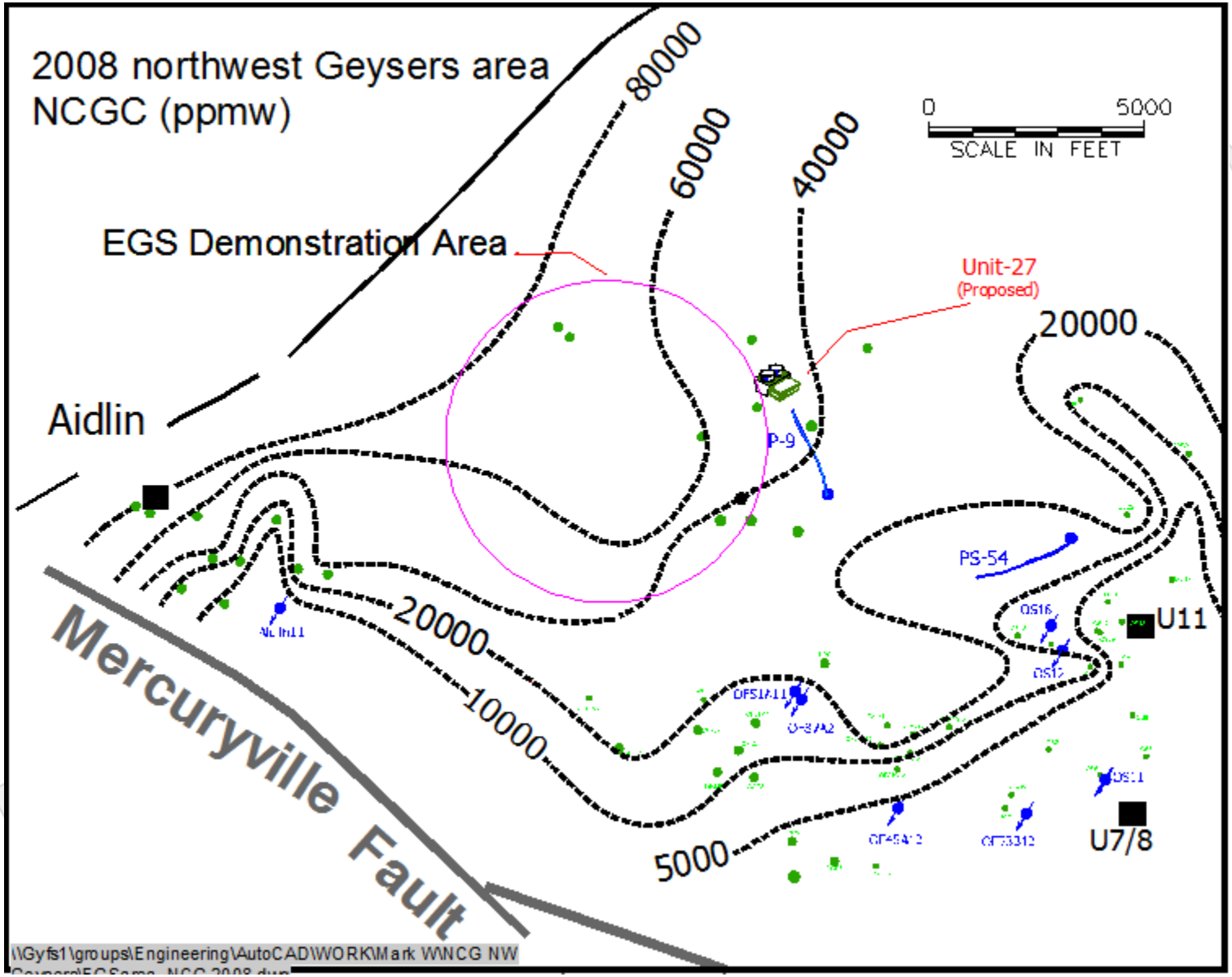
* GEISER Partners: GFZ Potsdam, BRGM, ISOR, TNO, ETHZ, STATOIL, GEOWATT, NORSAR, ARMINES, EOST, KNMI, AMRA, INGV

Northwest Geysers EGS Demonstration

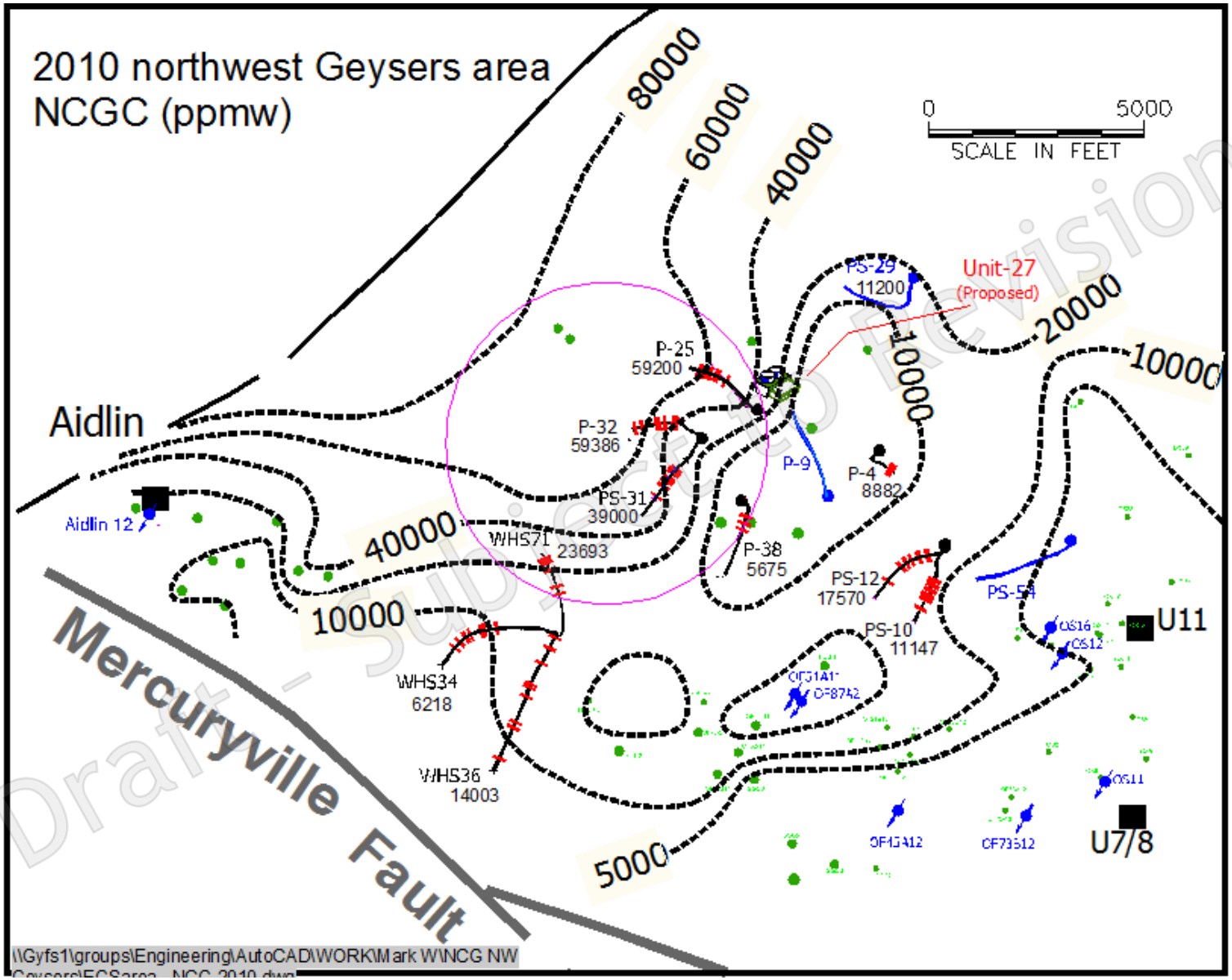
Stimulation (Injection started: 10/06/2011 10:00 AM)



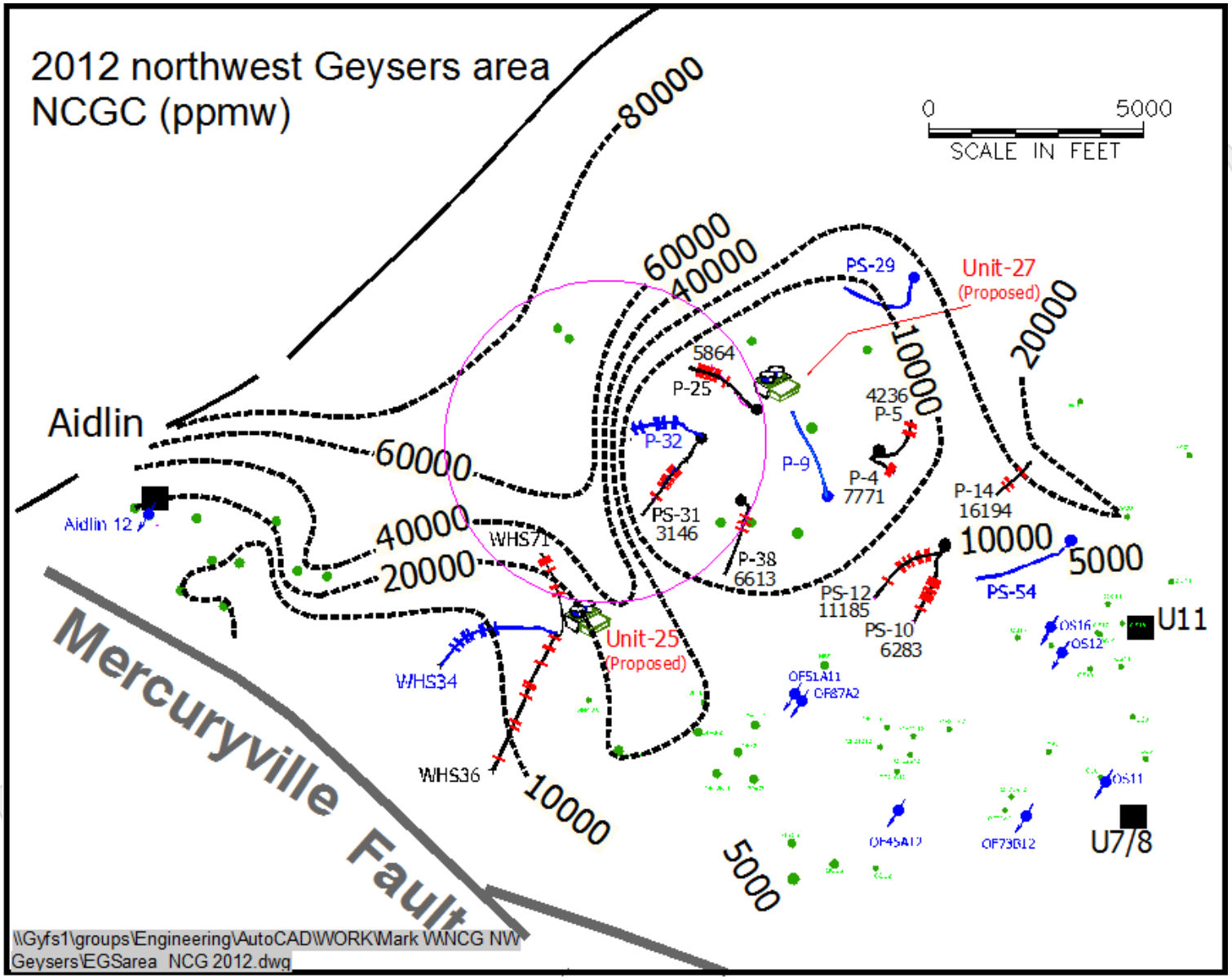
Calpine NW Geysers EGS Demonstration
Geochemical Analysis



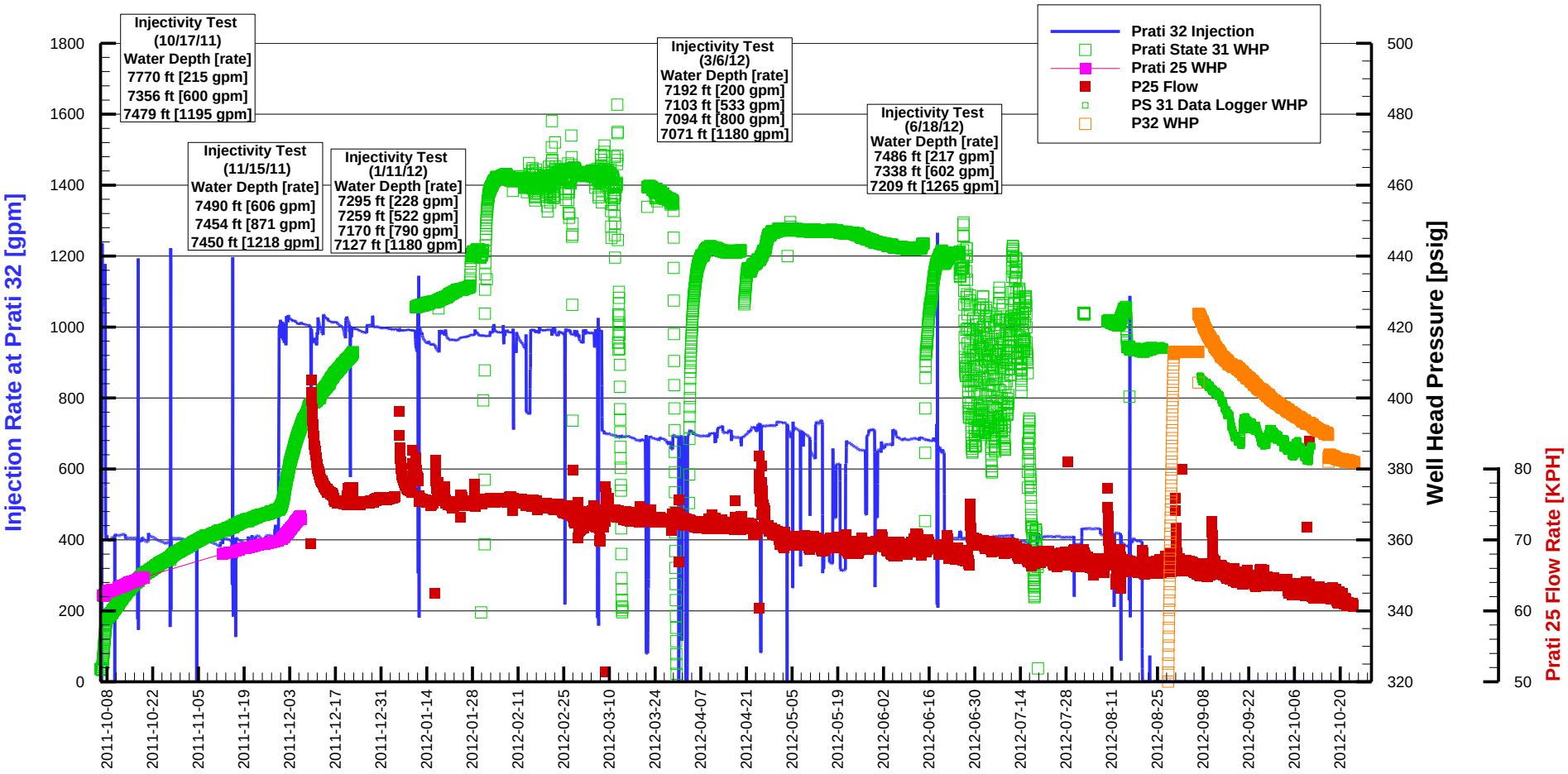
Calpine NW Geysers EGS Demonstration
Geochemical Analysis



Calpine NW Geysers EGS Demonstration
Geochemical Analysis



Prati 32 Injection and Prati State 31 Pressure Response



The injection of SRGRP wastewater into Prati 32 resulted in wellhead pressures Increasing in Prati State 31 from about 320 psi before injection to 460 psi after five months of injection. Consequently, the steam flow increased in Prati State 31

Northwest Geysers EGS Demonstration

Prati State 31 Flow Test Results

- Flow rate of PS-31 increased from 55,000 lb/hr prior to the October 2011 stimulation, to 93,000 lb/hr when tested in January 2012.
- Total NCG decreased more than 90% following the injection of water at P-32.
- About 5 MW equivalent of new injection-derived steam from SRGRP wastewater which is produced from PS-31 and P-25 may result if the proposed Wild Horse Power Plant is constructed near the EGS demonstration.

		Flow Testing			Geochemistry		
	WELL	KPH (klbs/hr)	WHP (psig)	SIWHP (psig)	NCG (wt.%)	H_2S (ppmw)	Cl (ppmw)
Test prior to October 2011 stimulation →	PS-31	55	100	320	3.9	1280	135
January 31, 2012 test results →	PS-31	72	100	465	0.3	550	125
June 14, 2012 test results →	PS-31	93	100	440	0.5	645	15

CALPINE®

NYSE CPN